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Generalized transport costs and index numbers: A geographical analysis of economic and infrastructure fundamentals

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ABSTRACT

We rely on the economic theory approach to index numbers to improve the existing definitions and decompositions of variations in generalized transport costs (GTCs). As a value index, we decompose GTCs into price and quantity indices associated to economic—market—costs and infrastructure variables—distance and time within a network. The methodology allows the accurate identification of the sources of GTCs decline. We illustrate it for the case of road freight transportation in Spain between 1980 and 2007 and at a highly detailed geographical level. Average GTCs weighted by trade flows have decreased by 16.3%, with infrastructure driving that reduction. We find large territorial disparities in GTCs, but also significant geographical clusters where the market and network indices show spatial association.

1. Introduction

The importance of accessibility from a locational perspective both for firms and individuals is paramount. This is particularly true for both macro and microgeographical analyses regarding the distribution and specialization of economic activity across space, and their associated volumes of trade. Both locational and trade patterns are highly influenced by transport costs, which constitute a prime measure of accessibility to markets. Although the importance of transport costs has been steadily declining in the past decades (Glaeser and Kohlhase, 2003), the world is still quite far from being flat. Given their importance, many studies have been devoted to accurately defining and measuring transport costs and their determinants. Considering different transportation modes and freight cargo, we can highlight several studies measuring transportation costs: Combes and Lafourcade (2005) for the case of road transportation, Ivaldi and McCullough (2007) in train haulage, Hummels et al. (2007) in air delivery, and Tolofari (1986) and Hummels (2007) in maritime shipping. From the point of view of a static cross-section definition, the cost engineering and accounting methodology followed by these studies is thoughtfully and competently executed, enhancing the customary and simpler unit value and value of time indices into a comprehensive generalised transport cost measure.[1] However, when it comes to define their evolution time, the approach that

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[1] See World Bank (2009) for a detailed summary of these studies. Oum et al. (1992) discusses the alternative concepts of productivity and methods of measurement (including index numbers) in the transport sector. Our approach based on costs represents the dual of the total factor productivity definition that they consider.

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they follow does not rely on the formulation of a producer price index consistent within the economic theory framework, which is completely disregarded. It is as though the authors interested in these issues were reluctant to take their static cross-section efforts when studying transport costs to their logical extension to time-series analysis, in order to obtain consistent definitions, measures and calculations within the standard analytical framework represented by index numbers theory. Laying out this framework and its associated time series extension constitutes the main methodological goal of this study.

This somewhat lax attitude towards modelling changes in transport costs has serious consequences: (i) studies on the same transportation mode carried out by researchers at different times and in different countries are not comparable as they use different methodological approaches; (ii) scholarly work has a limited influence in encouraging national statistical agencies to adopt a standard methodology for the compilation and provision of price index series on transport costs on a regular basis; and (iii) the lack of time-series information hampers long term assessments of economic and infrastructure policies and the definition of guidelines associated to their strategic planning. In this context, the first contribution of this study is theoretical, and involves improving the existing methodology to accurately measure the change in transport costs over time within an index number framework and, by doing so, to provide a consistent decomposition of these changes that allows us to determine precisely the effects that both economic and infrastructure determinants have on transport cost variations. We accomplish this goal by adopting Fisher's (1922) formulation for each of the price and quantity indices into which the GTC variation decomposes. Specifically, for the price index we rely on the (normally unobservable) price aggregate corresponding to the Konüs (1924) true cost of producing index, which can be consistently used to recover its associated implicit quantity index by means of the product rule. Adopting this methodology we avoid theoretical and measurement biases that may have important implications when results are normatively used to propose policy guidelines with respect to market regulation and infrastructure policy.

It is now accepted that a transport cost measure must meet several criteria in order to prove useful for analysis. It must be based on information reflecting the specific itinerary, the transport mode, and the nature of the commodity being transported. A measure satisfying these requirements represents a generalized transportation cost, or GTC, which is defined as the minimum cost of transporting a given load of a particular commodity between a specific origin and a destination, considering the economic variables related to the input costs necessary to produce the transportation service (*e.g.*, labour and capital costs), and the physical features of the available transport infrastructure (*e.g.*, network topology). Because the measure depends on all these elements, it can be decomposed so as to identify its different economic (market) and infrastructure (geographical) determinants. Taking this into consideration, and from the empirical perspective, we consistently calculate the variation in GTCs for the case of road freight transportation in Spain between 1980 and 2007, and decompose it into price (economic) and quantity (infrastructure) components. Therefore, the second main contribution of this study is the calculation of the true cost of producing index and its associated quantity index. Our measurement of GTC variations and their sources represents the first application in the transportation literature to consistently apply index number theory to calculate the true change in the cost of producing a transportation service.

Finally, we have selected the road transportation industry to illustrate our methodology because: (i) this mode represented about 70% of all ton-kms transported in Spain in 2007 –90% of all land transportation including road, railroad and pipeline (MFOM, 2008); and (ii) there are some previous studies to which we can refer and compare our results: particularly, the empirical framework defining GTC in trucking transportation as presented by Combes and Lafourcade (2005) or Teixeira (2006), or the work by Martínez-Zarzoso and Nowak-Lehmann (2006) on GTC determinants. However, comparing our contribution to these studies, we work with a richer database from both an economic and road network perspective. We have collected economic data for individual operating costs at a regional (NUTS 2) and—when available—provincial (NUTS 3) level (*e.g.*, labour and fuel costs, which represent over 50% of the overall costs, differ at the provincial level), allowing us to determine alternative economic cost structures for firms operating in different geographical areas. From a geographical perspective, the road network database includes features that are normally overlooked, such as the degree or steepness of the road sections comprising the arcs, which influence several variables such as actual speed and fuel consumption. As for the nature of the commodity being transported, the proposed methodology allows for commodity specific costs as well as possible restrictions on the use of the road network, both of which condition the optimal least cost routes. Therefore, even if in the empirical section we take as reference vehicle the 40-ton articulated truck, suited for transportation of a wide range of goods (representing about 80% of road freight transport), the methodology lays the framework to accommodate other types of goods such as hazardous materials, perishable commodities.

The paper is structured as follows. Section 2 presents the theoretical framework based on the economic theory of index numbers by defining the volume index corresponding to GTC variation and its decomposition into the Konüs cost of producing price index and its associated quantity index, related to transport economic costs and network infrastructure respectively. Section 3 starts with a detailed description of the economic (unit-price) and GIS databases used in the calculation of the GTCs for the Spanish road freight transportation industry since 1980. Here we present the empirical results regarding the GTCs as well as their Konüs price and quantity indices components, and discuss the sources of GTC decline. Using Moran's indicator and Anselin's local indicator, in Section 4 we explore the existence of significant geographical clusters where the variations in GTCs and their economic and infrastructure components exhibit significant patterns of spatial association. In this section we also calculate several inequality measures to determine whether the steady decline in all the indices has been characterized by a convergence process, thereby reducing territorial disparities in terms of GTCs, economic costs, and accessibility. Finally, Section 5 concludes with relevant policy implications and final remarks.