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Does infrastructure have a transitory or longer-term impact? Evidence from China☆

Yin-Fang Zhang [a,*], Shengbao Ji [b]

[a] Global Development Institute, School of Environment, Education and Development, University of Manchester, Oxford Road, Manchester, M13 9PL, UK
[b] China University of Mining and Technology, Xuzhou, Jiangsu, China

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ABSTRACT

It is ambiguous in the literature whether infrastructure only has transitory effects by lifting the level of aggregate output, or a longer-term impact by boosting the growth rate of output. The paper attempts to shed empirical light on this issue by looking at the case of China. It employs an infrastructure-augmented production function framework and a growth regression model, and adopts panel threshold regressions to address non-linearity. The results show that infrastructure stocks (except railways) are more productive than other physical capital in raising output levels, but not so when it comes to the effect on long-term growth rates. The analysis also finds that infrastructure's productivity depends on whether it is oversupplied or in shortage relative to non-infrastructure capital.

1. Introduction

There has been a revived interest among researchers in the role of infrastructure in economic development since the seminal work of Aschauer (1989). However, some issues are still ambiguous in the literature. One of them is whether infrastructure capital only has transitory effects by lifting the level of aggregate output, or it has a more permanent impact so as to boost the growth rate of output.[1] Needless to say, a temporary positive shock in output induced by infrastructure is in itself beneficial. It is desirable if improvement in infrastructure can lift low-income economies to high output levels. However, the issue of transitory *v.s.* permanent effects is of interest not only to economists but also to policy makers who are keen to use infrastructure investment to help poor regions catch up with rich ones within a country. To catch up with rich areas, poor regions need to raise their output as well as grow for a long period, preferably at higher rates. Whether investing in infrastructure in less-developed regions can help achieve this end, to a great extent, hinges upon whether infrastructure has a positive effect on long-term growth rates.

From a theoretical perspective, having an impact on growth rates requires infrastructure to be able to generate enough externalities to induce constant or even increasing returns to scale on aggregate (Straub, 2011).[2] Otherwise, infrastructure will only have the effect of boosting output levels with the growth rate ultimately converging back to its initial level. The sources for infrastructure's externalities are well documented by the endogenous growth literature and new economic geography. The former argues that improvement in infrastructure reduces transaction and other costs, leading to more efficient uses of conventional factor inputs. The latter sees infrastructure as a central determinant of the location and scale of economic activity, and patterns of agglomeration and specialization (Baldwin et al. 2003; Krugman, 1991).

There is little explicit empirical evidence on this issue. Many studies examine the contribution of infrastructure to aggregate output adopting an infrastructure-augmented production function (APF), with mixed results reported. Empirical analyses focusing on infrastructure's impact on the long-term growth potential usually employ specifications using either

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* Corresponding author.
E-mail addresses: Yin-fang.zhang@manchester.ac.uk (Y.-F. Zhang), jishengbao9646@126.com (S. Ji).

[1] In the paper, the phrase 'permanent effect of infrastructure' is used to refer to its impact on long-term growth rates (as in contrast to the level) of aggregate output.

[2] More specifically, in a Cobb-Douglas production function $Q = (A \cdot K_I^{\varphi}) \cdot K^{\alpha} \cdot K_I^{\beta} \cdot L^{\gamma}$ (where Q is output, K physical capital, K_I infrastructure, and L labor), $\alpha + \beta < 1$ due to diminishing returns. If infrastructure's externalities captured by ϕ lead to constant/increasing returns on aggregate, i.e. $\alpha + \beta + \varphi \geq 1$, additions to infrastructure stocks will raise long-term growth rates.

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output growth rates or productivity as the explained variable (e.g., Barro, 1991; Hulten et al., 2006). Again, the evidence is inconclusive. Based on a review of existing studies, Straub (2011) notes that specifications using output as the regressant are generally more likely to find positive effects of infrastructure than those using productivity or growth rates. She interprets this as a rough indication that transitory effects are observed more often. However, it could be misleading to compare the results of these two sets of studies because of differences in the country coverage and time period under study. An arguably better strategy is to apply both model specifications to the same empirical context and then compare the results. This paper employs this approach to shed light on the research issue, by looking at the case of a large, fast-growing economy – China.

While enjoying rapid economic growth over the last three decades, China has witnessed increasing regional disparities in income levels as well as large regional differences in infrastructure facilities (Demurger, 2001). In recently years, several schemes have been initiated to promote economic growth in less developed regions and help them catch up with richer, coastal provinces.[3] The development of infrastructure has been a main component of such schemes. Thus, a panel dataset of Chinese provinces represents an interesting empirical context to examine the effects of infrastructure on both the level and growth rate of output. The analysis also has the potential to provide policy implications. Policy makers in less-developed countries who are eager to find the *road to prosperity* may be keen to learn from China's experience. With the analysis focusing on provinces, the research can shed light on whether recent policies involving massive infrastructure investments in western and central provinces of China can be effective in helping them to catch up.

