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Efficiency Estimates of Health Care Systems and their Comparative Study across Countries

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Abstract

Today and every day, the lives of vast numbers of people lie in the hands of health systems. From the safe delivery of a healthy baby to the care with dignity of the frail elderly, health systems have a vital and continuing responsibility to people throughout the lifespan. They are crucial to the healthy development of individuals, families and societies everywhere. Performance of health systems has been a major concern of policy makers for many years. Many countries have recently introduced reforms in the health sector with the explicit aim of improving performance. This study uses a comprehensive battery of models with different combinations of input and output variables. Outputs are the commonly reported health outcome indicators, such as life expectancy, healthy life expectancy and health care attainment and Inputs include (per capita) expenditure on health care and educational attainment.

Keywords: Health Care Attainment; DEA; Stochastic Model; Efficiency

Introduction:

The application of efficiency concepts to health care systems is challenging, raising both theoretical and practical problems. As an example, health care activities such as hospital discharges, are often seen as intermediate outputs (Jacobs et al., 2006), because health care activities do not necessarily have an immediate impact on improving health outcomes, which is what patients and practitioners are looking for. In practice, the relation between inputs, (intermediate) outputs and health outcomes is complex and multifaceted. Inputs and outputs differ in often inadequately measured dimensions, such as on quantity and quality, while health outcomes are also affected by past and current lifestyle behavior and environmental factors outside the immediate control of the health system. Also, data availability is rather limited over time and across country, restricting the use of different models, and thereby making the assessment of relative health efficiency challenging.

Despite the empirical difficulties in applying efficiency concepts to health systems, there is a considerable body of evidence at both the macro and micro levels on the pervasiveness of inefficiency in the health sector. Many findings of wasteful use of resources have been reported in the empirical literature, inter alia: i) sub-optimal setups for delivery of care; ii) inefficient provision of acute hospital care; iii) fraud and corruption in health care systems; and iv) a sub-optimal mix of preventative versus curative care. Consequently, reducing inefficiencies can lead to

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substantial gains. Conversely, holding health outcomes at current levels, while increasing efficiency to the level of the best performing countries, would free-up a considerable amount of resources. This could help reducing the long term growth rate of health expenditure without compromising access to (quality) care, which is a major concern for policy makers.

The term efficiency means technical efficiency, implying the maximization of outputs for a given level of inputs (or the minimization of inputs for a given level of outputs). Outputs are commonly reported health outcome indicators, such as life expectancy and composite measure of health care attainment. Inputs may include expenditure per capita, physical inputs and environmental variables. The aim is to assess whether efficiency scores are robust (i.e. within a relatively narrow interval) across a comprehensive battery of models.

Overview of Empirical Evidence on Health Inefficiency:-

There is a considerable body of evidence at both the macro and micro levels on the pervasiveness of inefficiency in the health sector. Many findings of wasteful use of resources have been reported in the empirical literature, inter alia: i) sub- optimal setups for delivery of care; ii) inefficient provision of acute hospital care; iii) fraud and corruption in health care systems; iv) large unexplained variation in the quantity and quality of care across and within countries; and, v) a sub-optimal mix of preventative versus curative care. In this Section, some major empirical results are summarized.

Joumard *et al* .(2010) argue that institutional characteristics can have a significant impact on measured efficiency, suggesting that a reconfiguration of current policies, together with appropriate institutional reform could improve overall efficiency. Efficiency scores seem to be closely related to a number of institutional features of health systems, inter alia: i) the allocation of resources between in- and out-patient care; and, ii) the payment schemes or incentives for care providers. The 2010 EPC/EC Joint Report on Health Systems (European Commission, 2010) and a study on fiscal sustainability challenges (European Commission, 2014), including the health and long-term care areas, provide a vast number of concrete country-specific examples of potential inefficiencies, listing possible remedies. Examples of potential inefficiencies relate to: i) suboptimal mix between private and public funding; ii) mismatch of staff skills; iii) suboptimal provision of primary health care services; iv) unnecessary use of specialist and hospital care; v) too few day-case surgeries and missing concentration of hospital services; vi) deficiencies in general governance of health systems and lack of managerial skills; vii) insufficient data collection, IT use, and health technology assessment to improve decision making processes; and, viii) inadequate access to more effective health promotion and disease prevention.

Literature Review:-

Health expenditure in percentage of GDP has continued to rise in all countries over the past decades, despite sustained policy efforts to arrest this trend. Increased spending was accompanied in the past by improved health outcomes. However, according to **Joumard *et al***., (2010); **Heijink R. *et al*., (2015),** the degree of improvement in health outcomes varies considerably across countries . High spenders do not necessary rank high in terms of health outcomes. To measure the performance of countries on the basis of health expenditures the measure objective of this project and to asses this goal, many theories has been used details of which are given below:-

Efficiency:-

Efficiency is defined as the ratio of the observed level of attainment of a goal to the maximum that could have been achieved with the observed resources. Normally, outputs are zero when inputs are zero. In health, however, health levels would not be zero if there were no health expenditures—that is, no health systems. So to measure the contribution of the health system we have to determine what it achieves in excess of what would be achieved in its absence (the minimum). Accordingly, we define performance as the current level of population health, in excess of the estimated minimum, compared with the maximum achievable level of health given the inputs. Because of the similarity between performance and efficiency, we use the terms interchangeably.

Efficiency is the (often measurable) ability to avoid wasting materials, energy, efforts, money, and time in doing something or in producing a desired result. In a more general sense, it is the ability to do things well, successfully, and without waste. In more mathematical or scientific terms, it is a measure of the extent to which input is well used for an intended task or function (output). It often specifically comprises the capability of a specific application of effort to produce a specific outcome with a minimum amount or quantity of waste, expense, or unnecessary effort. Efficiency, of course, refers to very different inputs and outputs in different fields and industries.

