The Role of Infrastructure in Economic Prosperity

Susanne Trimbath, Ph.D.

Working Paper STP2010_02

www.STPadvisors.com
Omaha, NE 68005
(402) 932-8888

THE ROLE OF INFRASTRUCTURE IN ECONOMIC PROSPERITY

Purpose

Policy makers and academics continue to profess that "nothing matters" when it comes to infrastructure and economic growth (starting with Levine and Renault 1992, based on Summers and Heston 1988). However, business behavior proves that infrastructure matters a great deal. Firms choose to locate where infrastructure is better. They leave areas where infrastructure is missing or deteriorated. U.S. firms look for good infrastructure when they consider placing offices overseas (Mataloni 2008), and foreign firms must do the same when they consider locating here. The idea that good infrastructure would enable economic specialization and lower costs – making U.S. businesses more efficient and more competitive – is again reflected in the way that businesses behave.

The purpose of this project is to create an Infrastructure Index that will be useful for exploring the contribution infrastructure makes in keeping American businesses competitive in an increasingly global economy. Emerging market countries remain economically competitive, and are constantly building and rebuilding their infrastructure as their economies develop. To illustrate the impact improving infrastructure has on those developing economies, an international study found that the labor pool expands by 15 percent for every 10 percent improvement in travel speeds, which improves productivity by three percent (Banister and Berechman, 2000, cited in Cevero 2006).

While data is still being collected on the impact improving infrastructure is having on countries around the world, it is becoming clear that deteriorating infrastructure in the United States may actually be contributing to increased costs (and decreased efficiency) for American businesses (Cambridge Systematics, 2008).

The differentiation of U.S. cities based on climate and geography, as well as public policies (taxes, regulation, public spending on capital improvements, institutions, etc.), highlights the critical need for the development of a national index capable of measuring how the U.S. competes not just among MSAs or states or even regions, but with the world.

The factors that differentiate infrastructure across geographic areas will be among those under review when the Infrastructure Index is broken down to state-by-state measurements. The challenge, however, is that because the four Component Indices of infrastructure under review – transportation, energy, broadband and water – are not necessarily geographically contained, and instead are interconnected through multiple states or regions, it will be virtually impossible to break down the results of the economic analysis by state. For example, the Transportation Index would rate the urban rail line that brings workers from the suburbs to jobs in the center of

Chicago as highly as the freight railway that ferries goods from Denver to the ports of Los Angeles for export. Therefore, because the Infrastructure Index measures the performance of the national infrastructure, the economic analysis will encompass a national scope.

What is innovative about the project team's approach is that it includes an unprecedented measure of the *performance* of infrastructure, and not just the size and cost of infrastructure.

Background

Prior research on infrastructure and its connection to the economy has achieved mixed results. Development of the analytical framework began thirty years ago with studies of government spending on public capital infrastructure projects (the stock or flow of investment money) to analyze the impact on economic growth and productivity as well as on social welfare (reducing income inequality).

Before the mid-1990s, infrastructure research was conducted separately from studies on economic growth (Holtz-Eakin and Schwartz, 1995). In the early 1990s, the basic model was extended to specifically endogenize economic growth and to include private spending on infrastructure. Starting around 1990-1995, empirical modeling with data appeared as academic and policy researchers contributed both theoretical and empirical studies on the contribution of infrastructure development to growth and productivity (Calderón and Servén, 2008a).

Most of the policy work (e.g., Henderson, Shalizi, and Venables, 2000; Gausch and Kogan 2001) is based on examinations of countries where development may have been delayed by the lack of infrastructure. These studies compared countries to each other, usually including some selection of developed countries, implying that good infrastructure has a positive effect on the economy. Generally, that kind of research makes use of comparative cross-regional perspectives in an international context, and the findings measure the contribution of infrastructure to the level and growth of aggregate output and productivity. World Bank economists Calderón and Servén (2008a) offer the best published account of the literature on the growth and inequality effects of infrastructure.

