Stochastic Frontier Analysis and Cancer Survivability

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INTRODUCTION

In this globalized and highly competitive, industries are successful and profitable when their operations are technically efficient. The managers and applied economists are periodically checking the pertinent data to confirm that the production in their industry is technically efficient and cost effective. The *stochastic frontier analysis* (SFA) is a statistical approach to make an assessment of the technical efficiency of chosen industries in the comparison pool. The SFA is based on a *linear model* connecting the observed production or cost variable, a bunch covariates to predict the prediction or cost using regression concepts and two error components. What is error component? The discrepancy between an observed and its prediction is defined the error. The usual regression methodology involves just one error component to indicate the *random noises* which influence the observable.

The SFA is a generalization of the regression methodology because of the two error components. In SFA, the second error is accommodated to portray the *technical inefficiency* (TE) of the production operation and it could have an impact on the observable. These two error components, namely the random noise and the technical inefficiency do not have to be statistically independent but are assumed to be independent in SFA. The expected values of the observable in the presence and in the absence of the technical inefficiency are involved to make an *efficiency score* of the operation of each industry in the comparison pool. This wonderful seminal thinking was promoted first by Meeusen et al. (1977) and independently by Aigner et al. (1977) within a month. The details are explained and illustrated later in the chapter.

The SFA is not the only methodology available to compare units. There is an alternate but nonparametric methodology to SFA and it is called *Data Envelopment Analysis* (DEA). Later, this chapter investigates the advantages versus disadvantages of SFA and DEA in order to compare a *decision making units* (DMUs) with an example about survivability from the melanoma cancer in nations around the world. The chapter briefly describes the differences between the DEA and SFA. The study of the melanoma cancer data is interesting from the point of view of learning SFA and DEA as well. The healthcare researchers are so far not fond of these two powerful methodologies. The SFA methodology is formally introduced, explained and then used to comprehend the survival chance without melanoma cancer due to ultra violet radiation for residents in 45 nations around the world. In contrast to the DEA which is a deterministic methodology, the SFA is a stochastic methodology. The SFA is a powerful, parametric methodology and it is valuable to sort out big data, to bring forth essential information and to contrast DMUs.

The basis of the comparison in SFA is called *technical efficiency.* This is done using an underlying statistical distribution for the given data. As demonstrated in this article, most often the given data follows normal distribution and it is confirmed using what is known as *Box plot.* The technical efficiency of the SFA is comparable to the *relative efficiency* of the DEA which makes use of the mathematical programming concept. Both SFA and DEA have advantages versus disadvantages though they are alternate to each other.

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In the application of SFA, the data are required to have stochastic components. In the application of DEA, the data are assumed to be deterministic type. The SFA is explained and is illustrated using a stochastic data of 45 nations with their *latitude, amount of falling ultra violet, survival rate among men and women from melanoma cancer* around the world in 2003.

BACKGROUND OF THE STOCHASTIC FRONTIER ANALYSIS

The concept of efficiency is much needed and often practiced criterion in the business world. In general, the efficiency in the business setting means attaining more productivity with a utilization of fewer resources. The productivity refers the outputs which includes services rendered to the customers, items manufactured etc. The resources often refer the number of employees hired, the raw materials to be used, the consumed time, or the available amount in the budget for the project etc. There is a hidden connection between the uncertain inputs and the uncertain outputs in any stochastic system including manufacturing situation. The hidden connections are well understood with the concepts which were initiated to compare production efficiency of manufacturing units. The units in the comparison are technically called DMUs. The inefficiencies could be from several factors but the factors have to be identified in terms of the: *technical, location, scale, and scope* factors. The Technical Efficiency (TE) arises when a DMU does not maximize its output given it uses a collection of inputs.

For an example, if a hospital has employed a combination of physicians, nurses, pharmacists, support staffs and utilizes several buildings, money, drugs, emergency transportations etc. among the resources (as inputs), how should its efficiency of operation be assessed? To capture the meaning of the hospital's inefficiency, suppose that the hospital is capable of serving more than 1,000 patients (which should be treated as outputs) served only 800 patients. Then; the hospital ought to be considered about 20% inefficient or 80% efficient. This is the basis of both SFA and DEA. Such inefficiency results in because the DMUs do not make use of the least amount of resources to produce maximum amount of outputs. This occurs when the ratio of the marginal price of the capital to the actual price of the capital is not equal to the ratio of the marginal price of the labor to the price of the labor in economic terms. The *scale inefficiencies* occur when the DMU fails to produce at the minimum point of its long-run average cost curve. When this occurs, the DMUs are said to be operating at a low point on their long-run average cost curve where either increasing returns (i.e., the DMU is too small) or decreasing returns (i.e., the DMU is too large) exist. Thus, the scale inefficiencies are reflective of the size of the DMU. The *scope inefficiencies* are due to the DMU's inability to reap the advantages that sometimes occur in the joint production of the outputs which require similar inputs. For an example, the hospital has chosen to provide both the adult and pediatric care service in the same general hospital with a minimal resource, and then the hospital as the DMU would have increased its efficiency. Such an operation would reflect an increased scope of the DMU's operations.

Farrell's (1957) defined the TE and pioneered the basic development of the stochastic frontier methodology to estimate the relative TE of the DMUs. Is a DMU operating efficiently? The answer to this question is vital to make an optimal decision. There are two options to make an optimal decision: (1) continue the operation when it is efficient or (2) terminate the operation until the reasons and remedies of its inefficient operation are found. So, what is efficiency? Like in the DEA, the SFA defines efficiency based on a ratio of the weighted sum of outputs to another weighted sum of inputs. Unlike the DEA which is a deterministic type, the SFA is a statistical procedure in which the inputs and outputs are stochastic and assumed to follow a probability pattern. When the *technical efficiency* (TE) score is one,