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Issue Report

Economic Returns to Rural Infrastructure Investment

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** The views expressed in this paper are those of the authors and should not be attributed to IBO.*

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Commissioned papers: This paper was one of six commissioned as part of the workshop, *Economic Returns to Rural Infrastructure Investment*, organized by Farm Foundation and USDA's Economic Research Service (ERS). The workshop took place April 10–11, 2018, in Washington, D.C. A seventh paper, which had already been published, was also presented at the workshop because of its high relevance to the topic. All seven full papers are available on the Farm Foundation website, *https://farmfoundation.org*. Farm Foundation gratefully acknowledges BNSF Railway for its support of the commissioned papers.

Productivity and Quality-of-Life Benefits to Rural Infrastructure

The benefits of infrastructure can take on many forms. Most analyses emphasize the effect of infrastructure on measures of output, or income, such as the dollar value of goods sold. These market-oriented impacts are associated with the "economy" by the public and are labeled by economists as productivity effects. However, infrastructure may also have important quality-of-life benefits involving no market transactions. If a new school saves a family 20 minutes a day in travel time, that may simply increase leisure time. Similarly, beautiful artwork may make locals happier, without boosting their income.

This study estimates the productivity and quality-of-life benefits of public infrastructure investments to rural counties using data back from 1970. To build these estimates, we first consider the impact that public infrastructure has on various local outcomes, including income, employment, housing prices and agricultural land values. Our economic framework allows us to consider three kinds of productivity—those in agriculture, other outputs tradable across counties, and non-tradable output.

Geographically, we consider whether the benefits of infrastructure spending are different in counties with greater natural amenities. These counties already have desirable natural geographic and climatic features, such as access to water, mild climates and attractive topography. These counties have experienced greater population growth than lower amenity counties.

Measuring Three Types of Productivity and Quality-of-Life Benefits

We estimate the relationship of infrastructure with the productivity of different economic sectors and the quality of people's lives. In our economic framework, each county is considered to have its own market for agricultural output, other tradable goods output, and non-tradable goods output (such as buildings). Therefore, infrastructure may improve the productivity in any of these sectors or directly enhance the quality-of-life for county residents.

We use the changes in county wages, housing prices, agricultural land value and population to measure productivity and quality-of-life improvements. For example, if a household pays $40,000 more for a home in county A than in county B, it is because most households think it is worth the additional $40,000 to live in county A over B. If not, they would move elsewhere more satisfying. Similarly, if firms pay workers $5,000 more in county A than in county B, it is because the firm finds it worthwhile because the workers are $5,000 more productive in county A than in B. If the productivity advantage did not exist, the firm would move elsewhere more profitable.

Taking this simple intuition to a rich economic framework, we measure different benefits of infrastructure as summarized in Table 1.

Measuring Infrastructure and Natural Amenities

Our county-level dataset spans back to 1970 using a number of datasets. Our panel contains data for six periods: 1970, 1980, 1990, 2000, 2007 and 2012.[1]

Infrastructure: County Area Finances dataset of the U.S. Census reports local government finance activities, aggregated for each of the more than 3,000 counties in the nation. Local governments comprise counties, municipalities, townships, special districts and independent school districts. By applying the perpetual inventory technique to gross-of-depreciation capital investment flows from 1902 to the present, we measure the stock of public capital at each point in time.

