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Time-varying production efficiency in the health care foodservice industry: A Bayesian method

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ABSTRACT

Cost containment, budget control, and improvements in efficiency are key drivers of the way health care foodservice operations (internal hospital foodservice departments that produce/reheat food and deliver them to patients) will respond to emerging economic and population trends. These factors are the motivation for this study, which aims to assist health care policy makers in identifying operational strategies for efficiency improvements. The study applies a Bayesian method in deriving to efficiency estimates, using panel data on key Australian hospitals. The results show that the model satisfies the theoretical economic requirements. Important relationships are identified between the level of meal production and other input and environmental variables. The efficiency results indicate that the performance of health care foodservice operations is improving over time and reached its highest level in the operating year 2007. The paper identifies some factors related to efficiency improvements, and offers some suggestions for future improvement strategies.

1. Introduction

The budgets that governments spend on the health care sector continue to increase at an alarming rate in most developed countries of the world. For example, in Australia, total health expenditure grew by over 7% between 2004–05 and 2005–06 to $87 billion; as a proportion of gross domestic product (GDP) it was around 9% (Health Expenditure Australia, 2006). The UK and New Zealand report similar figures whilst in the US the ratio is even higher; in 2005, it was around 15% of GDP (Health Expenditure Australia, 2006). Economic and industry trends such as inflation, increase in the age of patients, and high quality awareness are likely to create additional cost-containment challenges for hospital operators in the future.

The main cost control measures that Australian hospitals may take in response to current and future changes include reducing operational costs and improving productivity (Health Expenditure Australia, 2006). This paper focuses on the current challenges facing foodservice operations in the Australian health care sector. Many papers address the cost and scale efficiency of hospitals (Dranove and Lindrooth, 2003; Hughes and McGuire, 2003; Preyra and Pink, 2006), but few studies focus on the area of health care foodservice. The cost of food production in hospitals is high and is a key area of attention for hospital foodservice operators. New South Wales (NSW) Health, for example, provides meals to patients, staff and visitors within the NSW Health System, which is a large and complex operation that is providing over 40 million meals a year at a cost of around $300M. Similarly, the state of Victoria produces 10 million meals per annum with a provision for meal costs of around $90 million (NSW Health, 2006).

Current cost and technology trends have a direct impact on the quantity and quality of hospital foods. Hospitals are continuously reviewing their foodservice budgets and there are now serious pressures on foodservice managers to contain costs and improve the productivity of foodservice operations. The issue of maintaining high food quality in hospital kitchens is also a major issue due to its direct impact on patient recovery and health improvement. In the state of NSW, for example, around 1.5 million people suffer from food related illnesses (http://www.health.nsw.gov.au). The issue of food quality will also become more critical in the near future, where more patients will be at a nutritional risk due to the ageing Australian population. Thus, with high food quality awareness, hospitals will need to maintain a balance between lowering costs and at the same time maintaining high food quality.

In Australia, most health care foodservice operations are currently undertaking major reviews. In addition, a vigorous debate is taking place as to whether hospitals still require internal foodservice operations, or should outsource food production to commercial food

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companies, which are able to produce food in bulk and at competitive prices. Internal foodservice operations undoubtedly offer hospitals greater flexibility, especially in relation to the range of menu options and quality of food production.

However, the pressure continues on foodservice managers to ensure that these benefits do not come at an extra cost. Any inefficient operation is simply not sustainable. For example, many hospitals in Queensland are currently buying frozen foods from commercial suppliers and only producing minimal quantities of food items in-house. The Australian heath care foodservice industry has also experienced rapid technological and organisational change over the last few years. On the technological side, the introduction of new cooking technologies and the updating of existing cooking and reheating equipment has necessitated capital investment of millions of dollars. For example, the introduction of cook-chill technology at Westmead Hospital in New South Wales costed around $10 million. Organisational changes are also evident. Most area health services in all the states are currently restructuring the number and location of central production units in order to minimise the wastage that results from oversupply in inefficient foodservice operations. Finding one or two central production units in each health care area producing food and delivering meals to smaller hospitals is common.

In view of the current industry and economic trends, the importance of efficiency is therefore quickly increasing. The success of health foodservice operations in the future is essential in order to ensure that the health care sector is able to respond to an increasing number of patients and emerging nutritional and quality trends. The surprising fact, however, is that this topic is receiving little attention in the literature. Assaf and Matawie (in press) discuss the efficiency of Australian health care foodservice operations. However, they do not address the question of whether efficiency is changing over time, which is important to policy makers in the health care foodservice industry. Most efficiency measurements in this area also consist of simple productivity measures or restricted parametric techniques, which do not provide a comprehensive assessment of performance.

