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Much ado about nothing? – A meta-analysis of the relationship between infrastructure and economic growth

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A B S T R A C T

Investing in infrastructure is often seen as an important part of economic policy, at the regional, national as well as international level. Investing in infrastructure is often presented as a solution to a number of problems such as unemployment, depopulation of rural areas and low economic activity. A number of studies have tried to estimate the effects on production from investing in infrastructure. The aim of this study is therefore to provide a systematic analysis of previous studies of this relationship. For that purpose, a meta-analysis of 776 estimates of elasticity of production with respect to infrastructure, was performed. The estimated effect (elasticity of production) of investing in infrastructure varies from −0.06 to 0.52. The effects appear to vary depending on the type of infrastructure in with the investment is made as well as between industries. It is also found that the estimated effects exhibiting high precision, are clustered around zero. This is to say that the higher the reliability of the estimate, the closer it is to zero.

1. Introduction

Investments in infrastructure are often acknowledged as an important part of economic policy, at the regional, national as well as international level. Investing in infrastructure is seen as a means to combat unemployment associated with recessions as well as an instrument that can be used to foster development in areas with low economic activity (COM, 2011; prop 2014/15:100; Bergman & Hallberg, 2016). It is fairly obvious that, from a theoretical standpoint, there should be a connection between GDP growth and investments in infrastructure. In the short run, public spending in the form of investments in infrastructure will increase GDP if there is excess capacity in the economy. It will then create employment in the project itself and affect the rest of the economy through multipliers. In the long run, improvements in the transport system might increase the production capacity of an economy through increased capital stock and improved productivity (Berechman, 2002; Izquierdo, 2005; NCHRP, 1998). Based on these theoretical arguments it is easy to conclude that there might be a connection between infrastructure and changes in GDP, in the long run as well as in the short run, and from a public policy perspective it is obviously appealing to invest in infrastructure if it would result in lower unemployment and increased wealth.

It is therefore not surprising that there has been a lot of interest in trying to estimate the effects of infrastructure on economic growth. An early example is Fogel (1964) in which he evaluates the effects of building railroads in the USA, but the starting point of a wave of what is usually called "macro studies" of impacts of infrastructure is Aschauer (1989). He estimates several models of the relationship between aggregated output and public capital. The most referred findings from this study are that the elasticity of GDP with respect to (non-military) public capital is 0.39 and that the elasticity of GDP with respect to "core infrastructure" (highways, mass transit, airports, gas facilities, water facilities, sewers) is 0.24. The study by Aschauer (1989) has been criticized by many (e.g. Hulten & Schwab, 1991; Tatom, 1991) for methodological problems but it has undoubtedly inspired a vast number of researchers trying to recreate the results in different settings, trying to improve the methodology and/or simply proving him wrong. There should therefore be a great deal of empirical and theoretical knowledge on the effects of infrastructure investment on aggregated economic activity, which is interesting to try to summarize in a systematic way.

The aim of this study is to describe and explain the variation in estimated output elasticities with respect to (transport) infrastructure[1]

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[1] Output elasticity with respect to infrastructure (E_{K_I}) is the percentage change in output (Gross Domestic Product, Gross Reginal Product or in some cases output I a specific sector) due to a percentage change in infrastructure. This is usually defined as point elasticity, i.e. $E_{K_I} = \frac{\partial Y}{\partial K_I} \cdot \frac{K_I}{Y}$, where Y is GDP or GRP and K_I is infrastructure capital.

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through meta-analysis. The analysis is based on 776 observations originating from 78 different studies. Most of the studies included are published in peer-reviewed journals, while some are published as working papers by influential institutions such as the International Monetary Fund (IMF), the World Bank, and the National Bureau of Economic Research (NBER).

This study is in some aspects similar to that of Melo, Graham, and Brage-Ardo (2013). They published a meta-study in which they analysed the effects of using different kinds of data, model specifications, and estimators but also variations between industries, transport modes and time periods. However, this study complements that of Melo et al. (2013) in some important aspects. First of all, our data set is larger. Melo et al. (2013) was based on 33 previous studies (563 elasticity estimates) compared to our 78 (776). Melo et al. (2013) state that they identified their data from previous review articles (Boarnet, 1997; Gillen, 1996; Gramlich, 1994; Jiang, 2001; de la Fuente, 2000) and by searching google scholar. They stress the importance of using also non-published sources in order to reduce publication bias (section 6 of this paper is dedicated to a discussion on publication bias). We include the same studies as Melo et al. (2013) but in addition to searching in google scholar, we also search in Scopus, EconLit and Web of science. Of the 78 studies we identified, only two were published after 2013 (Shi, Bang, & Li, 2016; Song & van Geenhuizen, 2014) and two were published in 2013 (Chen & Haynes, 2015; Yu, De Jong, Storm, & Mi, 2013), indicating that our search strategy resulted in better coverage.[2] Other aspects in which our study differs from that of Melo et al. (2013) are that we investigate potential interaction effects between industry and mode of transport and that we also study the effect of controlling for the level of capacity utilization in the economy.