In the last 20 years, literally hundreds of research papers have been published devoted to assessing the effects of infrastructure on growth, productivity, poverty and development, etc. The variety of data and empirical methodologies is nearly as great as the number of measurements. While there are almost as many ways to measure "economy" (e.g., income, output, productivity, growth, etc.), this discussion's focus will be on the differences in the way that "infrastructure" is treated and in the methodologies applied in the analyses.

Challenges with Measurement

As we began our research, we discovered that past global and national studies on infrastructure and the economy reported contradictory findings because they measured "Infrastructure" as "Spending" (Straub 2007). This approach is flawed for several reasons.

First, not all money designated for infrastructure is spent the same way for a variety of reasons, from government inefficiencies and political corruption to purchasing power and the size of the economy, so inconsistency in quantity and quality of infrastructure based on money spent makes measurement difficult. Differences in the efficiency of spending on infrastructure explain one-quarter of the growth differential between Africa and East Asia, and more than 40 percent of the growth differential between low- and high-growth countries (Calderón and Servén, 2008a). Another study from Sanchez-Robles (1998) finds no relationship between infrastructure development and the economy when using spending to measure infrastructure. However, when an index is built based on physical infrastructure, the results are not surprising – economies grow with infrastructure development.

Measuring infrastructure in terms of spending has also resulted in "bi-directional results," where infrastructure affects growth and growth affects infrastructure. In other words, that a growing economy can afford more infrastructure is just as likely a cause of positive statistical results as the possibility that more infrastructure helps the economy grow. Further, where spending is used to measure infrastructure, the model usually considers only public spending, ignoring the contribution of investments from private companies (e.g., the contribution of private satellites to communications infrastructure). Calderón and Servén (2008a) report that less than half of the empirical studies using expenditure-based infrastructure measures find that developing or maintaining infrastructure has significant positive effects on the economy. In contrast, over three-fourths of the studies using physical indicators find a significant positive contribution from infrastructure to the economy.

Note, however, that even in studies where physical measures were used, most included only one or two indicators. This was done of necessity in studies that included developing nations, where more data is not available. For example, Estache, Speciale and Veredas (2005, cited in Calderón and Servén 2008a) present pooled linear growth regressions based on an augmented Solow model including a variety of infrastructure indicators, one at a time. Their main conclusion is that roads, power and telecommunications infrastructure – but not water and sanitation – contribute significantly to long-run growth in Africa.

Other studies are arriving at the same results: the relationship between infrastructure and its impact on the economy is buried in the dollars with a model that uses spending to measure infrastructure, but that relationship becomes clear using multiple indicators based on physical measures. Calderón and Servén (2008b, unpublished, discussed and cited in Calderón and Servén, 2008a) found significantly

positive effects "using a synthetic indicator of infrastructure quality." (Their index used only one measure of quantity and quality for each of three infrastructure components: broadband, energy and transportation.)

Methodological challenges

- **Social Welfare Goals:**
  Economic studies of growth by and large were initiated in search of answers to the questions: why are some countries poor while others are rich? And what do poor countries need to do to become rich? This latter question is addressed in research studies on "convergence." Existing research seeks convergence to a steady state of income equality – and so neglects the efficiency impacts, for example, which could improve global competitiveness. International studies look for a "social welfare" impact without differentiating the behavior and contribution of households from that of businesses.
- **Country Comparisons (including state versus state in the U.S.):**
  Money is often invested locally but policy is set nationally, making "convergence" unlikely in the horserace setting of existing empirical studies of the United States. Prior research may attribute the impact of local policies to infrastructure; for example, flexible parking and mortgage-qualification standards for housing near new rail investments in some states.
- **Upward Simultaneity Bias:**
  If it is true that rich countries spend more on infrastructure and get richer while poor countries spend less and stay poor, then upward bias may affect the results of time-series studies using production-function models (Straub, 2007). This problem is relevant in country comparisons and where infrastructure is measured by supply (size) and not performance.