These and other factors relating to the operational benefits of performance measurement drive the current research which aims to provide a clearer picture of the efficiency of health care foodservice operations, and to address the improvement in efficiency over the last few years. The study also aims to assist health care foodservice managers in identifying important factors related to cost containment and productivity improvements in their operations. In doing so, the paper is the first to apply a stochastic production frontier model with panel data to the area of health care foodservice operations.

In the efficiency literature, the methods available to measure efficiency include non-parametric and parametric approaches. Data envelopment analysis (DEA) is the most common non-parametric approach. The main disadvantage of the DEA technique is its deterministic nature, which does not take into account the error of measurement. This is an important drawback as it can lead to an overestimation of efficiency results. Many researchers overcome this problem by using the bootstrapping method, which provides a suitable way to analyse the sensitivity of efficiency scores relative to the sampling variations. This paper uses the Bayesian stochastic frontier approach to estimate the efficiency of health care foodservice operations. The stochastic frontier model takes into account the error of measurement in estimating efficiency and thus provides a more reliable efficiency measurement, especially in the case of panel data. A number of statistical tests, which enable testing the validity of the model and the reliability of the results, are also available.

The maximum likelihood method is usually the most popular estimation method for deriving parameter estimates of the stochastic frontier model (for examples see Chow and Yiu Fung, 1997; Giokas, 2008; Lio and Donthu, 2003; Rezitis, 2008). One advantage of the Bayesian estimation method lies in its ability to express the results in terms of probability density functions, and to make probability statements about the unknown parameters, hypotheses and models. Additionally, the sampling theory inferences in stochastic frontier models are based on asymptotic standard errors, whereas the Bayesian estimation is more reliable when working with finite samples. 'Prior' information about the parameters of the model is also possible. For a more detailed discussion of the advantages of the Bayesian methodology, see Koop et al. (1995). This paper applies the Bayesian methodology to the estimation of the stochastic frontier panel model, with time varying assumption. Later sections of the paper provide the specific details of the methodology and estimation method.

The paper proceeds as follows. Sections 2 and 3 provide a discussion of the methodology, and Section 4 presents results from the model estimation. Section 5 provides further discussion of the results and the conclusion summarises the results and provides directions for future research.

2. The panel stochastic frontier model

2.1. Traditional production frontier

Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) introduced the stochastic frontier model to the efficiency literature. The main contribution of this model is that it introduces to the traditional regression model an additional error term associated with the technical inefficiency of producers. Eq. (1) presents the panel stochastic production frontier:

$$y_{it} = x_{it}'\beta + v_{it} - e^{-\gamma(t-T)}u_i,$$
$$v_{it} \overset{IID}{\sim} N\left(0, \sigma_v^2\right), u_i \overset{IID}{\sim} \left|N\left(0, \sigma_u^2\right)\right| \quad (1)$$
$$i = 1, \ldots, n,\ t = 1, \ldots, T,$$

where y_{it} represents the production level for a firm "i" at a period "t", x_{it}represents a vector of inputs, β is a parameter vector to be estimated, v_{it} is a random error identically and independently distributed, and u_{it} is a random error identically and independently distributed which captures the level of technical inefficiency in production and ensures that each firm's technical efficiency lies on or below the frontier model. The estimation of the model usually follows the maximum likelihood method, using the following parameterization:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \lambda = \sigma_u^2 / \sigma_v^2. \quad (2)$$

After estimating the model parameters, the estimation of technical efficiency then follows. One of the most popular measures of technical efficiency is the ratio of observed output to the stochastic frontier output:

$$TE_i = \frac{\exp(X_{it}\beta + v_{it} - u_{it})}{\exp(X_{it}\beta + v_{it})} = \exp(-u_{it}). \quad (3)$$

Information about individual inefficiency can be obtained by extracting the information that the error term ($\varepsilon_{it} = v_{it} - u_{it}$) contains on u_{it}. Imposing certain restrictions on the model in Eq. (1) can also result in different model combinations (for specific details see Coelli et al., 1998). For example, in the case of panel data, the efficiency can follow time invariant or time varying assumptions. This paper adopts the time varying approach. The time invariant model is generally not popular in the literature as it is restrictive and assumes efficiency is