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An empirical analysis of three econometric frameworks for evaluating economic impacts of transportation infrastructure expenditures across countries

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ABSTRACT

Transportation infrastructure expenditures can lead to greater productivity and increases in economic output due to the reduction in transportation costs, improvements in access to markets and raw materials, reduction in travel times, congestion reductions, and many other benefits. These benefits can potentially allow countries to improve their comparative economic advantages. To better understand the impact of transportation infrastructure expenditures on national economies, the present paper undertakes an aggregate study of the relationship between transportation infrastructure expenditure and gross domestic product from economies in 40 countries. Three econometric frameworks (ordinary least squares, random-effects and random-parameters models) were used to investigate the impacts of transportation infrastructure expenditure across countries using data from 1992 to 2010. The random-parameters model was observed to adequately account for possible unobserved heterogeneity across countries. As expected, the estimation results showed considerable variability across countries, with the impact of transportation infrastructure expenditure varying greatly as a function of the country's existing transportation infrastructure and the reliance of specific economic sectors on transportation in each nation.

1. Introduction

Transportation infrastructure expenditures have significant impacts on the economies of many countries, with transportation infrastructure expenditures increasing the gross domestic product and personal income and decreasing in unemployment rates (Aschauer, 1990; Forkenbrock and Foster, 1990; Sheehan, 2006). The observed importance of transportation is not surprising given its large contribution to most countries' gross domestic product, its consumption of goods and services, its role as employment generator, and the revenue it brings to local, state and federal governments. Transportation infrastructure expenditures can lead to greater productivity and increases in economic output due to the reduction in transportation costs, improvements in access to markets and raw materials, reduction in travel times, congestion reductions, and many other benefits. These benefits can potentially allow countries to improve their comparative economic advantages. However, while transportation infrastructure expenditures may be a necessary condition for economic expansion, they are not a sufficient condition because the type and magnitude of the expenditure are critical in determining its overall impact (Sinha and Labi, 2007).

For example, Jiwattanakulpaisarn et al. (2010) investigated the impact of highway infrastructure on employment growth in three employment sectors: construction, service and manufacturing. Using panel data from 48 U.S. states over a period from 1984 to 1997, the study found that if a state extends its major highway network (defined in lane-miles) the expenditure would cause a significant increase in service-sector employment; however, employment growth in the manufacturing sector would be reduced. Furthermore, the study concluded that improvements in non-interstate major roads (outside a state's jurisdiction) had the greatest positive influence on the manufacturing sector. These results were roughly consistent with a number of other studies (Forkenbrock and Foster, 1990; Gkritza et al., 2008; Agbelie, 2013).

At the national level, a number of empirical studies were carried out in the past (see Table 1). Impact estimation, in terms of elasticity values, was generally carried out with a model using time series or cross-sectional data that included input variables relating to labor, private capital and government infrastructure expenditures. Results from these past studies showed considerable variations in the magnitude of estimated elasticity values; however, the consensus of most past studies was that a positive association between transportation infrastructure expenditures and economic output exists (Aschauer, 1989b; Munnell, 1990a; Berndt and Hansson, 1992; Waters, 2004; Cantos et al., 2005;

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Table 1
Summary of past studies on highway economic impact analysis (elasticity of expenditures with respect to economic output).

Study	Level of aggregation	Econometric method
Eberts (1986)	City	Ordinary Least Squares Regression (Cobb Douglas—Translog)
Waters (2004)	Province	Cobb Douglas, Translog
Ozbay et al. (2003), Ozbay et al. (2007)	County	Multiple Regression
Garcia-Mila and McGuire (1992)	State	Cobb Douglas
Munnell (1990b)	State	Cobb Douglas, Translog
Eisner (1991)	State	Cobb Douglas; Translog
Costa et al. (1987)	State	Cobb Douglas
Eakin (1994), Sloboda and Yao (2008)	State	Cobb Douglas, Translog
Munnell (1990a), Crescenzi and Rodríguez-Pose (2012)	National	Cobb Douglas, Translog
Aschauer (1989a)	National	Cobb Douglas

Berechman et al., 2006; Ozbay et al., 2007; Jiwattanakulpaisarn et al., 2010; Álvarez-Ayuso and Delgado-Rodriguez, 2012), while few studies reported no statistically significant (Evans and Karras, 1994) or negative (Sloboda and Yao, 2008; Crescenzi and Rodríguez-Pose, 2012) association between economic output and transportation investments.

