Economic Development, Infrastructure and

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Abstract: This article reviews the evidence on the impact of public infrastructure on the economy. It also examines why public infrastructure is provided inefficiently. Several methodologies have been used to investigate the economic impact of public infrastructure investment. Additional infrastructure investment generally has a positive, but modest, impact on economic activity. The modest impact reflects the offsetting effects of higher taxes needed to finance projects and, for highways, the incentive to relocate economic activity.

Most infrastructure is provided at a zero price. This results in over use and congestion. Zero pricing makes it difficult to determine the optimal amount of infrastructure. The solution is to switch to a variable pricing system where the price reflects the social marginal cost of using the road or airport. New technology makes this possible at low administrative costs.

Political factors have an impact on infrastructure investment decisions. The evidence indicates political forces create incentives to underestimate costs and overestimate demand, inflating benefit-cost ratios, resulting in non-economic projects being funded. Many local infrastructure projects are funded by national governments. Legislators vote for non-economic projects because the local benefits exceed the local share of the total costs even when the local benefits from the project are less than the total cost. There is a significant net loss to society as a result of this type of voting behavior.

Keywords

- Infrastructure,
- Production function,
- Spatial reallocation,
- Localized benefits,
- Congestion
- Forecast bias
- Voting behavior

Introduction

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An economy's infrastructure provides valuable services to private firms and individuals. Infrastructure investment can influence the growth, level, and spatial distribution of economic activity. The bulk of the research since the 1990s has focused on the impact of public capital investment on productivity and overall economic development.

Initial studies suggested that public capital had a large impact on U.S. economic activity. More recent studies found only a modest overall impact on the economy. The low net return to public capital investment reflects diminishing marginal returns to infrastructure construction, the spatial reallocation of economic activity, higher tax rates needed to finance projects, and reductions in agglomeration economies in non-congested areas. More recent work on the economic impact of infrastructure is also mixed, but concludes infrastructure has a modest positive impact. In addition, research continues to argue that infrastructure pricing and political economy issues result in an inefficient level of infrastructure.

This article is organized in the following manner. First, U.S. infrastructure trends are briefly reviewed. What follows is a discussion of how infrastructure influences the economy. Key empirical studies that examine the impact of public capital on the economy are reviewed. Special attention is given to reasons why the estimated net impact in recent studies is so small. Policies to improve the efficiency of infrastructure provision and its use are discussed. Finally, the political economy of infrastructure is reviewed.

Public Infrastructure Trends

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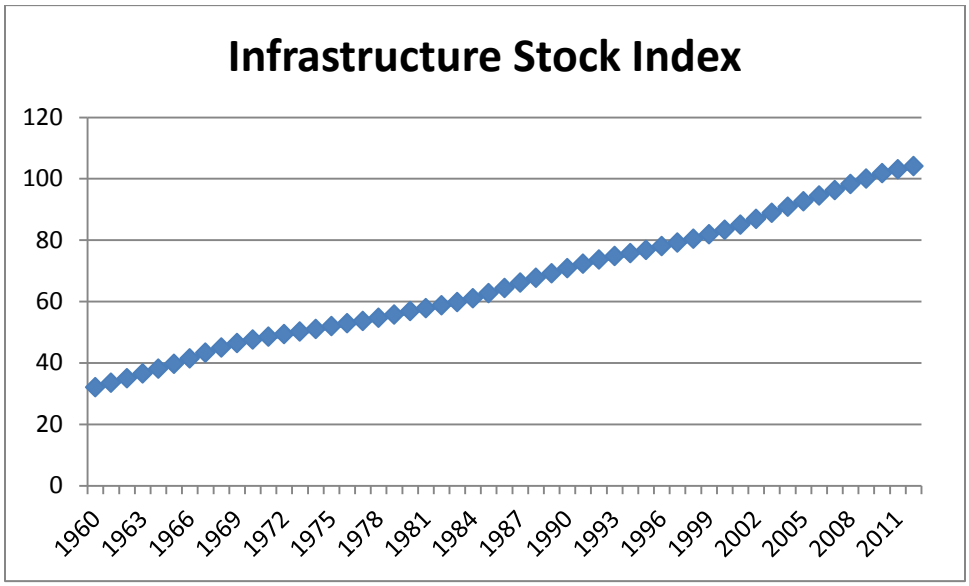
This section discusses the composition and trends in the public infrastructure stock of the United States. To get a sense of public infrastructure trends, Fig. 1 provides plots of a quantity index for federal-state & local fixed assets (the public capital stock) from 1960 to 2012. The non-military public capital stock data used in this section includes equipment and software, structures, highways and streets, conservation and development, sewer systems, water supply, and other structures. The data comes from the U.S. Department of Commerce *Fixed Assets and Consumer Durable Goods in the United States*.