Efficiency is very often confused with effectiveness. In general, efficiency is a measurable concept, quantitatively determined by the ratio of useful output to total input. Effectiveness is the simpler concept of being able to achieve a desired result, which can be expressed quantitatively but doesn't usually require more complicated mathematics than addition. Efficiency can often be expressed as a percentage of the result that could ideally be expected, for example if no energy were lost due to friction or other causes, in which case 100% of fuel or other input would be used to produce the desired result. This does not always apply, not even in all cases in which efficiency can be assigned a numerical value, e.g. not for specific impulse.

A common but confusing way of distinguishing between efficiency and effectiveness is the saying "Efficiency is doing things right, while effectiveness is doing the right things." This saying indirectly emphasizes that the selection of objectives of a production process is just as important as the quality of that process. This saying popular in business however obscures the more common sense of "effectiveness", which would/should produce the following mnemonic: "Efficiency is doing things right; effectiveness is getting things done." This makes it clear that effectiveness, for example large production numbers, can also be achieved through inefficient processes if, for example, workers are willing or used to working longer hours or with greater physical effort than

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in other companies or countries or if they can be forced to do so. Similarly, a company can achieve effectiveness, for example large production numbers, through inefficient processes if it can afford to use more energy per product, for example if energy prices or labor costs or both are lower than for its competitors. For example, one may measure how directly two objects are communicating: downloading music directly from a computer to a mobile device is more efficient than using a mobile device's microphone to record music sounds that come from a computer's speakers.

Efficiency is often measured as the ratio of useful output to total input, which can be expressed with the mathematical formula $r=P/C$, where P is the amount of useful output ("product") produced per the amount C ("cost") of resources consumed. This may correspond to a percentage if products and consumables are quantified in compatible units, and if consumables are transformed into products via a conservative process. For example, in the analysis of the energy conversion efficiency of heat engines in thermodynamics, the product P maybe the amount of useful work output, while the consumable C is the amount of high-temperature heat input. Due to the conservation of energy, P can never be greater than C, and so the efficiency r is never greater than 100% (and in fact must be even less at finite temperatures).

Efficiency of Health Care System:-

Decision makers are increasingly faced with the challenge of reconciling growing demand for health care services with available funds. Economists argue that the achievement of (greater) efficiency from scarce resources should be a major criterion for priority setting.

Efficiency measures whether healthcare resources are being used to get the best value for money. Health care can be seen an intermediate product, in the sense of being a means to the end of improved health. Efficiency is concerned with the relation between resource inputs (costs, in the form of labour, capital, or equipment) and either intermediate outputs (numbers treated, waiting time, etc) or final health outcomes (lives saved, life years gained, quality adjusted life years (QALYs)). Although many evaluations use intermediate outputs as a measure of effectiveness, this can lead to suboptimal recommendations. Ideally economic evaluations should focus on final health outcomes.

Economic Efficiency:-

Adopting the criterion of economic efficiency implies that society makes choices which maximize the health outcomes gained from the resources allocated to healthcare. Inefficiency exists when resources could be reallocated in a way which would increase the health outcomes produced.

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Technical Efficiency:-

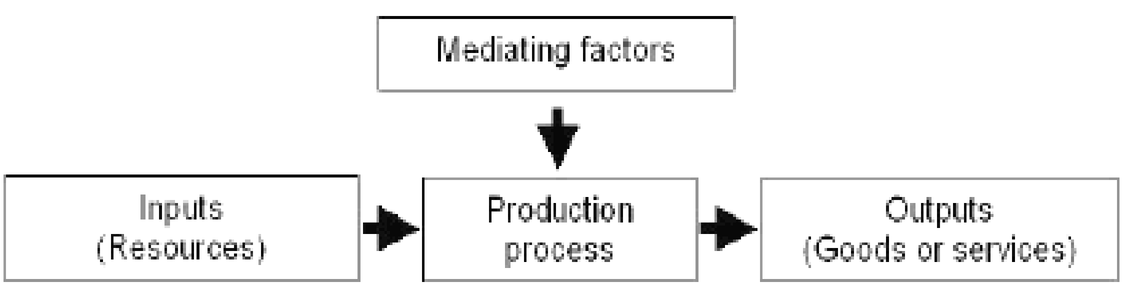
It refers to the physical relation between resources (capital and labour) and health outcome. A technically efficient position is achieved when the maximum possible improvement in outcome is obtained from a set of resource inputs. An intervention is technically inefficient if the same (or greater) outcome could be produced with less of one type of input. Consider treatment of osteoporosis using alendronate. A recent randomized trial showed that a 10 mg daily dose was as effective as a 20 mg dose. The lower dose is technically more efficient.

Productive Efficiency:-

Technical efficiency cannot, however, directly compare alternative interventions, where one intervention produces the same (or better) health outcome with less (or more) of one resource and more of another. Consider, for example, a policy of changing from maternal age screening to biochemical screening for Down‘s syndrome. Biochemical screening uses fewer amniocenteses but it requires the use of another resource—biochemical testing. Since different combinations of inputs are being used, the choice between interventions is based on the relative costs of these different inputs. The concept of productive efficiency refers to the maximization of health outcome for a given cost, or the minimization of cost for a given outcome. If the sum of the costs of the new biochemical screening program is smaller than or the same as the maternal age program and outcomes are equal or better, then the biochemical program is productively efficient in relation to the maternal age program. In health care, productive efficiency enables assessment of the relative value for money of interventions with directly comparable outcomes. It cannot address the impact of reallocating resources at a broader level—for example, from geriatric care to mental illness—because the health outcomes are incommensurate.

Allocative Efficiency:-

To inform resource allocation decisions in this broader context a global measure of efficiency is required. The concept of allocative efficiency takes account not only of the productive efficiency with which healthcare resources are used to produce health outcomes but also the efficiency with which these outcomes are distributed among the community.



