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Granger-causality between transportation and GDP: A panel data approach

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ABSTRACT

This paper investigates the Granger-causality relationship between income and transportation of EU-15 countries using a panel data set covering the period 1970–2008. In the study, inland freight transportation per capita in ton-km (TRP), inland passenger transportation per capita in passenger-km (PAS), and road sector gasoline fuel consumption per capita in kg of oil equivalent (GAS) are used as transportation proxies and GDP per capita is used as measure of income. Our findings indicate that the dominant type of Granger-causality is bidirectional. Instances of one-way or no Granger-causality were found to correspond with countries with the lowest income per capita ranks in 1970 and/or in 2008. Although we conclude that there is an endogenous relationship between income and transportation, this is not observed until after an economy has completed its transition in terms of economic development.

1. Introduction

We are in the age of mobility, in which not only physical goods but also human beings and even services move between locations in significant amounts. The facilities that collectively make this unprecedented mobility possible are known as transportation. A natural question that follows this observation is whether transportation enhances economic development and growth, or vice versa, or whether they boost each other. On the one hand, economic intuition suggests that transportation may have strong positive effects on economic development and growth, which we will call in this study *direct causation*.[1] Three possible channels that transportation may affect economic development positively are as follows. Firstly, improvements and developments in transportation (e.g., faster trains and oil tankers with more capacity) and facilities improve overall productivity of production units (Bougheas et al., 2000; Lakshmanan, 2007). Secondly, increasing transportation eases technology spillovers across economies. Finally, a micro-level feature with potential macro-level results is rising profitability due to reduced costs or increasing sales revenue. This occurs because transportation and its facilities allow firms to access the lowest cost inputs or factors of production for their production activities, and to access broader markets and perhaps at potentially more advantageous prices.

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[1] Most of the studies in the literature refer to the effect of transportation on economic development as *direct causation* and the effect of economic development on transportation as *reverse causation*, as we do in this study.

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There is an enormous literature on the positive role of transportation on income. One branch of the literature considers infrastructure as an argument in production, which may be labeled as "the production function approach".[2] For example, Munnell and Cook (1990), investigating the impact of highways on Gross State Product (GSP), show that the elasticity of GSP with respect to highways is 0.06. Duffy-Deno and Eberts (1991), Eisner (1991), Garcia-Mila and McGuire (1992) and Moonmaw et al. (1995) similarly obtain positive relationships between transport infrastructure and income per capita by using production function approach. Jones (1990) and Mofidi and Stone (1990) show that highway spending per capita has positive impact on various measures of development, whereas Reynolds and Maki (1990) fail to find it. While Easterly and Rebelo (1993) find that public investment in transportation and communication (T&C) leads to higher economic growth in developing countries, Devarajan et al. (1996) find that there is a negative correlation between the two for 43 developing countries between 1970 and 1990. Boopen (2006) shows that, in Africa, investment in transportation capital is more productive than physical capital (investment) on average. Zhou et al. (2007) show that highway construction has significant and positive effect on economic growth in China. Singletary et al. (1995), Crihfield and Panggabean (1995), Garcia-Mila et al. (1996) and Fernald (1999) all show that increases in resources allocated to highways cause employment in the manufacturing industry to rise, leading to productivity growth. In a similar manner, Jiwattanakulpaisarn et al. (2010) found that investments in highways are likely determinants of state-level employment growth in the services sector.

Another branch of research, again investigating the relationship between transport measures and economic development, show that transport measures have cost reducing effects, therefore it may be called the "cost function approach". Berndt and Hansson (1992), Lynde and Richmond (1993), Seitz (1993), Nadiri and Mamuneas (1994), Conrad and Seitz (1994) and Boarnet (1996, 1998) may be considered in this vein. For example, Bougheas et al. (2000) introduce (transportation) infrastructure as a cost reducing technology in their cross-country study and find that improvements in the transportation infrastructure allow specialization and long run growth. They also show that, a cost reducing technology in infrastructure makes production of intermediate inputs more efficient compared to its impact on the efficiency in production of final goods.

On the other hand, the growing income, essentially due to technological progress, allows general demand to rise and leads to the development of the services sector (e.g., Eichengreen and Gupta, 2013). As transportation is an important component of services sector, intuition suggests that economic development may also have strong positive effects on transportation, which in this study we refer to as *reverse causation*. For example, Kim (2002), examining the determinants of optimal demand for transportation infrastructure using a recursive computable general equilibrium model, finds that higher levels of transportation capital stock are associated with higher economic growth and inflation. Specifically, he finds that a 1% increase in GDP generates 0.99% capital formation in transportation sector. Similarly, Randolph et al. (1996) find that per capita government expenditures on T&C increase with GDP per capita, among other indicators using pooled cross-sectional and time series data on 27 low and middle income economies between 1980 and 1986.

All these studies clearly indicate a potentially strong relationship between economic development and transportation, perhaps in both directions. It is important to determine the direction of relationship between income and transportation for both econometric and economic reasons. First, in terms of econometrics, if this relationship is in fact bidirectional, then studies undertaking one-way relationship between transportation and income involve a misspecification problem, that is, they will produce biased and inconsistent estimates of the structural parameters given the endogenous relationship between income and transportation. Second, in terms of economics, policy makers need to know the direction of relationship to be able to apply effective policies. For example, if policy makers wait for a rise in income to boost transportation, when in fact the direction of causality is from transportation to income for economies below a certain level of economic development, both income and transportation will develop at a lower rate compared to a case in which transportation is strongly supported, e.g., through subsidization. Hence, it is critical to determine the direction of the causality between transportation and economic development (GDP per capita level) in advance. Applying the Granger-causality (or rather Granger non-causality) test is the most effective and practical way to test the direction of causality (e.g., Florens and Mouchart, 1982). The essence of determining the relationship between income and transportation for reasons explained above serving as our motivation.

This paper aims to investigate the direction of causation in the Granger sense between income and transportation for the EU-15 countries by using a panel data set covering the period 1970–2008. Rather than taking transportation as a physical stock or public investment in infrastructure, we define transportation to mean all the facilities that make physical goods, human beings and services move between locations. To this end, inland freight transportation per capita in ton-km (TRP) and GDP per capita are used as measures of transportation and income, respectively. In addition to this, inland passenger transportation per capita in passenger-km (PAS) and road sector gasoline fuel consumption per capita in kg of oil equivalent (GAS) are used as transportation proxies in robustness tests.[3]

[2] By definition, infrastructure entails transportation. Hence, studies on the role of public capital or infrastructure on economic development and growth may also be considered relevant for this approach. Aschauer (1989) is the pioneering study, which shows that the elasticity of private sector productivity with respect to public capital is positive, which is also confirmed by Munnell (1990). Some examples of more recent studies of this approach are Bucci and Del Bo (2009) showing a U-shaped relationship between public capital share and economic growth for 184 countries in the period 1970–2004, and Carboni and Medda (2011) showing that core infrastructure (roads, highways, telecommunication systems, R&D capital stock) leads to different growth rates depending on their elasticity. See survey studies such as Button (1998) and Romp and de Haan (2007) for extensive discussion of the literature on the relationship between infrastructure and/or public capital and income or economic growth.

[3] For example, Lu et al. (2010), Meersman and Van de Voorde (2013), Santanu and Samyadip (2012) and Xiong and Sun (2010) use freight transportation; Owen and Phillips (1987) use passenger transportation; Pradhan and Bagchi (2013) use both freight and passenger transportation; Liddle (2009, 2012) use gasoline consumption as transportation proxies to examine the interaction with economic activities such as GDP.