Fig. 1 Public Infrastructure Stock



The index trends upward over this period. A slowdown in federal infrastructure investment occurred in the late 1960s. This coincided with the completion of the interstate highway system. .

Table 1 Composition of Infrastructure Stock (in percentages)

	1960	1970	1980	1990	2000	2010
Federal						
Equipment	6.8	4.1	5.6	7.4	7.4	7.6
Buildings	12.8	11.0	11.5	13.3	11.1	10.8
Highways & Streets	4.0	3.7	3.7	3.2	3.6	4.1
Conservation & Development	59.9	37.0	34.7	30.0	14.2	14.2
Other Structures	1.0	1.4	1.5	2.0	3.8	4.1
Intellectual Property	15.2	42.8	43.0	41.8	44.0	44.6
State & Local						
Equipment	2.5	2.7	2.9	4.2	4.2	2.9
Highways & Streets	40.0	41.6	36.6	33.4	32.4	33.7
Conservation & Development	1.1	1.6	1.7	1.8	1.5	1.3

Sewage & Water	14.6	12.3	14.4	14.0	13.4	12.8
Other Structures						
Intellectual Property	0.4	0.6	0.7	1.2	6.5	1.2
Federal/Total	16.3	19.8	19.0	18.8	17.2	13.7

Table 1 provides information on the composition of non-military government fixed assets for selected years between 1960 and 2010. The shares do not change radically over the period. For the federal government, the exception is the increase in intellectual property products which includes software and R & D . This is no surprise, as the government significantly increased its use of computers, beginning in the late 1980s and continuing into the 1990s and 2000s. There is a noticeable decline in the federal conservation component over the period. Buildings, equipment, and highway's shares remained fairly stable during this period. The composition of state and local fixed assets remains fairly stable over the period as well.

State and local governments own the vast majority of the public infrastructure stock. As shown in Table 1, the federal government owned approximately 18% of total non-military government fixed assets in 1960. By 2012, the federal government's share had declined to roughly 14%.

Infrastructure's Impact on Economic Activity

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Public infrastructure is made up of public goods typically subject to economies of scale, such as roads, sewage treatment facilities, and water supply systems. Increases in infrastructure can have a significant impact on economic activity in various ways. The effects on output can be direct and indirect.[1] In the case of a direct effect, the infrastructure provides intermediate services to the private sector. For example, a new or wider road can reduce congestion, reducing travel time. Local businesses can now make more deliveries with the same number of trucks and drivers, resulting in higher output. Investments by firms in additional trucks would have produced the same result—an increase in the number of deliveries the firm is capable of making.

The indirect output effect works through the impact of greater infrastructure on the marginal product of private inputs hired by firms. If a complementary relationship exists between public capital and private inputs, increases in public capital result in a higher marginal product of private inputs. The marginal product of the private inputs rises because they have more public capital to work with in the production process. The higher marginal product of private inputs raises the firm's demand for those inputs. Continuing with the road example, the improved road

system makes existing trucks and drivers more productive. As a result, the firm buys more trucks and hires additional drivers, causing the firm's output to rise.

The previous example illustrated a complementary relationship between public and private capital. Alternatively, higher public capital can substitute for private capital, reducing private inputs in production. For example, a city can decide to produce electricity itself, rather than have it produced privately. In this case, public capital crowds out private capital. It may even reduce economic activity if government is a less efficient provider.

New infrastructure can influence the spatial distribution of economic activity in a region.[2] The building of a new road can cause businesses to relocate to take advantage of lower transportation costs and greater customer flows. The new road raises the marginal product of private inputs near it, creating an incentive for the private inputs to relocate closer to the road. Economic activity increases near the new road, but declines in areas away from the road. In this case, the road provides only localized benefits to firms near the road. As a result of spatial reallocation of economic activity, net output increases little in the region as a whole.