Toward a Better Implementation

Our economic study will take, as given, the accuracy of the Infrastructure Index and its appropriateness to the analysis. There is no dispute that economic growth is necessary as long as there is an increasing population. We seek to address the question: is it possible for the economy to "hit a wall" because it runs out of usable infrastructure? In other words, the question is not if infrastructure helps the economy but rather can a lack of infrastructure impede the economy? Can the economy outgrow its infrastructure?

The specific improvements

- Existing research seeks convergence to a steady state of income equality and so neglects the efficiency impacts that could improve U.S. global competitiveness. Our goal is to provide a better understanding of why business cares about infrastructure. In the process, we will move this topic

outside discussions solely focused on government spending and social policy. When we go to the data, we intend to "take the theory seriously" (Sala-i-Martin, 2002).

- We will not measure infrastructure as money spent, but by the actual content of the infrastructure: does it fulfill the purpose for which it was created? Since no other comprehensive index of infrastructure performance is available, the few prior studies that used one have created and implemented an index within their study. Sanchez Robles (1998) is one of the few published examples we found that used an index to measure infrastructure. She used a principal components methodology with a weighted sum of standardized variables. Because the index is very data rich, the economic model is a simple linear regression, taking advantage of the depth of the data included in the index. Our analysis will use some similar technologies.
- Most research that attempted to improve on earlier studies sought to disaggregate the data from the country level to the regional or state level. This was often done to overcome the problems described earlier where policy and implementation are at different levels. In a national study, this would only have an impact if the policy is so widespread as to be universally adopted across the United States. We believe that the aggregate level removes many of the problems that come about with regional comparisons. For example, Gale (1997) reports survey evidence that the rural-urban technology gap is eliminated in data after accounting for differences in the industry mix. A national study would not be affected by geographic gaps.

Time series approach

As the economy changes, so will the demands for infrastructure. By including the four Component Indices – transportation, energy, water and broadband – in the Index, we anticipate being able to have a consistent measure that can remain relevant across decades, even as the role of one industry may change within the economy. For example, while it is obvious that information-workers, such as computer programmers and software developers who increasingly work from remote locations, require access to broadband infrastructure, they also alter the way that transportation infrastructure is used. Knowledge-based activities which rely on spatial agglomeration place greater importance on rail/subway and less importance on roads (Cervero, 2006). Yet, that does not mean that a knowledge-based economy will need fewer roads – someone has to service those computers and that technician will likely travel to its customers on roads. Pure time-series models can suffer unless the researcher can establish "the existence of a single long-run relation" that "can be interpreted as 'the output equation'" (Calderón and Servén, 2008a). We rely on the specification and construction of the Infrastructure Index to provide the solution to measure the ability of infrastructure to meet the performance demands of productive businesses.

Our plan

Multiple infrastructure components represented by multiple performance indicators will be included for the first time in one economic study of the United States. The Infrastructure Index will measure performance defined as "the degree to which the infrastructure system serves U.S. economic and multi-level business community objectives." Our economic analysis can consider productivity, growth, efficiency effects, etc. from a business perspective, and does not set a limit on economic prosperity because it does not include a pre-conceived notion of "convergence," nor rely on analytics that do not accommodate competitive business models. The Infrastructure Index and the economic analysis can be updated regularly to take into consideration changes in the composition of the U.S. economy.

The specifications

We will rely in Sala-i-Martin (1996, 1997a, 1997b, 2002) for the specification of a pure time-series model following cointegration methods to estimate a long-run relation between infrastructure and the economy. The general form of the model is:

> Economic Prosperity = f (Infrastructure | size of economy, government policy, population health)

The Infrastructure Index will be used to measure "Infrastructure." If we were to include all of the performance indicators that are combined in the Index in our model, that data would likely overwhelm any evidence provided by the economic data. An Infrastructure Index in this setting might function much as the imposition of distribution restrictions on the underlying variables, a scenario that can easily be tested in statistics (Calderón and Servén 2008a). Likewise, we avoid problems of applying very general functions to a large number of measures by using the Infrastructure Index instead of the hundred or so underlying indicators (Moreno et. al., 2002).