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Such a societal perspective is rooted in welfare economics and has implications for the definition of opportunity costs. In theory, the efficient pattern of resource use is such that any alternative pattern makes at least one person worse off. In practice, strict adherence to this criterion has proved impossible. Further, this criterion would eliminate as inefficient changes that resulted in

many people becoming much better off at the expense of a few being made slightly worse off. Consequently, the following decision rule has been adapted: allocative efficiency is achieved when resources are allocated so as to maximize the welfare of the community.

Thus technical efficiency addresses the issue of using given resources to maximum advantage; productive efficiency of choosing different combinations of resources to achieve the maximum health benefit for a given cost; and allocative efficiency of achieving the right mixture of healthcare programmes to maximize the health of society. Although productive efficiency implies technical efficiency and allocative efficiency implies productive efficiency, none of the converse implications necessarily hold. Faced with limited resources, the concept of productive efficiency will eliminate as ―inefficient‖ some technically efficient resource input combinations, and the concept of allocative efficiency will eliminate some productively efficient resource allocations.

Health Economics:-

From a public health point of view, health economics is just one of many disciplines that may be used to analyze issues of health and health care, in particular as one of the set of analytical methods labelled health services research. But from an economics point of view, health economics is simply one of many topics to which economic principles and methods can be applied. So, in describing the principles of health economics, we are really setting out the principles of economics and how they might be interpreted in the context of health and health care. As Morris, Devlin and Parkin (2007) put it: ‗Health economics is the application of economic theory, models and empirical techniques to the analysis of decision-making by individuals, health care providers and governments with respect to health and health care.

There are many different definitions of economics, but a definition given in a popular introductory textbook by Begg, Fischer and Dornbusch, (2005) is instructive: ‗The study of how society decides what, how and for whom to produce'. In analyzing these issues, health economics attempts to apply the same analytical methods that would be applied to any good or service that the economy produces. However, it also always asks if the issues are different in health care.

Production, resources, scarcity and opportunity cost:-

The definition of economics above includes the term to produce, emphasizing that economics deals with both health and health care as a good or service that is manufactured, or produced. All production requires the use of resources such as raw materials and labour, and we can regard production as a process by which these resources are transformed into goods:

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The inputs to this productive process are resources such as personnel (often referred to as labour), equipment and buildings (often referred to as capital), land and raw materials. The output of a process using health care inputs – for example health care professionals, therapeutic materials and a clinic - could be, for example, an amount of health care of a given quality that is provided. How inputs are converted into outputs may be affected by other mediating factors, for example the environment in which production takes place, such as whether the clinic is publicly or privately owned.

The key observation of economics is that resources are known to be limited in quantity, but there are no known bounds on the quantity of outputs that is desired. This both acts as the fundamental driving force for economic activity and explains why health and health care can and should be considered like other goods. This issue, known as the problem of scarcity of resources means that choices must be made about what goods is produced, how they are to be produced and who will consume them. Another way to view this is that we cannot have all of the goods that we want and in choosing the basket of goods that we will have, we have to trade off one good for another.

The term economic goods is sometimes used to describe goods and services for which economic analysis is deemed to be relevant. These are defined as goods or services that are scarce relative to our wants for them. Health care is such an economic good: first, because the resources used to provide it are finite and we can only use more of these resources to create health care if we divert them from other uses; and secondly, because society‘s wants for health care, that is what society would consume in the absence of constraints on its ability to pay for it, have no known bounds. Nowhere in the world is there a health care system that devotes enough resources to health care to meet all of its citizens wants.

Model Used:-

DATA ENVELOPMENT ANALYSIS:-

Data envelopment analysis (DEA) is a nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (or DMUs). Although DEA has a strong link to production theory in economics, the tool is also used for benchmarking in operations management, where a set of measures is selected to benchmark the performance of manufacturing and service operations. According to **Cook, Tone and Zhu, (2014) ,** in the circumstance of benchmarking, the efficient DMUs, as defined by DEA, may not necessarily form a ―production frontier‖, but rather lead to a ―best-practice frontier . DEA is referred to as "balanced benchmarking" by **Sherman and Zhu (2013).**Non-parametric approaches have the benefit of not assuming a particular functional form/shape for the frontier, however they do not provide a general relationship (equation) relating output and input. There are also parametric approaches which are used for the estimation of production frontiers mentioned in paper **Lovell & Schmidt (1988) for an early survey**. These require that the shape of the frontier be guessed beforehand by specifying

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a particular function relating output to input. One can also combine the relative strengths from each of these approaches in a hybrid method by using paper of **Tofallis, (2001)** where the frontier units are first identified by DEA and then a smooth surface is fitted to these. This allows a best-practice relationship between multiple outputs and multiple inputs to be estimated.

According to **Berg (2010),** "The framework has been adapted from multi- input, multi-output production functions and applied in many industries. DEA develops a function whose form is determined by the most efficient producers. This method differs from the Ordinary Least Squares (OLS) statistical technique that bases comparisons relative to an average producer. Like Stochastic Frontier Analysis (SFA), DEA identifies a "frontier" which are characterized as an extreme point method that assumes that if a firm can produce a certain level of output

utilizing specific input levels, another firm of equal scale should be capable of doing the same. The most efficient producers can form a 'composite producer', allowing the computation of an efficient solution for every level of input or output. Where there is no actual corresponding firm, 'virtual producers' are identified to make comparisons".

