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Estimating the provincial economic impacts of high-speed rail in Spain: An application of structural equation modeling

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Abstract

This paper presents the preliminary steps on an investigation about the impacts of the Spanish high-speed rail (HSR) network on the provincial economic development from 1990 to 2010 using a panel Structural Equation Modeling (SEM) formulation. The SEM model incorporates education level (proxied by number of people finished high-school or above) as the exogenous variable, endogenizes provincial accessibility brought by the introduction of the HSR service, and analyzes its long term impacts on the endogenous variables, employment and GDP, as well as the causal relationships among them. Panel structure helps to reveal the temporal effects with a time lag of 5 years. Comparison between SEM formulation and single-equation formulation is carried out in the paper as well to reveal the applicability and advantages of SEM formulation.

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Keywords: High-speed Rail; economic development; panel model; structural equation modeling.

1. Introduction

The investment on High-Speed Rail (HSR) infrastructure has been widely encouraged and supported in Europe due to the firm belief that transport infrastructure has spatial, social and economic impacts on urban/regional development, such as increase in employment, income, production and changes in land use patterns (Vickerman, 1997; Banister and Berechman, 2000). It is commonly acknowledged that investment on transport infrastructure increases the accessibility to resources, goods and markets, and thus improves the competitiveness of a region (Dodgson, 1974; Gutiérrez, 2001; Levinson, 2012) and enhances economic integration (Blum, 1982; Rietveld, 1989). Reductions in travel time and travel cost can also give rise to productivity growth through reinforcing the agglomeration benefits (Venables, 2007; Graham, 2007; Hensher et al., 2012). The improvement in transport infrastructure is seen as a means of stimulating production and

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influencing the location decisions of firms, which then induce more employment and private investments through expanding the existing businesses and attracting new economic activities (Button, 1998; Rietveld and Bruinsma, 1998; Rietveld and Nijkamp, 2000).

Despite the ample and extensive literature about the contribution of transport infrastructure to the economic development, the magnitude and significance of the economic effects have been continuingly inconclusive and controversy. The empirical findings from the existing literature vary severely, from no significance to strong significance, according to the geographical scale of analysis, employed data set, modeling frameworks etc. (Holtz-Eakin, 1994; Garcia-Mila et al., 1996; Boarnet, 1998; Jiwattanakulpaisarn et al., 2011). For the case of HSR, although in general the spatial impacts of investments in HSR networks on development are proven to be positive (Martin, 1997; Vickerman, 1997; Gutiérrez, 2001; Levinson, 2012), there has been no clear consensus on their magnitudes or scopes. Nakamura and Ueda (1989) found a high correlation between high growth rate of population and employment and the presence of HSR stations. Bonnafous (1987) argued that the arrival of the TGV in Lyon strengthened the city's business base. But Facchinetti-Mannone (2009) reached disappointing results that exurban HSR stations failed to act effectively as polarizing infrastructures and accentuated centrifuge forces in small towns in France. This accentuates the complexity and challenges in examining the links between HSR and economic development. One has to note that, from a systematic perspective, the incentives for the growth in various economic aspects are not always directly derived from the transport infrastructure. The indicators such as production, employment, population, education level, income level, transport investment, etc., are in fact interdependent on each other, and the causal direction is not always unambiguous. In the big pool of literature, rather few researchers focused on exploring the impacts induced by HSR quantitatively and analyze the relationship between HSR and regional development holistically. To avoid potentially misleading model estimates, an obvious and important improvement is to estimate the joint evolution of transport infrastructure, population, private investment, employment and other related socioeconomic aspects, in the context of a more interactive and realistic model.

Structural equation modeling (SEM), one of the approaches employed for this paper, is a modeling technique capable of dealing with several difficult modeling challenges, unobservable or latent variables, endogeneity among variables, and complex underlying data structures often found in the social phenomena, such as transportation applications (Washington et al., 2003). Most of SEM applications have been in psychology, sociology, the biological sciences, educational research, political science, and market research. In transportation field, numerous studies using SEM methods have been conducted on travel demand and travel behavior (Golob, 2003; de Abreu e Silva et al., 2012); Aditjandra et al., 2012). Several authors used simultaneous equation models in transportation related issues (Fujii and Kitamura, 2000; Sakano and Benjamin, 2011). To our knowledge, there are no applications of SEM on the assessment of the economic impacts of HSR investment. Furthermore, panel data modeling is one possible application for SEM. Models can be specified with repeated variables variables joined by lagged causal effects and possibly autocorrelated error structures. Moreover, time-invariant individual-specific terms can be incorporated in error structures, and period effects can be isolated with certain types of panel data (Bollen and Brand, 2010).

The objectives of this paper are two-fold. Firstly, it is to explore the applicability of the SEM approach on the estimation of the economic impacts of transport infrastructures, particularly HSR in this case. Secondly, it is to preliminarily investigate the impacts of the Spanish HSR network on the provincial economic development from 1990 to 2010, through a panel model with fixed effects using SEM approach (Bollen and Brand, 2010). The SEM model endogenizes provincial accessibility brought by the introduction of HSR service, analyzes its long term impacts on the other endogenous variables of provincial development, employment and GDP, and as well as the causal relationships among them. Education level, proxied by number of people finished high-school or above, is included exogenously to control the effects of accessibility. A fixed effects panel structure was adopted to reveal the temporal effects with a time lag of 5 years, and as well as the reverse direction of how provincial employment is affecting the accessibility level in 5 years.