The key determinants of economic growth, based on nearly twenty years of empirical analysis (Sala-i-Martin 2002), are 1) the initial level of the economy; 2) the "quality of government;" 3) health (but not "human capital"); 4) free market institutions; and 5) open economies. In our case, we are concerned only with the first three. Free market institutions are widely available in the U.S. In addition to being a globally open economy, advances like the Uniform Commercial Code have made U.S. markets open across state borders for decades. The other factors need to be accounted for since they may change across time in our study. Policy variables, in particular, are consistently found to matter in economic growth studies: "a government in disarray affects the nation's growth performance adversely" (Sala-i-Martin 1994). Examples of variables that could proxy for government policy include inflation, budget deficits and regulatory interference.

Key statistical problems encountered in similar economic studies of growth include heterogeneity, identification and measurement. Since we have only one unit under

study (the United States), we are less concerned with heterogeneity. The cointegration method provides for the use of lead and lag variables. Common time effects can be managed by using period dummy variables, and "omitted variable" problems are avoided by using the new Infrastructure Index which includes multi-dimensional indicators for multi-component infrastructure.

Identification (or two-way causality) has been an issue in earlier studies that relied on measuring infrastructure based on spending – spending that is usually included in measures of the economy. Here, we will measure infrastructure performance independent of the public or private investment dollars. Calderón and Servén (2008a) employed demographic variables as instruments to address the issue of identification. The Infrastructure Index (described in this report) already accounts for population in the sample selection.

Measurement problems in the past also have resulted from the use of only one or two indicators (most often telephone density) and then usually only on one or two components of infrastructure (e.g., energy and roads but not water; similarly water and sewage but not storm runoff). In our case, we have a multitude of indicators entering the analysis by way of the Infrastructure Index. This measure of infrastructure is determined independent of the economic analysis.

Finally, we find no reason to think that endogeneity is a problem in this analysis. Economic production is just as likely to use up or deteriorate infrastructure performance as it is to induce the creation of and improvement in infrastructure.

Prior statistical studies have sought to measure the impact of the development of infrastructure (Ayogu, 2007), but ignore the question of whether or not better performing infrastructure aids the economy, because those studies were focused on developing infrastructure as a way out of poverty. Instead, we assume the existence of infrastructure and go on to measure whether its performance serves the needs of the business community.

Conclusion

We recognize that our analysis will not be the last word on the relationship between infrastructure and the economy. The purpose of the economic analysis in this project will be to demonstrate the usefulness of the Infrastructure Index for exploring the contribution of infrastructure to keeping American businesses competitive in an increasingly global economy. (For an example of a similar demonstration using another index, see Gelos and Wei, 2002.)

The Infrastructure Index is designed to accommodate the changing and diverse patterns of an economy as dynamic as that in the United States. We anticipate that the development of the Infrastructure Index will move the discussion away from the "one-size-fits-all" approach being taken on infrastructure development toward better integration with the economic activity that uses it. Infrastructure has the

power to influence the spatial distribution of economic activity as well as to lead to sectoral restructuring (Moreno et. al., 2002). In our study, we will be looking to define the relationship between infrastructure and the economy, not just to measure it.

While our emphasis in this stage of the project has been on working with the Infrastructure Index for our economic analysis, it may be possible to break out the relationship of the economy to the Component Indices as well. There are two complications to overcome. The first is that businesses make tradeoffs and substitutions among certain elements of infrastructure. A simple example is when they use video conferencing in place of face-to-face meetings – in this case, they are using broadband infrastructure as a substitute for transportation. That problem results in the necessity of requiring a more complex methodology, for example, involving simultaneous equations (where one economic model is set up for each of the Component Indices and then all four models are solved as one problem). It is impossible within the scope of this project to sort out all the potential tradeoffs. Still, we anticipate being able to identify some of the relationships of the individual infrastructure components without having to account for every unmeasured substitution. The problem will be addressed in more detail during the Project Development Stage (detailed in the Next Steps chapter).

