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Highways and productivity in manufacturing firms

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ABSTRACT

Using a geo-coded micro-level panel dataset for Spanish manufacturing firms, I estimate the effect of access to highways on firm-level productivity. To identify the causal effect of highways, I have relied on different fixed-effects specifications, instrumental variables and controls for geography, geology and history. Since highways also attract economic activity, leading to local density increases, which in turn could affect productivity through agglomeration benefits, I also present estimations that control for local employment densities. The results show that highways raise firm-level productivity directly and beyond the effect of density. Additional results show that highway benefits are unevenly distributed across sectors and space.

1. Introduction

The effects of infrastructure investment on economic outcome are of central concern to both policymakers and academics alike. The subject has attracted increasing attention in recent decades. The emphasis has traditionally been on macro-economic studies (for a recent review see Melo et al., 2013), but recently the focus is shifting to micro-economic analyses. However the exact effects, whether or not there are causal effects and through which channels transport investment impacts on economic activity, still remain a matter of debate (Funderburg et al., 2010; Crescenzi and Rodríguez-Pose, 2012; Leduc and Wilson, 2012; Redding and Turner, 2015).

Using a rich geo-coded micro-level panel dataset for Spain from 1997 to 2007, I focus on the effects of access to highways on firm-level productivity. Highways can have a direct effect on firm-level productivity by yielding savings in transport costs which consequently result in reduced input and output costs. This can increase market size, facilitating sales and exports in more distant markets, but it can also bring more competition to the goods market. Highway improvements may also provide opportunities for new forms of production organisation and to improve supply chains and client services through time savings. This can lead to greater productivity via the optimisation of production and input and output market relations. Shirley and Winston (2004) showed, for example, that highways reduce firms' inventories and consequently their logistics costs. A similar picture was observed by Datta (2012) and Li and Li (2013) for India and China respectively.[1] Transport, travel cost, and time savings derived from improved access to highways and the resulting benefits in terms of production organisation will be reflected in firms' productivity.

At the same time, transport investment affects the location of economic activity (see, for example, Chandra and Thompson, 2000; Holl, 2004; Baum-Snow, 2007; Michaels, 2008; Atack et al., 2010; Duranton and Turner, 2012; Gibbons et al., 2012; Ghani et al., 2016). Redding and Turner (2015) provided a recent survey of the theoretical and empirical literature regarding the relationship between transport infrastructure and the spatial organization of economic activity. This literature provides evidence that highways attract firms and economic activity into the surrounding vicinity, thereby increasing the local density of economic activity. The fact that density boosts productivity is well-established in the literature (for a recent review, see Combes and Gobillon, 2015). Building on the work of Marshall (1890), the basic idea is that the presence of other firms nearby generates positive agglomeration externalities in terms of knowledge spillover, labour market pooling and input sharing. Transport investment - by reducing transport costs and facilitating the movement of goods, the labour force and information - can extend the geographic scope over which

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[1] This is consistent with transport investment induced changes in the organisation of production towards an increasing reliance on transport that substitutes for traditional inventory holding (Hesse and Rodrigue, 2004).

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agglomeration economies may materialise, or what Graham (2007a, 2007b) has termed "effective density". As such, transport investment can indirectly impact on firm-level productivity via agglomeration economies.

Few studies have investigated the impact of transport infrastructure on firm-level productivity. Lall et al. (2004), Graham (2007a, 2007b), Gibbons et al. (2012), Holl (2012) and Martín-Barroso et al. (2015) are some recent examples. However, these studies use different types of area market potential measures to capture road improvement effects. In this paper, I use the variation in the distance between each firm and its nearest limited-access highway (*autovías* and *autopistas*, i.e., motorways). Moreover, to date, the effect of transport on firms' productivity has not yet been estimated conditional on its agglomeration effect. Estimates in the few studies that have investigated the impact of transport infrastructure on firm-level productivity have reflected the sum of both effects. Here, I explicitly test whether highways increase firm-level productivity directly and beyond the effect of density.

The present study is also close in spirit to that of Chandra and Thompson (2000), Banerjee et al. (2012), Faber (2014), and Ghani et al. (2016). However, these studies analyse the effects of access to transport networks on local and regional outcomes. My study differs insofar that it estimates the effect of access to highways in a firm-level panel data setting. This means I can control for unobserved as well as observed heterogeneity across firms and for differences in impacts across sectors and space.

