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How Much Infrastructure Is Too Much? A New Approach and Evidence from China

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Summary. — This paper extends the Ackerberg–Caves–Frazer approach to a nonparametric aggregate production function to address both the endogeneity and the function misspecification issues in estimating the returns to infrastructure and private capital and thus the optimal allocation between them. Based on Chinese provincial data over 1995–2011, we find that in 1997 most Chinese provinces were under-invested in infrastructure, whereas in 2008 most of the western provinces were over-invested in infrastructure. Such findings suggest that the nationwide large-scale infrastructure investment enacted by the Chinese government after the 1997 and 2008 financial crises may be of different economic efficiency.

Key words — infrastructure, private capital, investment efficiency, East Asia, China

1. INTRODUCTION

Facing the shocks from the 2008 global financial crisis and the potential economic slowdown, the Chinese government once again fell back on infrastructure investment to revive its economy. For example, of the additional investment of Ren Min Bi (RMB)4 trillion enacted by the Chinese government in 2009 and 2010, approximately 53% were invested in infrastructure including, for example, railroads, highways, airports, water conservancy construction, and the upgrading of power grids. This stimulus package triggered the largest infrastructure investment boom in China since 1985. According to the National Bureau of Statistics (NBS henceforth) of China, the total investment in infrastructure in 2009 was RMB6.18 trillion, and this number rose to RMB7.2 trillion in 2010. Compared with 2008, the total infrastructure investment in 2009 and 2010 increased by 45% and 63%, respectively, higher than the two historical records in China since 1985: 36% in 1992 and 37% in 1998.

However, the magnitude of China's investment in infrastructure has raised many concerns and controversy among economists and policy makers. On the one hand, advocates argue that China's infrastructure remains underdeveloped and that the large-scale infrastructure investment can help China to avert the contagion effects of the 2008 global economic slowdown and further speed up China's economic growth in the future. On the other hand, opponents believe that China's current infrastructure stock is already ahead of the real needs of its economy. They are afraid, therefore, that such a large-scale infrastructure investment plan will not only lead to vastly underused infrastructure in the economy, but it will also add to the government's debt burden and expose the government to substantial fiscal risk.

This controversy regarding China's large-scale infrastructure investment following the 2008 global financial crisis actually reflects the debate in the literature on the contribution of infrastructure to the productivity of private factors of production and to aggregate output. Such a debate can be traced back to the very early empirical work by Aschauer (1989, 1990) who, using a production function approach and the United States' time-series data over 1949–85, finds that a 10% rise in the infrastructure stock would raise multifactor productivity by almost 4%. [1] According to him, therefore, the declining output per capita in the United States over 1970–85 was associated with the decline in infrastructure investment during that period. However, the high return to infrastructure found by Aschauer (1989, 1990) has been questioned by many economists from both the methodological and the econometric perspectives (e.g., Gramlich, 1994; Haughwout, 2002). Issues ranking high on the list of potential problems include the reverse causality from productivity to infrastructure and a spurious correlation due to nonstationarity of the data. The reverse causality from productivity to infrastructure is not limited to time-series studies only. Holtz-Eakin (1994), for example, points out that a more prosperous state is likely to spend more on infrastructure. Such a positive correlation between infrastructure and productivity, however, should not be misunderstood as that greater infrastructure could lead a state to be more productive.

Not taking into consideration the reverse causality from productivity to infrastructure is likely to bias the estimated returns to infrastructure. The literature on the contribution of infrastructure to economic growth, in fact, has suggested various ways of solving this problem. For example, by introducing fixed effects in the specification of the error structure to control for unobserved state characteristics, Holtz-Eakin (1994) finds no contribution of infrastructure on multifactor productivity. However, as admitted by Holtz-Eakin himself, this approach may not work well for a panel of short duration as it ignores the information from cross-state variation in the variables. Duffy-Deno and Eberts (1991) and Cadot, Roller, and Stephan (2006) propose a simultaneous equation estimation method, where the first equation models the aggregate production function and the second models how infrastructure investment is determined. Therefore, the estimated contribution of

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infrastructure to economic growth depends on the assumptions imposed on how infrastructure investment is determined under constraints that are primarily political (Drazen, 2000; Grossman & Helpman, 2001; Persson & Tabellini, 2000).

Acknowledging the difficulty of dealing with the reverse causality from productivity to infrastructure in the production function approach, some studies (e.g., Lynde & Richmond, 1992; Morrison & Schwartz, 1996; Nadiri & Mamuneas, 1994) switch to the cost function approach to examine the contribution of infrastructure to aggregate output. The cost function approach uses input prices as explanatory variables, which are more likely to be exogenous than input variables. In the cost function approach, infrastructure is usually assumed to be an unpaid factor of production, and the contribution of infrastructure to aggregate output is measured by its effect on the level of variable cost curves. As it is, this cost function approach is viewed by many economists as a better way to estimate the contribution of infrastructure to aggregate output. However, the need for information on input prices, at least at the industry level, limits the application of this approach in empirical studies.

