Research in Transportation Economics xxx (2016) 1–10

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

Implication of spatial heterogeneity for airports' efficiency estimation

Dmitry Pavlyuk

Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

ARTICLE INFO

Article history:
Available online xxx

Classification codes:
L93
D24
C21
C51

Keywords:
Spatial heterogeneity
Airport
Efficiency
Productivity
Spatial econometrics
Stochastic frontier

ABSTRACT

This research is devoted to the analysis of a role of spatial heterogeneity in estimation of airports' efficiency. Spatial heterogeneity, caused by uneven distribution of influencing factors over space, is widely acknowledged in the European airport industry, but rarely included in airport benchmarking procedures. We utilise modern methods of spatial econometrics to identify the importance of spatial heterogeneity for estimates of airports' resource elasticity and efficiency values. A set of utilised models includes the spatial error model, spatial stochastic frontier model, geographically weighted regression model, and their modifications.

The empirical findings of the research are based on a sample of 356 European airports (in 2011) and include evidence of the significant effect of spatial heterogeneity on airport's efficiency and productivity estimates. A multi-output approach to production frontier specification is utilised; served passenger and cargo traffic flows are considered as airport outputs. Elasticities of airport input resources that are infrastructure (runways), catchment area characteristics (population size and welfare), regional tourist intensity, and airport status (hub, international) were estimated and discussed. We paid special attention to the geographical variability of input elasticities over Europe. The paper also contains individual estimates of the sample airports' efficiency levels.

The main contributions of this paper are the proved necessity of incorporation of spatial heterogeneity into airport benchmarking procedures and the suggested methodological framework for spatial analysis of airports' productivity and efficiency.

1. Introduction

Since 1980-ties great efforts have been made in developing of productivity measurements in the airport industry. The growing demand for studies in this area was stimulated by air industry deregulation and led to a wide range of theoretical and empirical researches. More than a hundred of research papers, devoted to airport benchmarking, were published during last two decades.

Despite a large number of airport benchmarking studies, spatial effects are rarely included into consideration. At the same time, two types of such effects, spatial dependence and spatial heterogeneity, are widely acknowledged in the airport industry. Spatial dependence refers to interactions between neighbour airports, mainly explained by spatial competition for passenger and cargo traffic, for served airlines, for local labour force, and for other resources. Spatial heterogeneity reflects the uneven distribution of various productivity-related factors over space. These factors like climate features and legislative environments significantly affect airport productivity and must be taken into account for airport benchmarking.

Almost all commonly used approaches to measurement of airport productivity and efficiency are based on a ratio of airport outputs (results) and inputs (resources) and fail to distinguish between airport's individual efficiency and the heterogeneity of its environment. Meanwhile heterogeneous spatial distribution of factors can play a crucial role for final results and conclusions. Researches, conducted by Borins and Advani (2002), Scotti, Malighetti, Martini, and Volta (2012), and Adler and Liebert (2014), can be mentioned among a few others, where spatial effects are included into analysis of the airport industry. Mainly empirical researchers focus on identification of spatial competition between airports, while spatial heterogeneity is not directly included into consideration. Basically spatial heterogeneity is modelled via a set of observable variables of a spatial nature like an average annual temperature or acting government regulations. At the same time, modern methods of spatial econometrics that explicitly deal with spatial dependence and spatial heterogeneity are rarely utilised.

In this research we apply methods of spatial econometrics for identification of spatial heterogeneity in the European airport

E-mail address: Dmitry.Pavlyuk@tsi.lv.

http://dx.doi.org/10.1016/j.retrec.2016.07.002
0739-8859/

industry. The paper is organized as follows: a short review of existing researches of airport performance and a motivation of spatial heterogeneity in the airport industry are presented in Section 2; Section 3 presents an overview and a formal definition of used spatial regression models and a description of the research data; the estimation results and main findings are presented in Section 4; and Section 5 contains the conclusions and the outline of the most valuable results.

2. A background of spatial heterogeneity in airport benchmarking

The methodological background of airport performance measurement is very extensive. On the base of the presence of a random component, all methodologies are commonly classified to deterministic (partial factor productivity indicators, data envelopment analysis) and stochastic (classical regression, stochastic frontier analysis). The main advantage of stochastic methodologies, used as a base for this research, is their statistical background, which makes statistical procedures like confidence intervals, significance and hypothesis testing naturally available. A list of recent researches, where stochastic methodologies are utilised for airport performance analysis, includes works of Pels, Nijkamp, and Rietveld (2003), Abrate and Erbetta (2007), Barros (2008), Martin, Roman and Voltes-Dorta (2009), Muller, Ulku, and Zivanovic (2009, p. 31), and Scotti et al. (2012), Adler and Liebert (2014), Merkert and Mangia (2014), D'Alfonso, Daraio, and Nastasi (2015), Pavlyuk (2015), among others. Detailed reviews of existing applications was presented by Liebert and Niemeier (2011) and Bezerra and Gomes (2016).