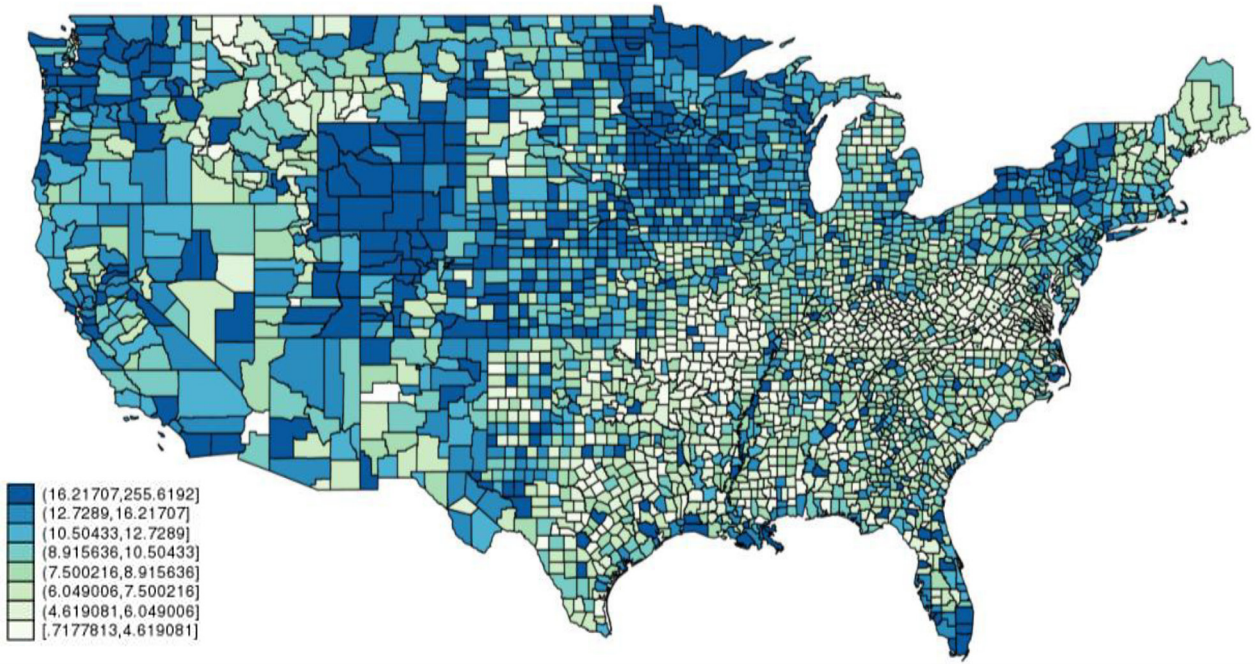
The county public infrastructure investment per capita is mapped in Figure 1. The differences between urban and rural areas are not very extreme. Overall, per capita infrastructure levels are generally higher in the North and West, with the exceptions of Southern Florida, Louisiana and certain urban agglomerations, like Houston.

Natural Amenities Scale: According to the U.S. Department of Agriculture (USDA), the natural amenities scale is "a measure of the physical characteristics of a county area that enhance the

Table 1 - Form of Benefit and How it is Measured

Form of Benefit	Description	How it is Measured
Trade Productivity	How efficiently local firms can use labor and capital to produce output that can be traded with neighboring counties	Wage levels of local workers, weighted by their share of costs in total production
Agricultural Productivity	How efficiently local producers can use labor, land, and capital to produce agricultural output	Value of agricultural land and wage levels of local workers, weighted by their share of costs in agricultural production
Home Productivity	How efficiently local producers can use labor, land, and capital to produce goods and services not tradable across counties	Population levels relative to housing prices, adjusted for local income levels
Quality-of-life	How much local households benefit directly from an improvement, holding the consumption of produced goods constant	Willingness to pay of households measured by housing prices relative to income levels **plus** local population levels

Figure 1. Infrastructure investment per capital in 2012



location as a place to live." The scale is calculated based on warm winter, winter sun, temperate summer, low summer humidity, topographic variation and water area, which are environmental qualities that people generally prefer. According to USDA, the amenities predict which counties have seen their populations grow up to 1980.[2]

Basic Correlations: Correlations between counties show that high-amenity counties have less infrastructure per capita than low-amenity counties. Since 1970, investment in their infrastructure has grown more quickly than in low-amenity areas. Their population and employment levels have also grown more rapidly as have their housing prices. At the same time, manufacturing employment has decreased faster in high-amenity counties.

Cross-sectional relationships are mere correlations and are unlikely to uncover true causal relationships. We try to provide more plausible estimates using changes over time within counties. These estimates capture only the benefits of infrastructure in the counties it is provided, and do not capture potentially important spillover effects.

Relationship of Infrastructure with County Outcomes

We can now probe the relationship of county infrastructure with population, family income, farm land value and housing value over time. We estimate these relationships net of fixed county characteristics, such as their geography, and net of time varying variables that similarly affect all counties, such as national swings in income and capital. Furthermore, we control for a range of potentially important confounding variables that change endogenously over time, such as shares of the population by age, race and education levels, state tax rates and state infrastructure.

These estimates are not guaranteed to provide the true causal effects of infrastructure. Infrastructure investments may be targeted towards areas where greater growth in employment and income are projected. In that case, our estimates will be biased upwards towards finding larger effects. In a sense the results could suffer from "reverse causality," as greater (expected) future growth causes infrastructure investments, rather than the other way around.

Figure 2 shows the percentage change in outcomes that is related to a 10% increase in infrastructure. For example, the first bar (green) shows that a 10% increase in infrastructure, predicts a 2.2% increase in population in high-amenity counties. The second and third bars (red) show that this relationship is weaker for average-amenity counties, and even weaker for low-amenity counties. For the latter, a 10% increase in infrastructure, predicts only a 1.3% increase in population, which is highlighted by the arrow under the third bar from the left. Note that the other

relationships are more modest in magnitude and the relationships are weaker for low-amenity counties across the board. The percent change estimates of Figure 2 on average translate into $125 of family income, $636 of residential land value, and a $13.8 appreciation per acre of farm land value for average-amenity counties.