Turning to specific previous studies, the decline in the United States' infrastructure expenditures during the late 1970s and 1980s motivated Aschauer's (1989a) empirical study. Using an ordinary least square (OLS) framework with data from 1945 to 1989, he examined the effects of public policy relating to transportation expenditures on the economy. The variables used included economic output, labor hours, private capital, and non-military public-capital expenditures (expenditures on highways, airports, etc). The results showed that impact of non-military public capital was two to four times higher than that of private expenditures, suggesting the critical role public-capital expenditures played in the economic slowdowns of the 1970s and early 1980s in the U.S.

Eberts (1986) used data from 1958 to 1981 for 38 metropolitan cities to investigate the impact of public capital expenditures (highways, water supply, etc) on an economy. The study concluded that public capital expenditures have a positive and statistically significant with respect to economic output with a fixed impact of 0.03. This means that a 1% increase in public expenditures would increase the economic output of a metropolitan city by 0.03%.

A number of studies carried out in other countries have found positive effects of transportation expenditures on economic development. In Sweden, Berndt and Hansson (1992) used annual data from 1960 to 1988 to estimate ordinary least square parameters in order to determine the contribution of public infrastructure expenditures to economic output. The elasticity of public infrastructure expenditures with respect to economic development was a fixed value of 0.149.

In Ireland, Kavanagh (1997) used data from 1958 to 1990 to estimate an aggregate function where public infrastructure expenditures were included as an explanatory variable in order to investigate the link between public infrastructure expenditures and economic output. The elasticity of expenditures with respect to economic output was found to be 0.36. In order to examine the existence of a long-run relationship between highway expenditures and economic output in Greece, Mamatzakis (1999) used data from 1959 to 1993 using a Cobb–Douglas model and found the elasticity of highway expenditures to be 0.25 with respect to economic output.

While there have been an abundance of studies at the country level, particularly in industrialized economies such as the U.S. and elsewhere, few have considered the effects of transportation infrastructure expenditures across countries, which would presumably be interesting due to variations in economic bases and levels of industrialization. In developing countries, there have been a few studies that have considered multiple countries using cross sectional or panel data, but these have often been limited by econometric approach and available data (Calderon and Serven, 2002; Ozment, 2006). In addition, many past studies concentrated exclusively on highway expenditures and did not consider the relative returns from other transportation modes.

The majority of existing research literature on economic impact analyses of transportation infrastructure expenditures at the county, state or country levels employed fixed parameter modeling frameworks on the basis of Translog production function. This indicates that the estimated parameters for the variables are assumed to be the same, and by implication the computed economic impacts are considered fixed, regardless of the county/state/country. This assumption may not be realistic; because transportation infrastructure expenditure in any county/state/country depends on a number of factors signifying that the estimated parameters may vary across observable units (county, state or country) and could not be captured using fixed parameters.

The objective of this present paper is to examine the impact of highway and railway infrastructure expenditures across a wide variety of countries, using three econometric frameworks: traditional OLS (as used in past empirical studies), random-effects model (REM) and random-parameters model (RPM). Because the selected countries have considerably different economic foci and are at different stages of industrialization, it will be extremely important to account for unobserved heterogeneity across countries, due to peculiar characteristics of national economies which may not be observed with available data (Farrell, 1957; Zellner, 1969; Swamy, 1970; Aigner et al., 1977; Kalirajan and Obwona, 1994; McFadden and Train, 2000; Greene, 2008; Washington et al., 2011). In order to have a better understanding of the observed differences across countries, the final econometric approach selected will address the critical heterogeneity concerns and provide defensible estimates of impact of infrastructure expenditures on a country's economic output.

2. Data and empirical setting

The economic indicator variables, including gross domestic product, producer price index, percentage of gross domestic product from the service sector, demographic data, including labor participation rates, and unemployment rates, were obtained from the websites of the World Bank (2012), OECD (Organization for Economic Cooperation and Development) (2012), CIA (Central Intelligence Agency) (2012), IRF (International Road Federation), (2012). Transportation infrastructure data, including infrastructure expenditures, maintenance and preservation expenditures by infrastructure type, and route-kilometers of infrastructure were available from IRF (International Road Federation) (2012), World Bank (2012), ITF (International Transportation Forum) (2012) and OECD (Organization for Economic Cooperation and Development) (2012).