All benchmarking methodologies are based on direct comparison of airport results. Thus, their effective utilisation requires compatibility that is homogeneity of airports and their environments. But there is an extensive background for heterogeneity of airports. This heterogeneity is related to airport size, traffic specialisation (passengers or cargo, international or local), ownership (public or private), local social particularities, government regulations, and others. Factors of airport heterogeneity are commonly arranged to endogenous, or controlled by airport management, and exogenous, lying beyond managerial control. In practice endogenous heterogeneity is frequently noticed as inefficiency, while exogenous heterogeneity is stated as a difficulty for benchmarking. Discussing exogenous heterogeneity, Forsyth, Gillen, Müller, and Niemeier (2010) stated that “a central problem of benchmarking is the heterogeneity of airports, which must be taken account”. The importance of heterogeneity in airport benchmarking is widely acknowledged in literature (Assaf, 2009; D'Alfonso et al., 2015; Oum, Yan, & Yu, 2008).

For modelling purposes, airport heterogeneity is classified to observed and unobserved. Observed heterogeneity is included into models using a set of measurable and practically available factors. For example, ownership of airports is publicly available and can be included into a model as a set of polytomous variables for airports' primary owners or as a set of ownership shares for more complicated ownership structures. Observed climate heterogeneity is usually represented in models via an average temperature, average annual precipitation, annual number of days with snow cover, and so on. Acting heterogeneity, which cannot be directly represented by a set of indicators, is classified as unobserved. Barros (2008) and Liebert (2011) note the importance of unobserved heterogeneity for airport benchmarking.

In this research, we focus on spatial aspects of heterogeneity, related with airports' geographical location. A theoretical and empirical background of the spatial heterogeneity in the airport industry is very extensive. Generally, spatial heterogeneity is explained by regional differences in the environment of airports, which affect their productivity and efficiency. The most obvious and widely acknowledged source of spatial heterogeneity is related to the natural environment. Climatic peculiarities such as a temperature regime, snowfalls, and thunderstorms significantly affect airport activity. A natural landscape also plays an important role – a mountainous landscape limits aircraft landing trajectories and leads to a higher risk of weather changes; a high altitude creates additional landing problems; and so on. The importance of these spatial characteristics is reflected in several empirical researches (Palk, 2000; Yu, 2004). Another reason of spatial differences is legislative and economic regulation of airports. Significant effects of different types of regulatory regimes (unregulated, cost-based and price-cap single-till and double-till) are discovered by Adler and Liebert (2014), Bel and Fageda (2009), Gitto and Mancuso (2010, p. 28), Marques and Barros (2010), among others. Note that these factors are usually country- or region-specific, which allows us to consider their effects as spatial. Another wide source of spatial heterogeneity consists in regional differences of traffic flows. Demographics, economic and social conditions, labour market, population habits, surface infrastructure and other region-specific factors play an important role in airports' activity.

After liberalisation of the airport market the growing competition between airports becomes an important driver of airport activity. Due to fixed locations of airports, competition between them has a spatial pattern. The theory of spatial competition (Hotelling, 1929; Irmen & Thisse, 1998) creates the extensive background for analysis of airports, thus spatial competition between airports is analysed in several recent studies in this area (Adler & Liebert, 2014; D'Alfonso et al., 2015; Gitto & Mancuso, 2012; Merkert & Mangia, 2014; Scotti et al., 2012; Starkie, 2002).

The mentioned factors of spatial heterogeneity are typically included into empirical models via observed indicators. A selection of these factors is under the researcher's responsibility and frequently they are completely ignored in practice. Indeed, even the careful selection of these factors leaves unobserved spatial heterogeneity out of a model. Spatial econometrics explicitly deals with spatial dependence and spatial heterogeneity in regression models and is widely used in different research areas. The main premise, which allows the explicit inclusion of airport heterogeneity into model specifications, is a similarity of unobserved spatial effects for neighbour airports. Nevertheless, to the best of our knowledge, Ulku, Jeleskovic, and Muller (2014) and the author's papers are the only applications of these methods to analysis of airport productivity and efficiency.

Summarising the arguments above, we state that a wide range of spatial factors create a very heterogeneous structure of the airport industry. Thus, taking spatial heterogeneity into account for modelling can be stated as a methodological necessity. The main objective of this research is to develop a methodological framework for estimation of spatial heterogeneity and to highlight the importance of spatial heterogeneity for airport benchmarking.

3. Research methodology and data

3.1. Methodology

A general approach to analysis of productivity and efficiency is based on comparison of resources, used by an economic unit, (inputs) and its obtained results (outputs). This research utilises a set of specific techniques of regression analysis, which allows estimating of efficiency and productivity subject to spatial heterogeneity. A list of utilised regression models includes:

Please cite this article in press as: Pavlyuk, D., Implication of spatial heterogeneity for airports' efficiency estimation, *Research in Transportation Economics* (2016), http://dx.doi.org/10.1016/j.retrec.2016.07.002