Building on the ideas of **Farrell (1957)**, the seminal work "Measuring the efficiency of decision making units" by Charnes, Cooper & Rhodes (1978) applies linear programming to estimate an empirical production technology frontier for the first time. In Germany, the procedure was used earlier to estimate the marginal productivity of R&D and other factors of production. Since then, there have been a large number of books and journal articles written on DEA or applying DEA on various sets of problems. Other than comparing efficiency across DMUs within an organization, DEA has also been used to compare efficiency across firms. There are several types of DEA with the most basic being CCR based on Charnes, Cooper & Rhodes, however there are also DEA which address varying returns to scale, either CRS (constant returns to scale) or VRS (variable). The main developments of DEA in the 1970s and 1980s are documented by **Seiford & Thrall (1990).**

Data envelopment analysis (DEA) is a linear programming methodology to measure the efficiency of multiple decision-making units (DMUs) when the production process presents a structure of multiple inputs and outputs.

Berg (2010) stated that "DEA has been used for both production and cost data. Utilizing the selected variables, such as unit cost and output, DEA software searches for the points with the lowest unit cost for any given output, connecting those points to form the efficiency frontier. Any company not on the frontier is considered inefficient. A numerical coefficient is given to each firm, defining its relative efficiency. Different variables that could be used to establish the efficiency frontier are: number of employees, service quality, environmental safety, and fuel consumption. An early survey of studies of electricity distribution companies identified more than thirty DEA analyses indicating widespread application of this technique to that network industry. A number of studies using this technique have been published for water utilities. The main advantage to this method is its ability to accommodate a multiplicity of inputs and outputs.

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It is also useful because it takes into consideration returns to scale in calculating efficiency, allowing for the concept of increasing or decreasing efficiency based on size and output levels. A drawback of this technique is that model specification and inclusion/exclusion of variables can affect the results."

Under general DEA benchmarking, for example, "if one benchmarks the performance of computers, it is natural to consider different features (screen size and resolution, memory size, process speed, hard disk size, and others). One would then have to classify these features into ―inputs and ―outputs in order to apply a proper DEA analysis. However, these features may not actually represent inputs and outputs at all, in the standard notion of production. In fact, if one examines the benchmarking literature, other terms, such as indicators, outcomes, and metrics, are used.

Some of the advantages of DEA are:

1. No need to explicitly specify a mathematical form for the production function
2. Proven to be useful in uncovering relationships that remain hidden for other methodologies
3. Capable of handling multiple inputs and outputs
4. Capable of being used with any input-output measurement
5. The sources of inefficiency can be analyzed and quantified for every evaluated unit

Some of the disadvantages of DEA are:

6. Results are sensitive to the selection of inputs and outputs.
7. You cannot test for the best specification.
8. The number of efficient firms on the frontier tends to increase with the number of inputs and output variables.

A desire to Improve upon DEA, by reducing its disadvantages or strengthening its advantages has been a major cause for many discoveries in the recent literature.One such approach is the Stochastic DEA, which makes a synthesizes of DEA and SFA, improving upon their drawbacks.

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Applications and Example of DEA Model:-

1. DEA is commonly applied in the electric utilities sector. For instance a government authority can choose Data Envelopment Analysis as their measuring tool to design an individualized regulatory rate for each firm based on their comparative efficiency. The input components would include man-hours, losses, capital (lines and transformers only), and goods and services. The output variables would include number of customers, energy delivered, length of lines, and degree of coastal exposure. (Berg 2010)

2. DEA is also regularly used to assess the efficiency of public and not-for- profit organizations, e.g. hospitals (**Kuntz, Scholtes & Vera 2007, Kuntz & Vera 2007, Vera & Kuntz 2007)** or police forces **(Thanassoulis 1995, Sun 2002, Aristovnik *et al.* 2013, 2014)**

Stochastic Production Function:-

Stochastic production frontiers were initially developed for estimating technical efficiency rather than capacity and capacity utilization. However, the technique also can be applied to capacity estimation through modification of the inputs incorporated in the production (or distance) function. A potential advantage of the stochastic production frontier approach over DEA is that random variations in catch can be accommodated, so that the measure is more consistent with the potential harvest under normal working conditions. A disadvantage of the technique is that, although it can model multiple output technologies, doing so is somewhat more complicated, requires stochastic multiple output distance functions, and raises problems for outputs that take zero values **(Paul, Johnson and Frengley 2000)**.

The underlying theory:-

A production function defines the technological relationship between the level of inputs and the resulting level of outputs. If estimated econometrically from data on observed outputs and input usage, it indicates the average level of outputs that can be produced from a given level of inputs (Schmidt, 1986). A number of studies have estimated the relative contributions of the factors of production through estimating production functions at either the individual boat level or total fishery level. These include Cobb-Douglas production functions (**Hannesson 1983**), CES production functions (**Campbell and Lindner 1990**) and translog production functions (**Squires 1987, Pascoe and Robinson, 1998**).

An implicit assumption of production functions is that all firms are producing in a technically efficient manner, and the representative (average) firm therefore defines the frontier. Variations from the frontier are thus assumed to be random, and are likely to be associated with mis- or un-measured production factors. In contrast, estimation of the production frontier assumes that the boundary of the production function is defined by ―best practice‖ firms. It therefore indicates the maximum potential output for a given set of inputs along a ray from the origin point. Some

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white noise is accommodated, since the estimation procedures are stochastic, but an additional one-sided error represents any other reason firms would be away from (within) the boundary. Observations within the frontier are deemed inefficient, so from an estimated production frontier it is possible to measure the relative efficiency of certain groups or a set of practices from the relationship between observed production and some ideal or potential production (Greene, 1993).

A general stochastic production frontier model can be given by:

$$\ln q_j = f(\ln X) + v_j + u_j \quad (1)$$

where q_j is the output produced by firm j, x is a vector of factor inputs, v_j is the stochastic (white noise) error term and u_j is a one-sided error representing the technical inefficiency of firm j.