REFERENCES

Ayogu, Melvin (2007). "Infrastructure and Economic Development in Africa: A Review,"
Journal of African Economies 16 (Supplement 1):75-126.

Banister, D. and Berechman, J. 2000. *Transport Investment and Economic Development*. London: University College, London Press. (cited in Cerevo 2006.)

Calderón, César A. and Luis Servén (2008a). "Infrastructure and Economic Development in Sub-Saharan Africa", *World Bank Policy Research Working Paper* No. 4712.

Calderón, César A. and Luis Servén (2008b). "The effects of infrastructure development on growth and income distribution", unpublished manuscript.

Cambridge Systematics (2008). *The Transportation Challenge: Moving the U.S. Economy*, prepared with Boston Logistics Group, Inc. and Alan E. Pisarski, report to US Chamber of Commerce, Chamber Foundation and Americans for Transportation Mobility. Available from National Stone, Sand & Gravel Association (Alexandria, Virginia) http://www.nssga.org/government/The_Transportation_Challenge.cfm#Executive_Summary (Accessed 8 January 2010).

Cervero, Robert, (2006). “Economic Growth in Urban Regions: Implications for Future Transportation,” Resource Paper prepared for Forum on the Future of Urban Transportation (December), Eno Transportation Foundation, Washington, D.C..

Estache, A., B. Speciale and D. Veredas. (2005). “How much does Infrastructure Matter to Growth in Sub-Saharan Africa?”, unpublished, World Bank, June.

Gale, H. Frederick (1997). “Is There A Rural-Urban Technology Gap? Results of the ERS Rural Manufacturing Survey”, *Agriculture Information Bulletin* Number 736-01 (August).

Guasch, J. Luis and Joseph Kogan (2001). “Inventories in Developing Countries: Levels and Determinants - a Red Flag for Competitiveness and Growth,” *World Bank Policy Research Working Paper* No. 2552.

Holtz-Eakin, D., Amy Ellen Schwartz (1995). “Infrastructure in a Structural Model of Growth,” Regional Science and Urban Economics 25, pp. 131-151.

Levine, R. and D. Renelt, 1992. A sensitivity analysis of cross-country growth regressions, American Economic Review 82, Sept., pp. 942-964.

Mataloni, Raymond J. Jr. (2008). “Foreign Location Choices by U.S. Multinational Companies,” *Research Spotlight* (March), Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis, p. 40-43.

Moreno, Rosina, Enrique López-Bazo and Manuel Artis (2002). “Public Infrastructure and the Performance of Manufacturing Industries: Short- and Long-Run Effects,” *Regional Science and Urban Economics* 32, pp. 97-121.

Sala-i-Martin, Xavier (1994). “Cross-sectional regressions and the Empirics of Economics Growth,” *European Economic Review* 38, pp. 739-747.

Sala-i-Martin, Xavier (1997a). “I Just Ran Four Million Regressions,” Mimeo, Columbia University, (December) New York.

Sala-i-Martin, Xavier (1997b). “I Just Ran Two Million Regressions,” *The American Economic Review*, Vol. 87, No. 2, Papers and Proceedings of the Hundred and Fourth Annual Meeting of the American Economic Association (May, 1997), pp. 178-183.

Sala-i-Martin, Xavier (2002). “15 Years of New Growth Economics: What have We Learnt?” mimeo, Columbia University and Universitat Pompeau Fabra.

Sala-i-Martin, Xavier (1996). “Regional Cohesion: Evidence and Theories of Regional Growth and Convergence,” *European Economic Review* 40, pp. 1325-1352.

Sanchez-Robles, Blanca (1998). “Infrastructure Investment and Growth: Some Empirical Evidence,” *Contemporary Economic Policy* (16, January), pp. 98-108.

Straub, S. (2007): “Infrastructure: recent advances and research challenges,” unpublished manuscript.

Summers, R. and A. Heston, 1988, A new set of international comparisons of real product and price levels: Estimates for 130 countries, 1950-1985, Review of Income and Wealth 34, March, pp. l-25.