Quality-of-Life and Productivity Benefits

Evaluating the benefits of infrastructure investments relative to the costs of those investments requires converting the estimated relationship presented above into dollar amounts. Doing this requires comparing changes in assets, like housing prices and land values, to changes in incomes, which are flows. Thus, we capitalize the income flows using a somewhat conservative rate of 7%, based on a standard user-cost of housing formula.

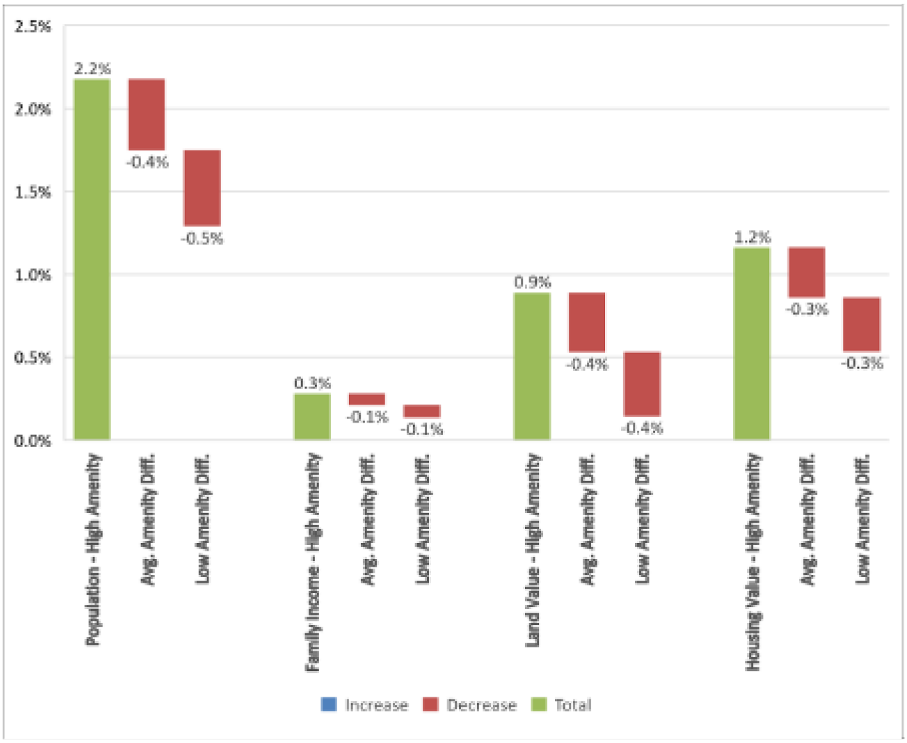
The dollar values for the quality-of-life and productivity benefits of public infrastructure are calculated using the economic framework that was overviewed in Table 1. These benefits are stacked in Figure 3 below for low- and high-amenity counties.

In low-amenity counties, most of the benefits accrue in the form of trade productivity and home productivity, with small benefits in agricultural productivity and quality-of-life. In high-amenity counties, the benefits of trade productivity and quality-of-life are much higher. This suggests that for the most part, amenities scale and public infrastructure are complements, especially when it comes to quality-of-life benefits, but also for traded forms of productivity. High-amenity areas appear to have a hard time seeing gains to home productivity benefits for reasons that deserve further investigation.