Given that the production of each firm *j* can be estimated as:

$$\ln \hat{q}_j = f(\ln X) - u_j \quad (2)$$

while the efficient level of production (*i.e.* no inefficiency) is defined as:

$$\ln q^* = f(\ln X) \quad (3)$$

then technical efficiency (TE) can be given by:

$$\ln TE_j = \ln \hat{q} - \ln q^* = -u_j \quad (4)$$

Hence $TE_j = e^{-uj}$ and is constrained to be between zero and one in value. If u_j equals zero, then TE equals one, and production is said to be technically efficient. Technical efficiency of the j^{th} firm is therefore a relative measure of its output as a proportion of the corresponding frontier output. A firm is technically efficient if its output level is on the frontier, which implies that q/q^* equals one in value.

While the techniques have been developed primarily to estimate efficiency, they can be readily modified to represent capacity utilization. In estimating the full utilization production frontier, a distinction must be made between inputs comprising the capacity base (usually capital inputs),

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and variable inputs (usually days, or variable effort). If capacity is defined only in terms of capital inputs, the implied variation in output, and thus variable effort, from its full utilization level is sometimes termed an indicator of capital utilization.

If variable inputs are assumed to be approximated by the number of hours or days fished (i.e. nominal units of effort), estimating the potential output producible from the capacity base with variable inputs unconstrained implies removing this variable from the estimation of the frontier. The resulting production frontier is thus defined only in terms of the fixed factors of production, or *K*. In particular, it will be supported by observations for the boats that have the greatest catch per unit of fixed input (which generally corresponds to the boats that employ the greatest level of nominal effort for a particular level of *K*). The resulting measure of technical efficiency is equivalent to the technically efficient capacity utilization (TECU); accommodating both the impacts of technical inefficiency and deviations from full utilization of the capacity base. That is, it represents the ratio of the potential capacity output that could be achieved if all fixed inputs were being utilized efficiently and fully to observed output.

Only limited attempts to estimate stochastic production frontiers for fisheries have been undertaken (**Kirkley, Squires and Strand, 1995, 1998, Coglan, Pascoe and Harris, 1999, Sharma and Leung, 1999, Squires and Kirkley, 1999; Pascoe, Andersen and de Wilde, 2001; Pascoe and Coglan, 2002**). These have focused upon an estimation of efficiency rather than capacity, although the capacity problem has recently been addressed by **Kirkley, Morrison and Squires (2001) and Tingley and Pascoe (2003)** using SPF procedures. The techniques used and problems encountered are similar, and distinction between the utilization and efficiency components - thus providing an unbiased estimate of capacity utilization requires first computing the more standard inefficiency measure.

Functional forms for the production function:

Estimation of the SPF requires a particular functional form of the production function to be imposed. A range of functional forms for the production function frontier are available, with the most frequently used being a translog function, which is a second order (all cross-terms included) log-linear form. This is a relatively flexible functional form, as it does not impose assumptions about constant elasticities of production nor elasticities of substitution between inputs. It thus allows the data to indicate the actual curvature of the function, rather than imposing *a priori* assumptions. In general terms, this can be expressed as:

$$\ln Q_{j,t} = \beta_0 + \sum_i \beta_i \ln X + \frac{1}{2}\sum_i \sum_j \sum_k \beta_j \ln X_{j,i,t} \ln X_{j,k,t} - u_{j,t} - v_{j,t} \tag{5}$$

Where $Q_{j,t}$ is the output of the vessel j in period t and $X_{j,i,t}$ and $X_{j,k,t}$ are the variable and fixed vessel inputs (i,k) to the production process. As noted above, the error term is separated

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into two components, where $v_{j,t}$ is the stochastic error term and $u_{j,t}$ is an estimate of technical inefficiency.

Alternative production functions include the Cobb-Douglas and CES (Constant Elasticity of Substitution) production functions. The Cobb-Douglas production function is given by:

$$\ln Q_{j,t} = \beta_0 + \sum_i \beta_i \ln X_{j,i,t} - u_{j,t} + v_{j,t} \tag{6}$$

As can be seen, the Cobb-Douglas is a special case of the translog production function where all $b_{i,k} = 0$. The production function imposes more stringent assumptions on the data than the translog, because the elasticity of substitution has a constant value of 1 (i.e. the functional form assumption imposes a fixed degree of substitutability on all inputs). And the elasticity of production is constant for all inputs (i.e. a 1 percent change in input level will produce the same percentage change in output, irrespective of any other arguments of the function).

The CES production function is given by:

$$Q_{j,t} = \left[\delta X_{j,i,t} + (1-\delta) X_{2,j,t}\right]^{-1/\theta} - u_{j,t} + v_{j,t} \tag{7}$$

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where q_j is the substitution parameter related to the elasticity of substitution (i.e. $q = \frac{1}{s} - 1$ where s is the elasticity of substitution) and d is the distribution parameter. The CES production function is limited to two variables, and is not possible to estimate in the form given in (7) in maximum likelihood estimation (MLE) (making it unsuitable for use as the basis of a production frontier). However, a Taylor series expansion of the function yields a functional form of the model that can be estimated.

Given that both the Cobb-Douglas and CES production functions are special cases of the translog, ideally the translog should be estimated first and the restrictions outlined above, tested. However, the large number of variables required in the process of estimating the translog may cause problems if a sufficient data series is not available, resulting in degree of freedom problems. In such a case, more restrictive assumptions must be imposed.