Aggregate and Regional Empirical Studies

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This section reviews empirical studies that have played an important role in shaping the literature on infrastructure investment (see Ref.[3] for more details). Much of the research in this area was stimulated by a controversial 1989 study by David Aschauer.[4] Aschauer estimated an aggregate production function for the United States using annual data for the period from 1949 to 1985. He found public capital to have a large positive impact on total factor productivity and the productivity of private capital. In addition, he showed that the slowdown in the accumulation of public capital during the 1970s contributed significantly to the overall decline in U.S. productivity growth during the 1970s and 1980s.

John Tatom[5] questioned Aschauer's results on three counts. First, Aschauer ignored significant time trends in the data; this could lead to a spurious finding of a relationship between public capital and productivity when none is present. Second, Aschauer ignored significant energy price changes that might have affected productivity during the sample period. Tatom found that including energy prices in the model and adding time trends reduced the measured impact of public capital on productivity by one-half. Tatom also provided evidence that some of the variables in the model are not stationary. Because of this, the model should be estimated in first differences. When Tatom estimated the model in first differences, public capital is no longer significant.

John Fernald [6] reexamined the link between public capital and productivity. Fernald used a growth accounting approach to assess the impact of the growth in highway construction on U.S. industry-level productivity growth for the period from 1953 to 1989. He tested whether the increase in the highway capital stock had a disproportional impact on productivity growth in industries that are vehicle intensive. He found this to be true.

His results explained the productivity slowdown in the United States in the 1970s. Road construction was unusually productive before 1973, but not since that time; road construction today provides below normal returns. In other words, building the interstate highway system was exceptionally productive, but a second one would not provide comparable returns.

Rather than focusing on aggregate measures, some researchers began examining the impact of public capital on the economy at the state and local levels. Analysis at the state level increases sample size, improving statistical inference. It also makes sense because decisions and ownership of the public capital stock are primarily at the state and local levels.

Alicia Munnell [7] constructed estimates of state-level public capital to examine the relationship between infrastructure and economic development. Munnell estimated production functions using state level data for the period 1970 to 1986. She found that a 1% increase in a state's public capital stock raises per-capita real gross state product by 0.15 of a percent point. This estimate is smaller than some aggregate results, but is statistically significant.

Munnell's results were challenged by Holtz-Eakin [8] and Krol. [9] Both researchers pointed to the fact that Munnell failed to control for unobserved differences in state production functions. Ignoring these differences can significantly bias estimates of public capital productivity. Both Holtz-Eakin and Krol found that once unobserved production function differences are controlled for, public capital is generally no longer a significant determinant of productivity. These results question the widespread view that large increases in state infrastructure investment are an important source of state economic development.

Morrison and Schwartz [10] focused on the manufacturing sector, examining the impact of additional infrastructure investment on regional manufacturing costs. Estimating cost functions for regions of the United States for the period from 1970 to 1987, they found that additional public capital significantly lowers manufacturing costs in all regions. An additional $1 million worth of infrastructure lowered manufacturing costs by about $160,000 to $180,000 per year. But a positive marginal product is not enough in and of itself to justify additional investment; there must be a positive net return after the costs of financing the investment are considered.

Other recent papers have moved away from the production function approach. The production function approach ignores dynamic effects. Also, there may be feedback effects from output to public capital formation. Faster economic growth can increase the size of the tax base, potentially increasing public investment in roads and bridges.

These econometric problems can be handled by estimating a vector autoregression (a multivariate time-series model). The model includes a measure of public capital or public investment plus private sector variables of interest, such as output, employment, and investment.

Each variable included in the model is regressed on lagged values of itself and the other variables in the model. The lagged variables capture the dynamics and because each variable has its own regression equation, feedback effects are taken into account.

Pereira and Flores de Frustos (27) and Pereira (28) take this approach. Using data from the United States, these authors draw three conclusions. First, an increase in public capital has a positive impact on output, but the impact is smaller in magnitude than that estimated Aschauer. Second, public capital crowds in private capital. Third, the type of public capital matters. Electric and gas facilities have a larger impact on the economy than do highways.

Recent detailed reviews of the economic impact of additional infrastructure on the economy can be found in Shatz et. al. (29) and Pereira and Andraz (30).

Tax and Spatial Issues

The studies discussed in the previous section indicate that additional infrastructure investment will lead to only modest increases in productivity and output. Three factors contribute to muting the net affect of public capital on productivity and output. First, financing additional infrastructure can result in higher taxes and interest rates. Second, new infrastructure causes economic activity to be reallocated, resulting in small net regional increases in output. Third, because new highways lower transportation costs, spatial density falls, reducing agglomeration economies in areas that do not suffer from significant traffic congestion.