Cost-Benefit Test

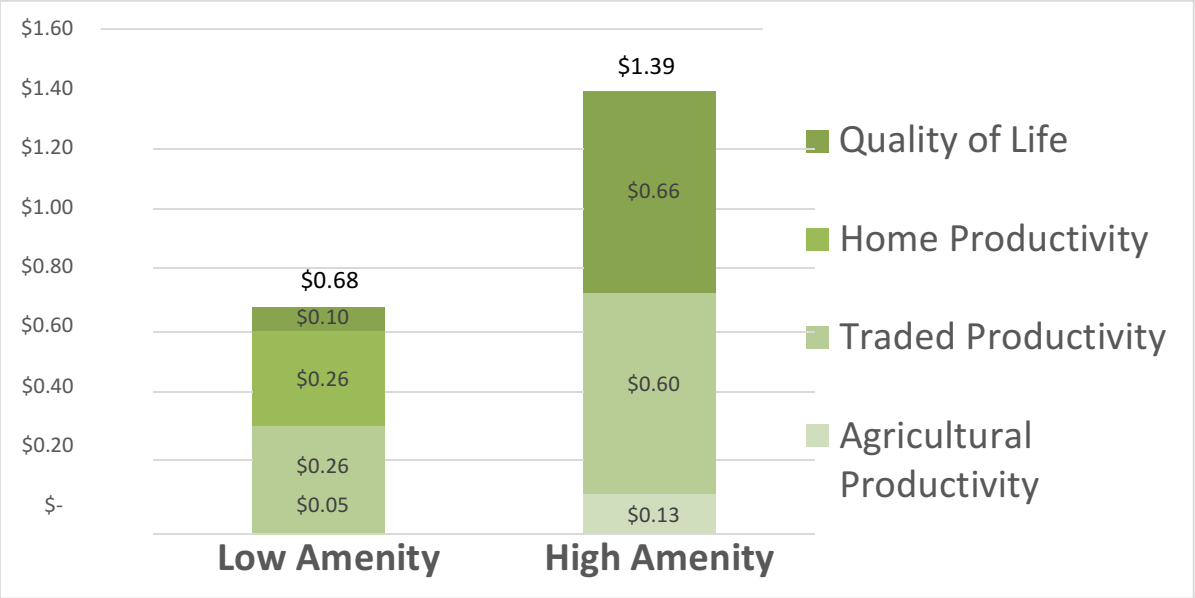
Whether infrastructure investments pass the cost-benefit test depends much on how those investments were financed. If funds were generated locally, the benefits we estimate may be seen as net benefits after netting out the cost. However, if funds were

Figure 2 Percentage Change in Outcomes in Relationship To a 10% Increase in Infrastructure for High-, Average-, and Low-Amenity Rural Counties



Note: Low/high amenity coefficient is calculated by multiplying average amenities scale of low/high amenity counties (-1.48 and 1.38 respectively) to the interaction coefficient. Green bars show the elasticity in high amenity counties and the next two red bars show the decrease from the previous bar. Average elasticity and elasticity in low amenity counties are lower than those of high amenity counties.

Figure 3 - Form of Benefits of Public Capital per Dollar Invested in Rural Counties by Amenities Scale



provided externally, it appears to be more appropriate for gross benefits per dollar spent, given the nature of our empirical estimates. In this case, the minimum threshold for return on investment that needs to be achieved is the $1 benchmark. According to the marginal cost of public funds (MCPF) literature, depending on the method that federal government raises funds, $1 dollar of additional funds costs between $1 and $1.35.

If the federal-fund interpretation holds, infrastructure projects in high-amenity counties are likely to pass a standard cost-benefit test. This considers that the marginal cost of public funds, while above $1 because of the administrative and economic costs of raising taxes, is probably less than $1.39 of benefits that we estimate. The situation is more precarious for low-amenity counties, where the benefits are significantly below the $1 mark, which is the lowest possible marginal cost of public funds.

Main Results and Conclusions:

- Quality infrastructure is related to higher rates of population growth, greater incomes, higher housing prices and greater agricultural land values. These results are all stronger in high-amenity areas. These relationships may not be causal since reverse causality is a concern.

- In high-amenity counties, $1 of infrastructure is correlated with $1.39 of productivity and quality-of-life benefits. Quality-of-life benefits comprise $0.66 or 48% of these benefits.

- In low-amenity counties, on the other hand, $1 of infrastructure is correlated with only $0.68 of productivity and quality-of-life benefits. Quality-of-life benefits are only 10 cents for each $1 of infrastructure in these counties.

- Natural and artificial amenities are complements in consumption and often in production, increasing quality-of-life and firm productivity most in areas that are already naturally desirable.

- Much of the benefit of infrastructure improvements takes the form of harder-to-measure quality-of-life effects. These benefits would be missed by studies that only focus on productivity benefits of infrastructure.

Cost-Benefit Implications:

- According to other researchers, raising $1 of additional public funds may cost the society between $1 and $1.35 depending on how the funds are raised in the United States.

- Based on a conservative (7%) discount rate that disfavor investment,
    - In high-amenity counties the benefits of $1 of infrastructure are $1.39 and higher than the marginal cost of public funds.

    - In low amenity counties, infrastructure investments do not pass the cost-benefit test, unless discount rates are much lower than 7%.

End Notes:

[1] 2007 and 2012 are chosen to match to the years of Census of Agriculture.

[2] McGranahan, D. (1999). *Natural Amenities Drive Rural Population Change*. Economic Research Service. Washington, D.C.: U.S. Department of Agriculture.

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