Transportation Research Part A 65 (2014) 33–43

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

The influence of the road network on private productivity measures using Data Envelopment Analysis: A case study from Spain

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ARTICLE INFO

Article history:
Received 23 September 2012
Received in revised form 22 March 2014
Accepted 1 April 2014
Available online 4 May 2014

Keywords:
Data Envelopment Analysis
Total Factor Productivity
Infrastructures and public capital and economic development and transportation

ABSTRACT

We evaluate the economic effects of investment in the road network on private regional activity. We employ provincial Spanish panel data from 1980 to 2007 to perform non-parametric frontier techniques based on Data Envelopment Analysis and to obtain the Malmquist productivity indexes, thus enabling us to examine the evaluation of the productivity growth via technological changes or efficiency gains. Additionally, we analyze the role of transport infrastructure on the evolution of Total Factor Productivity and its components through econometric techniques. Our results show important spillover effects. Moreover, our findings have significant implications for policy makers if we take into account the fact that the use of the road network in economic activity or in commercial relations greatly influences productivity growth.

1. Introduction and motivation

The traditional literature on the determinants of production does not take into account the possible existence of inefficiency in the use of productive factors. Thus, in most of the works that use the methodology of production functions, it is assumed that all the productive units work efficiently and reach the frontier of potential production; nonetheless, the existence of breaches between the potential technical efficiency and that observed in the empirical reality has been recently recognized. These breaches occur because the best practices in the productive process are not being used.

In this context, we can observe an extended literature based on non-parametric frontier techniques that allow the efficiency of the use of productive factors to be contrasted with the performing estimates under those conditions. The empirical evidence based on the use of frontier estimates allows the existence of inefficiencies in private productive factors to be observed. Among the numerous works that are based on non-parametric techniques, Domazlicky and Weber (1997) introduce linear programming in order to decompose private productivity changes into efficiency and technological changes in the states in the United States.

This relevance is reflected by the large number of studies that endeavor to quantify the determinants of inefficiencies in private production. A great number of articles have focused on the public capital, as the principal contributing factor in growth and regional cohesion. In this regard, Lynde and Richmond (1999) propose a Data Envelopment Analysis (DEA) method for the decomposition of productivity growth into technical efficiency and technological progress contribution in UK manufacturing. These authors highlight the relevance in the intensity of the use of labor and the role of public capital

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http://dx.doi.org/10.1016/j.tra.2014.04.002
0965-8564/

in manufacturing production. Most of these articles concentrate on the U.S., given that it has one of the most developed economies in this type of infrastructure and given its comprehensive databases (Boisso et al. (2000) suggest that the components of Total Factor Productivity (TFP) change are affected by public capital and highways). In addition, several authors, as in the case of Pedraja et al. (2002), Salinas-Jimenez (2004) and Mas et al. (1994, 1996), have analyzed the effect of public capital on private productivity in Spanish regions. A frequent result of these studies shows the feasibility of public investment as a tool for stimulating productivity and efficiency in the private sector.

One of the public policy decisions that has the greatest impact is that of investing in transport infrastructure, both for its territorial structure effects and its capacity to reduce costs and increase economic production capacity. The interest in analyzing the effects of public investment in transportation infrastructure has increased considerably in recent years. The greatest part of this research has focused on the analysis of efficiency in transport infrastructure disaggregating by mode of transport. Adler and Golany (2001) use DEA to analyze the efficiency in airline companies in Western Europe and to select the most efficient network configuration. Moreover, some other studies have focused on railways. In this regard, Jain et al. (2008) conclude that ownership influences efficiency in urban rail transit system (URTS), while Yu (2008) explores the efficiency of a group of railway companies, comparing two methods based on DEA. Furthermore, Tongzon (2001) and Cullinane et al. (2006) quantify the technical efficiency in the infrastructure services of ports. Tongzon (2001) provides the efficiency for four Australian ports and another twelve international ones using DEA techniques, offering a satisfactory measurement and some policy implications for future research. Meanwhile in Cullinane et al. (2006) the authors offer the efficiency of the world's largest container ports, comparing the results with DEA and stochastic frontier. Both methods show robustness and that efficiency is associated with scale and private sector participation. In Spain, Martín and Roman (2001), Martín et al. (2004) and González and Trujillo (2008) have focused on applying DEA in the study of efficiency on airports, high speed trains and ports respectively. For this reason, their literature offers evidence of non-parametric frontier techniques as a tool to provide recommendations and policy implications about the role of public investment to encourage private productivity.

However, the study of the impact of road transport infrastructure on private productivity has been limited in Spain, due to the lack of estimates in Spanish regions. Development of the high capacity network, despite being initiated in the seventies, was not extended to the majority of Spanish regions until the nineties. This delay in expansion is partly due to the disparity in terms of infrastructure development between Spain[1] and other countries. The expansion in public investment in recent years has generated the necessity to analyze the impact of public decisions on regional growth and cohesion. The progress gained in this area is of particular interest, as it allows us to understand the results obtained by studies in this field and promote the discussion about policy implications of these decisions.

Keeping this aim in mind, the present study analyzes the effect of road network public investment on private productivity in the context of a non-parametric frontier approach. In doing this, we make our contribution by introducing the impact on private sector efficiency generated by road transport public capital, considering a new database provided by Álvarez et al. (2012) at provincial level in Spain. This is our main contribution within the context of transportation research literature. However, it is worth noting that we evaluate the role of road transport infrastructures on private productivity using a new concept reflecting their real use in commercial relations and a definition of "*spillover effects*" as the capital stock used by the rest of provinces, not only the adjacent as is usual in the related literature (Cantos et al., 2005; Delgado and Álvarez, 2007). So, we perform this analysis in two steps. In first step we obtain the productivity of private factors (labor and private capital) using non-parametric frontier approach based on DEA in the estimation of a Malmquist index of TFP and its decomposition into technical progress and changes in relative efficiency. In a second step we introduce some econometric specifications to analyze the impact of road transport infrastructures on private productivity and each of its components, allowing us to obtain interesting findings with significant implications for policymakers.[2]

Following this objective, the study is structured as follows: in Section 2, we explain the methodology of a non-parametric frontier approach based on Data Envelopment Analysis (DEA) in the estimation of a Malmquist index of Total Factor Productivity (TFP) and the econometric specification used in the second step; in the third section, we detail the databases and information sources employed; and in the fourth section, we present the results obtained, before lastly presenting our main conclusions.

2. Methodological approach

The motivation for adopting a frontier approach is to consider the possible existence of inefficiencies when evaluating the performance of an economy and to decompose Total Factor Productivity (TFP) growth into efficiency change and technological progress. In the empirical applications performed in this article, technical efficiency is analyzed following the measures by Farrell (1957). In order to study the efficiency with which productive inputs are employed, it is necessary to estimate a production frontier which represents the maximum technically attainable level of production. Inefficient behavior is

[1] The importance and interest in the *Plan Estratégico de Infraestructuras y Transportes* (Ministry of Public Works, 2005), has given rise to several studies on the effects of such investments (Delgado and Alvarez (2007) analyzing the impact of high capacity roads on sector production in Spanish regions in the context of a parametric frontier approach).

[2] Alternatively, the public capital can be considered as an additional input in DEA. Although, in the present study we introduce the second step procedure in order to obtain some elasticities corresponding to the effect of transport infrastructures on TFP and its components, technical progress and efficiency changes, on private factors.