Data and Methodology:-

Data Source:- http://people.stern.nyu.edu/wgreene

Data Description:-

These data are a country-level panel on health care attainment. The two main variables of interest are disability-adjusted life expectancy (DALE) and composite health attainment (COMP). The former is a standard variable used to measure health care attainment. The latter is an innovative survey-based measure created by the researchers at WHO. The health attainments are viewed as the outputs of a production (function) process and were modeled in this fashion by WHO (2000) and Greene (2004b). Two input variables are health expenditure (HEXP) and education levels (EDUC). There are a number of other covariates in the data set that I view as shifters of the production function or as influences on the level of inefficiency, but not direct inputs into the production process. The data are measured for five years, 1993–1997. However, only COMP DALE, HEXP, and EDUC actually vary across the years; the other variables are time invariant, dated 1997. In addition, as discussed by **Gravelle et al. (2002a, 2002b)**, among others, there is relatively little actual time (within country) variation in these data; the within-groups variation for the time-varying variables accounts for less than 2% of the total. This rather limits what can be done in terms of panel-data analysis. However, in spite of this limitation, this data set provides an interesting platform for placing heterogeneity in a stochastic frontier model. [The examples to follow will build on Greene (2004b).] The WHO data are described as

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World Health Organization Data on Health Care Attainment

Variable	Mean	SD	Description
COMP	75.00627	12.20511	Composite health care attainment
DALE	58.30827	12.14426	Disability-adjusted life expectancy
HEXP	548.2149	694.2162	Health expenditure per capita, PPP units
EDUC	6.317537	2.733706	Education, years
WBNUMBER	138.9893	79.83586	World Bank country number
COUNTRY	97.34218	54.08107	Country number omitting internal units
OECD	0.279762	0.44915	OECD member country, dummy variable
SMALL	0.37381	1.202215	Zero or number if internal state or province
YEAR	1995.213	1.424649	Year (1993–1997) (T = year— 1992; Tyy = year dummy variable)
GDPC	8135.108	7891.2	Per capita GDP in PPP units
POPDEN	953.1194	2871.843	Population density per square Kilometer
GINI	0.379478	0.090207	Gini coefficient for income inequality
TROPICS	0.463095	0.498933	Dummy variable for tropical location
PUBTHE	58.15536	20.23408	Proportion of health spending paid by government
GEFF	0.113294	0.915984	World bank government effectiveness
VOICE	0.192625	0.952226	World bank measure of democratization

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Some of the variables listed in table above (e.g., PUBTHE, SMALL) are not used here but are listed as a guide for the reader. These data and the issue they address have been analyzed and discussed widely by researchers at many sites. **Greene (2004b)** is part of that discussion. I do not replicate any of these studies here. Rather, we will use a subset of the data set (actually, most of it) to examine a few additional models that were not estimated above. Note some features of the data set and analysis: First, the WHO data consist of an unbalanced panel on 191 countries plus a large number of smaller political units (e.g., states of Mexico, Canadian provinces); 140 of the countries were observed in all five years (1993–1997), one (Algeria) was observed in four years, and the remaining units were all observed once, in 1997. Purely for convenience and for purposes of our pedagogy here, we will limit our attention to the balanced panel of the 140 countries observed in all five years. Second, given that the outcome variables in the model (life expectancy and composite health care attainment) are not obviously quantitative measures such as cost or physical output units, the numerical values of efficiency measures *(uit)* have ambiguous meaning.

Indicator Details:-

These indicators have been taken to analyse the performance of health of different countries. Name of the selected indicators are given below:

1. Composite measure of health care attainment
2. Disability adjusted life expectancy
3. Per capita health expenditure
4. Educational attainment
5. Gini coefficient for income inequality
6. Population density
7. Proportion of health expenditure paid by public authorities

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Results and Discussion:-For Year 1993:-

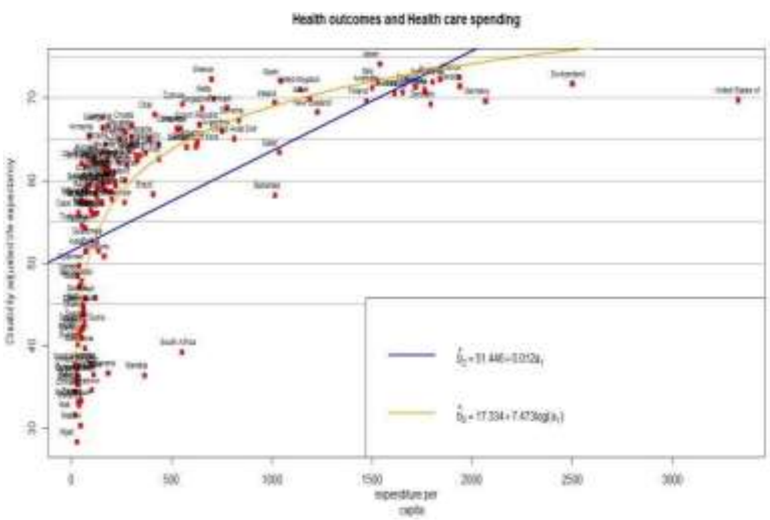

Fig. 5.1 Graph between health Outcomes and Health Care spending for year 1993

Data Envelopment Analysis(for 1993):

The technology is vrs and input orientated efficiency

Numbers of firms with efficiency==1 are 30

Mean efficiency: 0.735

Table5.2.Ranking of countries on the basis of their performances (Efficiencies) for health expenditure in the year 1993

These countries are ranked according to increasing order of efficiency. From the table, it is evident that South Africa has lowest efficiency (i.e. 0.2368150) and countries like Armenia, Benin, Chile,

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China(g), Colombia, Cape Verde, Spain, Ethiopia, France, Georgia, Greece, Croatia, Indonesia, Italy, Jamaica, Japan, Kazakhstan, Sri-Lanka, Morocco, Mali, Malta, Mozambique, Niger, Oman, Philippines, Poland, Senegal, Singapore, Ukraine and Yemen have maximum efficiency which is 1.This implies that South Africa is not able to spend his money efficiently to improve health of his countrymen. On the other hand all countries who have maximum efficiency have implemented their health policy efficiently.

