Omega 63 (2016) 111–122

Contents lists available at ScienceDirect

Omega

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

Performance of hospital services in Ontario: DEA with truncated regression approach ☆

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ARTICLE INFO

Article history:
Received 26 December 2012
Accepted 9 October 2015
Available online 20 October 2015

Keywords:
Hospital efficiency
DEA
Distributional analysis
Truncated regression
Bootstrap

ABSTRACT

In this work, we analyze production performance of hospital services in Ontario (Canada), by investigating its key determinants. Using data for the years 2003 and 2006, we follow the two-stage approach of Simar and Wilson (2007) [76]. Specifically, we use Data Envelopment Analysis (DEA) at the first stage to estimate efficiency scores and then use truncated regression estimation with double-bootstrap to test the significance of explanatory variables. We also examine distributions of efficiency across geographic locations, size and teaching status. We find that several organizational factors such as occupancy rate, rate of unit-producing personnel, outpatient–inpatient ratio, case-mix index, geographic locations, size and teaching status are significant determinants of efficiency.

1. Introduction

In this study, we analyze production performance of healthcare services in Ontario province (Canada) and its key drivers. In Ontario, the costs of all hospital services are covered under the Canada Health Act and are therefore fully funded by the provincial Ministry of Health and Long-Term Care (MOHLTC). Thus, irrespective of sizes, geographic location and teaching status, all hospitals operate under the same financing system and are indifferent to profit rather striving to maximize the quantity and quality of healthcare services as per service accountability agreement between hospitals and local health integrated network (LHIN)[1]. Therefore, the main research focus of our study has been to analyze the determinants of efficiency of hospital services considering different geographic locations (i.e., rural vs. urban), size (i.e., small vs. large), teaching status and other key characteristics. The performance measurement across the different groups of hospitals is very important for understanding the utilization of scarce resources. It also provides important information for development of healthcare reforms to improve global funding system while simultaneously promoting quality and efficiency [34,35,55,79,62,53,56] as well as better accountability among healthcare providers.

For our analysis, we followed the existing classifications of rural vs. urban, small vs. large, and teaching vs. non-teaching hospitals used by the MOHLTC, the public funder of all hospital services. The concept of a rural hospital, however, is generally defined by several components, including, but not limited to, population size and density, geographic and professional isolation and lifestyle factors. Small hospitals are normally located in rural areas, and rural hospitals tend to be smaller than urban hospitals. A small hospital in Ontario is defined by multiple criteria, including hospital activity, expected stay index (ESI), referral population size and whether it acts as a single provincial community provider (see [44]). Teaching hospitals provide both acute and complex patient care and are affiliated with a medical or health sciences school, involved in significant research activity and provide training for interns and residents[2].

The performance analysis in this study is based on production theory in economics, where one can determine the extent of resource utilization by estimating the production frontier and considering hospital services provision as a production process where inputs (e.g., nurses' hours, staffed beds, etc.) are

☆ This manuscript was processed by Associate Editor Podinovski.
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[1] http://www.lhincollaborative.ca/Page.aspx?id=1968, accessed on May 16, 2015.

[2] http://edrs.waittimes.net/En/Definitions.aspx?view=1, accessed on December 19, 2013.

http://dx.doi.org/10.1016/j.omega.2015.10.007
0305-0483/

transformed into different outputs (e.g., inpatient and outpatient volume). For empirical estimation, we used the data envelopment analysis (DEA) estimator along with both the non-parametric kernel-based density estimation method and truncated regression with double-bootstrap.

DEA is a frontier estimator based on a linear programming approach and is frequently used for assessing efficiency of a decision making unit (here hospital) relative to the observed best-practice frontier of all other hospitals in the sample[3]. The main advantage of DEA is that it can relatively easily handle a multi-output and multi-input environment without specifying any functional form of the production relationship[4]. As the hospital sector produces several types of services using several inputs, estimating hospital efficiency via DEA is appealing and is among the most popular approaches in academic literature.