New infrastructure projects must be financed through taxation or borrowing. Taxes levied on private economic agents distort decisions, resulting in a less efficient allocation of resources. In addition, the higher taxes raise the cost to businesses in the economy. The higher costs due to greater taxation can offset the lower production costs associated with the benefits of additional infrastructure.

Borrowing funds in capital markets to finance an infrastructure project can raise interest rates (interest rate effects are likely to be modest in global capital markets). As in the tax example, this raises business costs that can offset the benefits derived from additional infrastructure. In both cases, the net effect on business costs and production may be close to zero.

Morrison and Schwartz, [10] and Seitz, [11] found evidence to support this conclusion. Morrison and Schwartz found the annual benefits to businesses from additional public investment (lower costs) to be less than the annual marginal costs of funds in most years. Seitz found any increase in manufacturing employment resulting from additional infrastructure to be offset by the negative employment effects of the higher taxes.

The spatial reallocation of resources that results from the construction of a new highway was examined Chandra and Thompson. [2] They investigated this relationship for non-metropolitan counties with new highway constructed during the period between 1969 and 1993. Rather than estimating a production function, they instead estimate a county earnings function, controlling for national, regional, and local factors that influence economic activity.

They find that the construction of a new highway in a county draws economic activity away from adjacent counties. Earnings in counties where the highway was constructed rise relative to counties that do not receive a new highway. Total earnings are 6% to 8% higher in the long run in the counties that get a new highway. Total earnings fall 1% to 3% in adjacent counties. Services and retail rise 5% to 8% in the county with the new highway and fall 8% to 11% in the adjacent county. They conclude the net effect of the new highway is about zero.

Boarnet [12] confirmed this result, looking at California counties during the period from 1969 to 1988. He found negative spillovers in the case of the construction of new highways. He found the construction of a new highway to be positively related to within-county output, but negatively related to adjacent-county output. These two studies confirmed the idea that highway construction provides mostly localized benefits, with limited aggregate effects.

In contrast, Pereira and Andraz (31) use a vector autoregression approach and find large spillover effects across U.S. states. They find faster growth in road construction outside a particular state has a large impact on that state's economy, implying large spillover effects. However, because they aggregate all road investment nationally outside the state, the variable may simply be a proxy for aggregate economic activity, a key driver of any state economy.

Furthermore, the construction of a new highway can reduce productivity because it can lower the benefits derived from agglomeration economies. By lowering transportation costs, the incentive for businesses to locate near one another falls. As a result, firms are in less of a position to capture the local geographic externalities that arise with agglomeration economies.

Ciccone and Hall [13] found that if you double employment density in a state, average labor productivity rises by 6%. This supports the link between density and productivity. Haughwout [14] found lower benefits to densely populated urban areas from highway construction. This result links highway construction and the associated lower transportation costs to reduced agglomeration economies. It appears that highway construction in non-congested areas can cause movement of economic activity away from densely populated areas, reducing agglomeration economies, lowering productivity and output growth. However, in congested urban areas, additional highway construction may increase access to densely populated areas and, therefore, increase agglomeration economies. Assessing the impact of infrastructure on agglomeration economies requires controlling for the level of congestion in order to draw firm conclusions of the net effect.

Improving the Provision of Infrastructure

This section examines how infrastructure policy reforms can improve the efficiency associated with the construction and use of highways. Highways and roads represent one of the largest civilian public capital goods in the United States. Winston, [15] , Winston (32), and Boarnet and Haughwout, [16] discussed how changing the way we finance and price our highways and roads can lead to large net welfare gains. These policy reforms would also moderate the demand for additional highway construction.

Highway construction is financed primarily using funds from the Federal Highway Trust Fund. In most cases, 80% of the funds used to build a new highway come from the federal government. The justification for the federal government's major role in financing highways was the presence of significant spillover benefits captured by individuals living outside the area where a road is built. However, the studies discussed in the last section indicated that highway benefits tend to highly local.[2] [12] As a result, a case can be made for the elimination of federal financing of highway construction (repealing the federal gas tax and refunding the Highway Trust Funds to state and local governments).