Frontier Production Analysis (for 1993):

Country	Rank	Country	Rank	Country	Rank	Country	Rank
South Africa	1	New Zealand	36	United Arab Emir	71	Malaysia	106
Swaziland	2	United Republic	37	Honduras	72	Romania	107
Congo	3	Mexico	38	Tunisia	73	Egypt	108
Bahamas	4	Barbados	39	Republic of Mold	74	Cyprus	109
Lesotho	5	Kenya	40	Israel	75	Slovakia	110
Namibia	6	Estonia	41	Guyana	76	Armenia	111
Botswana	7	Latvia	42	Venezuela	77	Benin	111
Tajikistan	8	Uruguay	43	Thailand	78	Chile	111
Zimbabwe	9	Ireland	44	Switzerland	79	China (g)	111
Maldives	10	Hungary	45	Sweden	80	Colombia	111
Malawi	11	Nigeria	46	Burundi	81	Cape Verde	111
Zambia	12	Bulgaria	47	Jordan	82	Spain	111
Equatorial Guine	13	Bahrain	48	Costa Rica	83	Ethiopia	111
Peru	14	Slovenia	49	Lebanon	84	France	111
Samoa	15	Kuwait	50	Guatemala	85	Georgia	111
Mauritania	16	Guinea-Bissau	51	Sudan	86	Greece	111
Cameroon	17	Belarus	52	Nicaragua	87	Croatia	111
Haiti	18	Cote d'Ivoire	53	Belgium	88	Indonesia	111
Russian Federati	19	Uzbekistan	54	Myanmar	89	Italy	111
Ghana	20	Gambia	55	Turkey	90	Jamaica	111
Bolivia	21	India	56	El Salvador	91	Japan	111
Argentina	22	Trinidad and Tob	57	Burkina Faso	92	Kazakhstan	111
Rwanda	23	Czech Republic	58	Lithuania	93	Sri Lanka	111
Panama	24	Denmark	59	Netherlands	94	Morocco	111
Brazil	25	Turkmenistan	60	Iceland	95	Mali	111
Republic of Kore	26	Iran (Islamic Re	61	Saudi Arabia	96	Malta	111
Mauritius	27	Syrian Arab Repu	62	Central African	97	Mozambique	111
Qatar	28	Iraq	63	Bangladesh	98	Niger	111
Togo	29	Finland	64	Luxembourg	99	Oman	111
Tonga	30	Canada	65	Portugal	100	Philippines	111
Fiji	31	Uganda	66	Austria	101	Poland	111
United States of	32	Viet Nam	67	Dominican Republ	102	Senegal	111
Ecuador	33	Nepal	68	United Kingdom	103	Singapore	111
Pakistan	34	Germany	69	Norway	104	Ukraine	111
Comoros	35	Australia	70	Paraguay	105	Yemen	111

Cobb-Douglas Stochastic Production Frontier Model with Time-Invariant Effect- $\ln(\text{health})_{it} = \alpha + \beta_1 \ln(\text{HEXP})_{it} + \beta_2 \ln(\text{HC3})_{it} + \beta_3 \ln(\text{GINI})_{it} + \beta_4 \ln(\text{POPDEN})_{it}$

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$+ \beta_3 \ln(PUBTHE)_{it} + v_{it} - u_{it}$

Or

$\ln(health)_{it} = \alpha + \beta_1 \ln(a_1)_{it} + \beta_2 \ln(a_2)_{it} + \beta_3 \ln(a_3)_{it} + \beta_4 \ln(a_4)_{it} + \beta_3 \ln(a_5)_{it} + v_{it} -$

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Table 5.3.1 Maximum likelihood estimates

Variables	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	4.117726	0.992413	4.1492	3.336e-05
log(a_1)	0.042755	0.696813	0.0614	0.9511
log(a_2)	0.101241	0.970737	0.1043	0.9169
log(a_3)	-0.134163	0.988702	-0.1357	0.8921
log(a_4)	-0.010518	0.598274	-0.0176	0.986
log(a_5)	-0.02334	0.863718	-0.027	0.9784
Sigma Sq	0.279478	0.993244	0.2814	0.7784
Gamma	0.970103	0.719384	1.3485	0.1775

Log likelihood value: 0.5353154
Cross-sectional data

Total number of observations = 140

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Mean efficiency: 0.8094321

Table 5.3.2 Ranking of countries on the basis of their performances (Stochastic Production Frontier efficiency with Time-Invariant Effect) for Health expenditure in the year 1993

Country	Rank	Country	Rank	Country	Rank	Country
Ireland	1	Bulgaria	36	India	71	Nicaragua
Myanmar	2	Belarus	37	Qatar	72	Cape Verde
Nigeria	3	Burundi	38	Slovenia	73	
Namibia	4	Guyana	39	Estonia	74	Venezuela
Central African	5	Samoa	40	Iceland	75	Netherlands
Congo	6	Slovakia	41	Brazil	76	Thailand
Botswana	7	Haiti	42	El Salvador	77	Bahrain
Malawi	8	Latvia	43	Austria	78	Israel

Rwanda	9	Uzbekistan	44	Norway	79	France
South Africa	10	Peru	45	Republic of Mold	80	Indonesia
Mauritania	11	Syrian Arab Repu	46	Iran (Islamic Re	81	Italy
Zambia	12	Uganda	47	Comoros	82	Cyprus
Mozambique	13	Sudan	48	Jordan	83	Spain
Swaziland	14	Armenia	49	Lithuania	84	Jamaica
Equatorial Guine	15	Finland	50	Lebanon	85	Greece
Lesotho	16	Mali	51	United Arab Emir	86	Paraguay
Viet Nam	17	Romania	52	Belgium	87	Benin
Tajikistan	18	Ecuador	53	Croatia	88	Portugal
Cameroon	19	Uruguay	54	Russian Federati	89	Costa Rica