To estimate a causal impact, different fixed-effects specifications and instrumental-variable estimation were used because access to highways can be expected to be endogenous. Firstly, highways are not distributed randomly. Governments may specifically allocate new infrastructure to areas with higher predicted productivity growth in order to accommodate the resulting traffic increase or, conversely, this allocation may go to areas with lower predicted productivity growth in order to stimulate growth. Omitted variables may also influence both access to highways and firm-level productivity. Secondly, endogeneity can stem from the spatial sorting of firms. For instrumentation, I use the 1760 postal routes and the old Roman roads as sources of exogenous variation (for details, see Holl, 2012 and Garcia-López et al., 2015). To satisfy the exclusion restrictions, I include detailed controls for geography, geology and history. Endogeneity issues also arise for density. The higher productivity of firms in a given location may attract workers, thus increasing local density. Here I instrument contemporary density with 1900 geodesic market potential (Holl, 2012) and a new geological instrument for Spain based on the distance to the nearest underground body of water covered by highly and very highly permeable soil. Aquifers have represented a crucial factor in human settlements and agriculture since the beginning of time, but these geological characteristics can be considered exogenous to modern manufacturing productivity.

To estimate the productivity effects of access to highways, I calculated firm-level total factor productivity (TFP) using the Levinsohn and Petrin (2003) approach to further control for endogeneity problems in TFP arising from unobserved productivity shocks. Highway access was calculated using a geographic information system (GIS) in which the distance between each company's location and its nearest limited-access highway was based on the firm's geographical coordinates and annually geo-referenced road maps. I directly explored the time variation in the construction of a major limited-access highway network and, therefore, I could use distances that vary over time.

I find an elasticity of productivity with respect to access to highways in the range of 1.3–1.7%. This productivity-enhancing effect of highways is robust to a variety of alternative specifications and estimation methods and is not driven by agglomeration effects. My results show that highways have a significant positive effect on productivity beyond merely the effect of density. The literature on local determinants of productivity gains has mainly focused on the impact of local density. My findings reveal that highways have a significant direct effect on productivity even after controlling for agglomeration effects.

I also find significant heterogeneity in impacts across firms. Highways tend to have a greater effect on productivity in urban rather than rural areas, with this effect being concentrated near the new infrastructure. Furthermore, the estimation results suggest that benefits are highest among suburban firms in close proximity to highways, but the gains observed in these firms have in part been offset by losses among suburban firms in adjacent areas.

Additional estimation results show that highway effects vary across different types of industries and that it is mainly traditional manufacturing industries – which tend to have a higher weight to value ratio - that have seen significant positive productivity impacts. Finally, looking at relocating companies confirms that highways attract economic activity into their vicinity. Firms typically relocate closer to highways, but there is also heterogeneity in the types of firms attracted to different highway locations. Taken together, the results provide support for a significant distributional effect of highway infrastructure.

This research contributes to the literature analysing the economic impacts of transport infrastructure by empirically documenting a micro-economic mechanism through which transport infrastructure affects economic outcome. The findings presented are relevant for understanding the spatial distribution of economic activity within a country and the role transport infrastructure plays in shaping this distribution.

The paper is organised as follows. Section 2 presents the data. Section 3 introduces the estimation approach and variable definition. Section 4 presents the results of the empirical estimations. Section 5 concludes.

2. Data

2.1. Firm-level data

Geo-coded firm-level data was taken from the SABI database. SABI (*Sistema de Análisis de Balances Ibéricos*) is generated by INFORMA and Bureau Van Dyck, and contains annual financial information about Spanish and Portuguese companies. Here I have used data from firms in mainland Spain involved in manufacturing sectors. Most importantly, the database includes the geographic coordinates of firms. This means the exact distance from each firm to the highway network can be calculated and the firm-level data can be integrated with other spatial data on a fine-grained spatial scale.

The database contains exhaustive accounts and balance sheet information going back to 1997. SABI provides data on value added, employment and capital stock (used to calculate firm-level productivity) as well as a detailed industrial disaggregation, facilitating analysis of highway effects across different manufacturing sectors. Notable disadvantages of the SABI database are that it provides accounts and balance sheet data at a company and not a plant level, and so outputs and inputs cannot be assigned to individual plants in multi-plant companies with the information available. This means that plant-level productivity cannot be calculated. Similarly, in the case of multi-plant companies, it is impossible to ascertain the overall relevance of company location with respect to the highway network as each plant may be in a different region and at a different highway separation distance. Thus, the sample had to be restricted to single-plant firms and to that end I have applied