Federal financing raises concerns because it introduces biases toward excessive highway construction. Federal funds focus primarily on construction, rather than maintenance. Funding programs ignore the higher return to road maintenance, compared with the low return on road construction. The reason for this bias is believed to be political. Voters reward elected officials for opening a new spur of a highway, but tend to take regular maintenance to an existing road for granted.

In addition, Boarnet and Haughwout[15] pointed out that financing new highway projects with pooled tax revenues results in non-economic projects being funded. In many cases, the local benefits individuals capture from a new road exceed local costs. However, this does not make the project economic because the local benefits are often less than the total cost of building the road. As a result, total welfare is reduced when the road is built using federal funds. Instead, if local decision makers are required to finance their own roads, only those that can pass a full cost–benefit analysis will be constructed.

Congestion on many urban highways creates political pressure to build more roads. This approach has done little to solve the congestion problem. Duranton and Turner (33) find building more highways increases traffic volume but does not result in a reduction in congestion. Individual and commercial traffic increases. Furthermore, people tend to move to cities with major investments in highways and road infrastructure. This research suggests that the payback for additional construction may be an increase in economic activity rather than a reduction in congestion. They also find no relationship between public transportation and the distances people drive in a city.

Congestion indicates the price of using the highway is too low. An alternative to the costly "build your way out of congestion" approach is to move to an efficient pricing system. More efficient use of existing highways would significantly reduce the need for additional highway construction.

Today, in the United States, a flat gas tax is used to finance highways. This tax does not solve peak-load congestion problems, nor does it accurately reflect the pavement wear associated with using roads. Instead, a toll can be levied directly on users of the highway. Efficient tolls are higher during rush hours. This gives drivers an incentive to take into account the longer commuting time associated with increasing highway congestion. Tolls can be administered electronically to minimize the inconvenience of payment for road users The potential net welfare gain from imposing congestion tolls in the United States was estimated to be almost $45 billion per year in 2005 dollars. (32).

In addition to congestion problems on freeways, the interstate highway system is aging. This will require reconstruction in order to improve highway traffic flows. However, greater vehicle fuel economy has limited the growth of revenues needed to finance this work. The federal gasoline tax has not been increased since 1993. Making matters worse, the limited funds have been increasingly used for non-highway purposes, such as bike lanes, reducing the funds available for highway reconstruction. Poole (34) suggests replacing the gasoline tax with a mileage-based toll as a source of financing highway reconstruction. He calculates that a mileage-based toll of 3.5 cents per mile for cars and 14 cents per mile for trucks would be sufficient to finance the estimated reconstruction and expansion costs for the interstate highway system over the next 35 years. This toll could also be adjusted to reduce congestion problems in urban areas.

Not only can highway construction be offset by cheaper maintenance spending, but also maintenance expenditures can be lowered by a tax that reduces highway damage. The current gasoline tax worsens highway wear and tear by trucks. Because the tax is on a per-gallon basis, trucks are built using fewer axles to improve mileage. However, highway damage depends on weight per axle, not total vehicle weight. As a result, the current tax system leads to greater highway damage then one based on a toll system that factored in weight per axle.[15]

Road maintenance can also be forestalled by building thicker roads and highways. Winston[15] argued that the adoption of efficient pricing and building thicker roads has a benefit-to-cost ratio of 4. This suggests that these reforms are economic and would result in a net improvement in welfare, if implemented.

On a less optimistic note, Winston[17] argued that entrenched special interest groups, the construction industry, and public employee unions make serious transportation policy reform unlikely. The only way to get the needed reform is to privatize the construction, operation, and maintenance of the transportation system. He argued that market incentives are the only way to correct for government failure, and to improve the efficiency and quality of service.

Political Economy Issues

In order to enhance economic efficiency and taxpayer welfare, public infrastructure projects that are approved should pass a careful benefit-cost analysis. With a large number of potential projects, only projects with the highest benefit-to-cost ratios should be built. Unfortunately, political incentives often lead to an overestimation of the benefit-cost ratio resulting in non-economic projects being built, reducing taxpayer welfare. Infrastructure project evaluation involves forecasting the costs and benefits of a proposed project before a decision can be made. Krol (18, 19) finds systematic biases in government forecasts that are the result of the agencies' political structure and incentives.

Recent papers by Flybjerg et al. (20), Bain (21) and Button and Chen (22) confirm the presence of a systematic upward bias in forecasts of the benefit-cost ratios for transportation projects. These papers examine a large sample of private and public infrastructure projects over time and across countries. The projects include roads, fixed rail, bridges, and tunnels. If forecast errors were the result of model errors and general economic uncertainty, we would expect the errors to

be random. In fact, they find a systematic underestimate of project cost and an overestimate of demand. The size of the forecast errors tend to be large.