While issues of reverse causality have received considerable attention in the literature, little research exists to investigate how model misspecification may also bring about biased estimates of returns to infrastructure. In the production function approach, for example, the most frequently used form of the production function is the Cobb–Douglas form, which assumes that the output elasticities of all inputs are exactly the same across locations and/or over time. However, this assumption appears to be too restrictive, as many studies point out that the output elasticities of inputs exhibit large variations, either across locations or over time. Therefore, a trans-log production function is often also used to consider the nonlinear relationships between inputs and output. But it does not work well in practice either, as the form of nonlinearity remains highly restricted. Therefore, Henderson and Kumbhakar (2006) first propose a nonparametric approach that imposes no restrictions on the functional form when estimating the returns to infrastructure and other inputs to aggregate output. Using the U.S. state-level data over the period 1970–86, they find that there exist large differences in the estimates under the Cobb–Douglas, the trans-log, and the nonparametric approaches, and that only under the nonparametric approach is the contribution of infrastructure to economic growth found to be significantly positive. Henderson and Kumbhakar (2006), hence, question the validity of results from studies such as Baltagi and Pinnoi (1995) and Garcia-Mila, McGuire, and Porter (1996), which find no significant or even negative contribution of infrastructure to economic growth based on Cobb–Douglas or trans-log production functions.

With the various approaches devised to overcome the econometric difficulties in estimating the contribution of infrastructure to economic growth, there is an increasing consensus in the empirical literature on the generally positive impact of infrastructure on economic growth. For example, in a critical survey of the infrastructure-growth nexus, Romp and de Hann (2007) note that among 39 Organisation for Economic Co-operation and Development (OECD) countries, 32 of them find a positive effect of infrastructure on economic growth, three of them find inconclusive results, and only four find a negligible or negative effect. Likewise, recent studies that focus on developing countries also find a generally positive, and even larger, impact of infrastructure on economic development and poverty reduction (Démurger, 2001; Fan & Chan-Kang, 2005; Ligthart, 2002; Ramirez, 2004).[2] Given the observed large positive impact, Ramirez (2004) and Gibson and Olivia (2010), therefore, suggest a policy of increasing the supply of infrastructure as a way to stimulate economic growth in developing countries. Such a policy suggestion, although reasonable when infrastructure is the bottleneck of economic development, should not be taken without caution by policy makers. At least, it is very important to evaluate how much more to invest in infrastructure at a particular time point given the budget constraint and the current stock of infrastructure and private capital. It is also worth noting that among the empirical studies that find positive correlation between infrastructure and economic growth, the actual magnitude of the effect of infrastructure on economic growth varies greatly, and much of this variation arises from not carefully navigating the potential empirical and econometric pitfalls, as pointed out by Estache and Fay (2007). It is therefore our goal to address such issues in this paper and offer a more accurate and nuanced interpretation of the contribution of infrastructure to economic growth.

In both developed and developing countries, whether infrastructure is optimally provided is often a key question for policy makers and economists. One strand of the literature tries to answer this question by comparing the return to infrastructure with the marginal cost of raising funds for infrastructure (e.g., Berndt & Hansson, 1992; Conard & Seitz, 1994). The difficulty in approximating the marginal cost of infrastructure, however, impedes the implementation of this approach. Another strand of the literature focuses on the optimal allocation between infrastructure and private capital by examining the relative contribution of these two kinds of capital to aggregate output, as an increase in infrastructure (at the expense of lower investment in private capital) will raise or lower the aggregate output depending on whether the marginal product of infrastructure exceeds, or is exceeded by, the marginal product of private capital. Aschauer (2000) shows that, in an endogenous growth model where an increased investment in infrastructure requires a corresponding increase in tax rates, the maximum long-run growth rate could be achieved when the after-tax marginal product of private capital equals the marginal product of infrastructure. Turnovsky (1997) and Kamps (2005), however, point out that the maximum welfare is still achieved when the marginal product of private capital equals the marginal product of infrastructure.[3]

Based on the theory of optimal allocation between infrastructure and private capital and through our close examination of the relative marginal product of infrastructure to private capital at the provincial level, this study seeks to evaluate the efficiency of infrastructure investment in China, especially the two large-scale infrastructure investment plans enacted by the Chinese government after the 1997 and 2008 financial crises. It is worth noting that in this study we primarily focus on the question whether infrastructure as a whole is under- or over-invested, relative to the private capital stock, in China at the provincial level over the period 1997–2011. Issues such as the impacts of different types of infrastructure, quality *versus* quantity of infrastructure, or new investment in *versus* maintenance of infrastructure are beyond the scope of this paper. Studies that do address these aforementioned issues certainly abound in the literature. Gibson and Olivia (2010), for example, discuss the poor quality of, as well as the limited access to, infrastructure on economic development in rural Indonesia. Fan and Chan-Kang (2005) also compare the returns to express way and lower level roads in China over 1982–99. Agénor (2009) and Kalaitzidakis and Kalyvitis (2004) both discuss the optimal allocation between investment in new infrastructure and the expenditure on the maintenance