There has been a growing body of empirical analyses on the role of infrastructure in China's economic development. This paper departs from existing studies in terms of the research issue (i.e. permanent v.s transitory effects of infrastructure). In addition, it employs an empirical strategy that incorporates non-linearity in the productivity of infrastructure. Banerjee et al. (2012) have also attempted to differentiate between infrastructure's output and growth impacts by looking at the access to transport networks. There are analyses on China which control for non-linearity, but focus mainly on infrastructure's effects on growth rates (e.g., Demurger, 2001; Ding and Haynes, 2006). Different from these studies, this paper distinguishes the two impacts of infrastructure while simultaneously accommodating non-linearity.

Considering non-linearity in the analysis is important. Studies which fail to recognize the issue, when existent, tend to come to misleading findings and provide ill-fit policy implications. In specifications where infrastructure is modelled in a linear way, the estimated coefficients represent infrastructure's effects in an 'average' province, which may mask parameter heterogeneity across provinces. Conclusions based on the 'average' province are likely to provide a 'one-size-fit-all' type of policy recommendation which may not suit specific contexts of individual provinces.

A widely used empirical approach to allow for non-linearity is to include a quadratic term of infrastructure, as used in Datta and Agarwal (2004) and Demurger (2001). The strategy may be able to capture infrastructure's diminishing effects, but less able to shed light on more complicated non-linearity and that induced by other factors. In this paper, panel threshold regression (PTR) models developed by Hansen (1999, 2000) are adopted. The approach not only permits non-linearity but also provides insights into the underlying factors and how infrastructure's effect varies with them. The literature has suggested several factors causing non-linearity. One of them relates to the network nature of infrastructure. That is, the beneficial effects of infrastructure tend to be high when the construction of the networks comes near a critical level, and become low or null thereafter (Candelon et al., 2013; Fernald, 1999; Röller and Waverman, 2001). This motivates the paper to use the existing level of infrastructure stocks as one threshold variable to capture the related non-linearity. In addition, Calderón et al. (2015) and Straub (2011) note that the impact of infrastructure may vary according to the stages of economic development. Therefore, the income level is used as another threshold variable in this paper. There is also non-linearity associated with dynamics between infrastructure and other physical capital. Infrastructure investment can complement as well as substitute and crowd out non-infrastructure capital (Canning and Pedroni, 2008; Dreger and Reimers, 2016; Voss, 2002). Although well recognized, this type of non-linearity is relatively less often accommodated in empirical studies. This paper constructs the ratio of infrastructure to total physical capital as a third threshold variable to explore the dynamics.

Applying the PTR models to a dataset of 30 Chinese provinces for the period 1986–2012,[4] this paper examines the effects of four core infrastructure stocks – electricity, telecommunications, roads and railways.[5] The rest of the paper is organized as follows. Section 2 details the empirical approach. Regression results are reported and discussed in Section 3. The last section concludes.

2. Empirical strategy

2.1. Model specifications

Two models are employed. The infrastructure-augmented production function (APF) is used to examine the output elasticity of infrastructure, and a Barro-type framework is employed to relate infrastructure to growth rates of output. Following existing studies, a Cobb-Douglas specification is adopted for the APF. With variables taking logs and appearing in per worker terms, the following form can be obtained:

$$y_{it} = a_0 + \alpha_1 k_{it} + \alpha_2 h_{it} + \alpha_3 x_{it} + \mu_i + \omega_t + \varepsilon_{it} \tag{1}$$

Here *y, k, h*, and *x* represent real output, physical capital, human capital and infrastructure, respectively. *i* and *t* index province and year, respectively. μ_i and ω_t are province and time fixed effects, and ε_{it} is an *iid* error term.

In the growth regression specification, seven-year moving averages are used for all variables (unless otherwise indicated). Using averages can eliminate short-term fluctuations and choosing moving averages increases the number of observations in the panel dataset. It is common to take averages over a period of ten years or more when examining the impact on long-term growth rates. However, this will substantially reduce the number of observations given the length of the sample period. Seven-year averages are therefore employed.

Using moving averages, however, introduces serial correlation in the error term within a province sample. The standard errors obtained are therefore incorrect although the coefficient estimates are consistent. Hansen and Hodrick (1980) and Newey and West (1987) develop methods to construct heteroscedasticity and auto-covariance consistent estimators, but their application to non-linear models like PTR is practically complicated. Valkanov (2003) proposes a general but simple way to construct asymptotically efficient standard errors by rescaling the estimator obtained from OLS. Taking this approach and following Harri and Brorsen (2009), the magnitude of rescaling used in this paper is

[3] These schemes include the 'open-up the West' Strategy, the 'North-east Revival' Plan, and the 'Rise of Central China' Program.

[4] Due to the constraint of space, the paper does not provide detail on historical trends of the infrastructure sectors and regional disparities in China. Interested readers may go to Bai and Qian (2010) and Demurger (2001) for such information.

[5] Electricity is only one type of energy infrastructure. This paper looks at electricity generation instead of energy consumption because of China's heavy reliance on imports for oil and gas, which makes the latter a less reflective proxy. Nonetheless, using electricity to represent energy infrastructure has been widely adopted in both cross-country analyses (e.g., Calderón et al., 2015; Candelon et al., 2013; Canning and Pedroni, 2008) and country-specific studies (e.g., Bogetić and Fedderke, 2006; Fedderke and Bogetić, 2009).