For example, Flybjerg et al. (20) find actual costs were on average 28 percent higher than estimated costs. High-speed rail had the greatest error. Bain (21) found large overestimation of traffic forecasts on private toll roads. Button and Chen (22) found overestimation of traffic forecasts by more than 37 percent for private-public toll roads and 67.7 percent on public roads. The forecast bias results in an inflated benefit-cost ratio and an inefficient use of scare resources.

There is no question that forecasting costs and traffic flows of any proposed transportation project is difficult. You would think that greater experience and improved computer modelling would lead to more accurate forecasts today compared to the past. The studies discussed here suggest this is not the case. Forecasts today are no better than forecasts made twenty years ago. This suggests that political forces are driving the forecast errors. Politicians, government employees, and contractors gain from getting the project going. They are inclined to pressure forecasters to cook the books so that the project gets built. Flybjerg et al. (20) concluded that project promoters are willing to lie and intentionally deceive voters in order to get non-economic projects started.

The legislative process may also lead to a misallocation of funds for infrastructure projects. In the United States, a significant portion (80 percent during the 1998-2003 period) of the funding of local public goods comes from the federal government. This type of funding arrangement is justified if there are significant spillover benefits between districts. Federal funding internalizes the spillovers. However, this type of funding will influence the behavior of legislators because the benefits from any project are concentrated in a local area, while the tax costs are spread out over the entire nation. This creates a common pool problem. Legialators have an incentive to support own-district spending, while at the same time trying to limit the total tax burden accompanying aggregate spending.

Knight (23) investigates this issue using congressional votes on transportation funding for 1653 projects worth $9.5 billion over the period 1998 to 2003. He finds the probability of a legislator supporting a transportation project is positively related to own-district spending and negatively related to the total tax burden. This means a representative supports a proposal when district benefits exceed the district share of the total tax cost, rather than the project's total tax cost. He also finds transportation spending is three times higher in politically powerful districts compared to other districts. This suggests there is an under-provision of transportation projects in districts with less political power. He finds no evidence of significant spillover effects, an important justification for a federal role in financing local public goods. Knight also finds actual aggregate spending is greater than the efficient level of transportation spending. The efficient level of spending occurs when the marginal national cost equals the marginal national benefit. The result is, again over the period from 1998 to 2003, a deadweight loss of $7.2 billion or $.96 per dollar spent on transportation.

Costa-I-Font, Rodriguez-Oreggia, and Lunapla (24) and Sole´-Olle´(25) find evidence supporting similar conclusions in Mexico and Norway, respectively. Finally, Keefer and Knack (26) find public investment in infrastructure is higher in countries with lower quality

governments or weak institutions. The characteristics of low-quality governments are non-competitive elections, corruption, weak bureaucracies, and high risk of expropriation. They find projects approved in countries with low-quality governments have a low return and are generally unproductive. Infrastructure investment is used as a tool to provide rents to government officials or their connected friends, rather than as an input to raise economic development. The combination of over-estimating the benefits to costs, the common pool problem associated with national funding of local public goods, and weak institutions, results in non-economic projects being built. This inefficiency from political incentives results in a significant reduction in economic welfare. A far more efficient allocation of infrastructure resources can be achieved by properly pricing (non-zero pricing) the use of infrastructure, shifting funding of infrastructure from the national to the regional or local level, and improving institution quality in the developing world.

Conclusion

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In this article, I have argued that public infrastructure has both direct and indirect effects on the marginal products of private inputs. If the relationship between public and private inputs is complementary, public capital investment can raise productivity, employment, and output. When public and private inputs are substitutes, the impact of additional public capital on output is weaker.

The empirical evidence suggests that additional public infrastructure has only a modest impact on economic activity. The small impact is the result of diminishing marginal returns to public capital, the spatial reallocation of economic activity, higher taxation to finance the project, and reductions in agglomeration economies in non-congested areas.

With respect to highways, many observers have pointed to alternatives to costly highway construction. Net welfare can be increased by using congestion pricing, setting user fees that more accurately reflect road damage, building thicker roads, and by using cost–benefit analysis in project evaluation. Political forces create incentives that result in an inefficient amount of infrastructure investment occurring in the economy.

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