Hopefully, our study will provide researchers with valuable insights regarding the effect of different methodological choices as well as providing information on the expected effect of investing in infrastructure under different conditions. We also discuss the reliability of such results.

This paper is structured in the following way. In the next section, there will be a brief discussion on why we might expect a relationship between investments in infrastructure and economic growth. After that, section 3 presents the elasticity estimates obtained from previous studies, which is our dependent variable. Section 4 outlines our methodological framework, empirical model structure and our included variables. This is followed by a presentation of our estimation results in section 5, after which we present and discuss evidence of publication bias in section 6. Section 7 is dedicated to a discussion of the results and implications of this paper. In section 8, we present our main conclusions.

2. Infrastructure and economic growth – some theoretical aspects

A majority of the macro-based studies of the impacts of infrastructure take their point of origin in a Solow (1956) [3] inspired production function such as:

$$Y = f(A, K, L) \tag{1}$$

where Y is aggregated production (GDP), K is capital, L, is labour and A is factor productivity. A common assumption is that (1) is a Cobb-Douglas function so that[4]:

$$Y = A \cdot K^{\alpha} \cdot L^{\beta} \tag{2}$$

There are different ways of introducing infrastructure into the production function, the most common being to further specify capital (K) into different kinds of capital, e.g.

$$Y = A \cdot (K_{Private})^{\alpha 1} \cdot (K_{Public})^{\alpha 2} \cdot L^{\beta} \tag{3}$$

In this case the public capital (of which infrastructure is a part) is seen as necessary input in the production process. This approach was adopted by Aschauer (1989) and public capital (K_{Public}) is then assumed to have a direct effect on the level of production with an elasticity of $\alpha 2$. Public capital can be further divided into different kinds of public capital, e.g. different kinds of infrastructure. Aschauer (1989) divides public capital into military capital, core-infrastructure (highways, mass transit, airports, gas facilities, water facilities, sewers) and other non-military capital. Others have criticized Aschauer (1989) for making this division too crude and suggested the use of more precise measures of capital in the models, such as different kinds of infrastructure.[5]

Another way of modelling the relationship between infrastructure and production is to assume that the former affects factor productivity so that[6]:

$$A = g\left(K_{Infrastructure}\right) \tag{4}$$

where

$$A \frac{\partial A}{\partial K_{Infrasrtucture}} > 0 \tag{5}$$

i.e. better access to infrastructure will make other capital and/or labour more productive. Such effects could be due to agglomeration of activities and might work through different mechanisms. (Duranton & Puga, 2004; Venables, 2007) If improved infrastructure causes a higher geographical concentration of producers, this could result in an increased exchange of knowledge leading to higher productivity. Such concentration could also lead to improved possibilities for matching in the labour market, if high concentration of producers also cause a higher concentration of skilled labour. Better matching could also be a result of improved infrastructure due to increased market areas from which to recruit.

Concentration of activities could also lead to better utilization of public services since the public sector can improve quality through concentrating their own efforts if more service recipients are located closer together.

Another way in which the effects of transport infrastructure could be modelled is through the accumulation of private capital. If we denote change in private capital as:

$$\Delta K_{Private} = sY_t - \delta K_t \tag{6}$$

where s is the propensity to invest and δ is the rate of depreciation, we assume that

[2] It was of course helpful to have the list of studies from Melo et al. (2013) for comparison.

[3] See also Swan (1956).

[4] In this case, the production function is said to be Hicks-neutral. Other common approaches is to assume that the production is capital augmented, e.g. $Y = (A \cdot K)^{\alpha} \cdot L^{\beta}$ or labour augmented $Y = K^{\alpha} \cdot (A \cdot L)^{\beta}$ (see e.g. Romer (2001) for a textbook discussion of growth theory). The classic Cobb-Douglas function assumes that $\alpha + \beta = 1$.

[5] It should be noted that Aschauer (1989) and his early followers (e.g. Munnell, 1990; Munnell & Cook, 1990) were not specifically interested in the effects of (transport) infrastructure but more if public capital in general was productive and if the decline in growth could be explained by changes in public capital.

[6] For discussions on different ways of modelling this relationship see e.g. Hakfoort (1996) and Banister and Berechman (2000).