For our analysis of DEA-estimated efficiency scores, we apply the test of Li [51,52] adapted to DEA by Simar and Zelenyuk [73], with bootstrapping, for comparing distributions of efficiency scores across geographic locations, size and status of hospitals[5]. The use of a version of the adapted Li [51,52] test allows us to test the hypothesis of equality of distributions, i.e., whether there are any significant differences in efficiency distributions across geographic locations, size and status. Finally, we applied the two-stage procedure (DEA+truncated regression, bootstrapped) of Simar and Wilson [76] to examine the determinants of efficiency of hospital services[6]. In this two-stage approach, we find that several organizational factors, such as rate of unit producing personnel (UPP), occupancy rate, outpatient–inpatient ratio and case-mix index along with either geographic locations and teaching status or size and teaching status are significant determinants of efficiency.

The paper is organized as follows. Section 2 reviews the related works on hospital efficiency in relation to rural/urban location, size and teaching status. Section 3 presents a theoretical framework of the methods applied for estimation. Section 4 describes the data sources and variables used in the analysis. Section 5 discusses the results of truncated regression analysis, and Section 6 provides concluding remarks.

2. Related works

Although a large number of studies are available on hospital efficiency analysis (e.g., see [34,42,63,32,69] and references cited therein), there are only a handful of studies that focus on identifying the determinants of hospital efficiency (e.g., [38,50,8,78,18,24]). Table 1 briefly summarizes some of these studies. In our study, we focus on analyzing hospital efficiency by taking into account geographic locations (urban vs. rural), size (small vs. large), teaching status and other organizational factors that may influence hospital efficiency.

Due to differences in location, size and status, different hospitals face different sets of challenges even though they may provide similar types of services. Rural hospitals provide core medical services such as emergency care, obstetrics and newborn services

[3] See [27,11,6,25,71], etc.

[4] Multi-input–multi-output cases can also be handled in the so-called stochastic frontier analysis approach, e.g., using polar coordinates transformation as in Simar and Zelenyuk [74].

[5] A similar approach was undertaken in some other related works, focusing on hospital efficiency (e.g., see [30,41,48,49]).

[6] In a recent survey, Liu et al. [54] identified the five most active DEA subareas in recent years and among them the "two-stage contextual factor evaluation framework" has been found more active. And we thus follow our empirical work using Simar and Wilson (2007), which spawn many new works as seen from the explosive pattern surrounding the paper (see [54].

Table 1
Selected recent research in hospital efficiency analysis.

Authors	Method	Sample	Inputs	Outputs
Grosskopf et al. [38]	DEA and regression analysis	236 teaching hospitals and 556 non-teaching hospitals in the US in 1995	Beds, FTE MD, FTE RN, FTE PN, FTE RES, FTE others	No. of inpatients, surgeries, outpatient/ER
Kontodimopoulos et al. [47]	DEA	17 small-scaled Greek hospitals for 2003	Doctors, nurses, beds	Patient admissions, outpatients, preventive medicine services
Lee et al. [50]	DEA and multiple regression analysis	106 acute care hospitals in Seoul for 2004	Number of beds, doctors and nurses	No. of inpatients and outpatients visits
Blank and Valdmanis [8]	DEA second stage with bootstrap	69 Dutch hospitals for 2000	Staff and admin. personnel, Nursing personnel, Paramedical personnel, Other personnel, Material supplies	Discharges and first time visits
Garcia-Lacalle, and Martin [32]	DEA and multidimensional scaling	27 Andalusian Health Service (SAS) hospitals in Spain for 2003 and 2006	Beds, Physicians, Nursing staff	Outpatients visits, emergencies, stays, diagnoses, operations
Cristian and Fannin [18]	DEA second stage with bootstrap	Unbalanced panel data set of Critical Access hospital in the US for the period 1999–2006	Full time equivalent (FTE) personnel and staffed and licensed beds	Outpatient visits, admissions, post-admission days, emergency room visits, outpatient surgeries,and total births