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Guinea-Bissau	20	Bolivia	55	Germany	90	Dominican Republ
Nepal	21	New Zealand	56	Bangladesh	91	Guatemala
Ethiopia	22	Tonga	57	Ukraine	92	Oman
Gambia	23	China (g)	58	Canada	93	United Kingdom
Ghana	24	Sweden	59	Switzerland	94	Morocco
Turkmenistan	25	Egypt	60	Tunisia	95	Senegal
Georgia	26	Kenya	61	Luxembourg	96	Barbados
Niger	27	Denmark	62	United States of	97	Kazakhstan
Maldives	28	Fiji	63	Turkey	98	Mexico
United Republic	29	Czech Republic	64	Mauritius	99	Malta
Pakistan	30	Burkina Faso	65	Argentina	100	Malaysia

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Cote d'Ivoire	31	Republic of Kore	66	Trinidad and Tob	101	Chile
Togo	32	Panama	67	Japan	102	Philippines
Zimbabwe	33	Iraq	68	Poland	103	Singapore
Bahamas	34	Hungary	69	Australia	104	Saudi Arabia
Honduras	35	Yemen	70	Sri Lanka	105	Colombia

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These countries are ranked according to increasing order of efficiency. From the table, it is evident that Ireland has lowest efficiency (i.e. 0.01124364) and Colombia has highest efficiency (i.e. 0.93252364). Ireland is a cold European country and here it has lowest efficiency because of their climate condition and also shows that its health policy is not in proper manner. As a developed country it is a serious issue for Iceland. On the other hand all countries who have high efficiency like United Kingdom, Morocco, Senegal, Barbados, Kazakhstan, Mexico, Malta, Malaysia, Chile, Philippines, Singapore, Saudi Arabia and Colombia have implemented their health policy efficiently.

For Year 1997:-

Graph between health Outcomes and Health Care spending for year 1997

Data Envelopment Analysis(for 1997):

The technology is vrs and input orientated efficiency Numbers of
firms with efficiency==1 are 30

Mean efficiency: 0.752

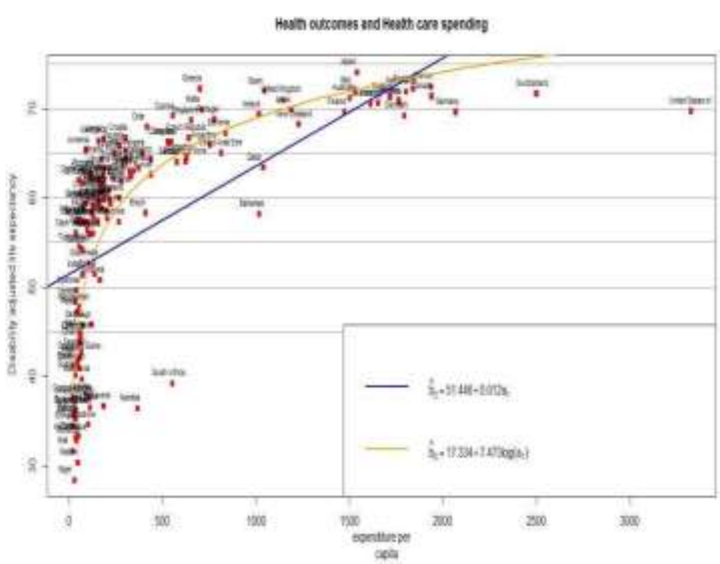

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Table.5.5.1.Ranking of countries on the basis of their performances (Efficiencies) for health expenditure in the year 1997

Country	Rank	Country	Rank	Country	Rank	Country	Rank
South Africa	1	Myanmar	36	Australia	71	Colombia	106
Swaziland	2	Iraq	37	United Arab Emir	72	Malaysia	107
Botswana	3	Kenya	38	Samoa	73	Chile	108
Congo	4	Kuwait	39	El Salvador	74	Guatemala	109
Lesotho	5	Barbados	40	Nicaragua	75	Norway	110
Namibia	6	Bulgaria	41	Venezuela	76	Armenia	111
Bahamas	7	Romania	42	Thailand	77	Burundi	111
Maldives	8	Republic of Mold	43	Turkey	78	Benin	111
Equatorial Guine	9	Nigeria	44	Honduras	79	China (g)	111
Lebanon	10	Rwanda	45	Nepal	80	Cape Verde	111
Zambia	11	Jordan	46	Viet Nam	81	Cyprus	111
Cameroon	12	Denmark	47	Belgium	82	Spain	111
Zimbabwe	13	Gambia	48	Switzerland	83	Ethiopia	111
Peru	14	New Zealand	49	Sweden	84	France	111
Russian Federati	15	Slovenia	50	Hungary	85	United Kingdom	111
Mauritania	16	Guyana	51	Togo	86	Georgia	111
Turkmenistan	17	Guinea-Bissau	52	Burkina Faso	87	Greece	111
Argentina	18	Iran (Islamic Re	53	Luxembourg	88	Croatia	111

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Mauritius	19	Uzbekistan	54	Sudan	89	Indonesia	111
Malawi	20	India	55	Netherlands	90	Italy	111
Panama	21	Uganda	56	Iceland	91	Jamaica	111
Tonga	22	Syrian Arab Repu	57	Ireland	92	Japan	111
Bolivia	23	Slovakia	58	Paraguay	93	Sri Lanka	111
Tajikistan	24	Mexico	59	Kazakhstan	94	Morocco	111
Uruguay	25	Pakistan	60	Ghana	95	Mali	111
Brazil	26	Israel	61	Costa Rica	96	Malta	111
Fiji	27	Central African	62	Comoros	97	Mozambique	111
Latvia	28	Belarus	63	Dominican Republ	98	Niger	111
Qatar	29	Estonia	64	Lithuania	99	Oman	111
Cote d'Ivoire	30	United Republic	65	Saudi Arabia	100	Philippines	111
United States of	31	Tunisia	66	Portugal	101	Poland	111
Haiti	32	Finland	67	Austria	102	Senegal	111
Republic of Kore	33	Canada	68	Bangladesh	103	Singapore	111
Bahrain	34	Germany	69	Czech Republic	104	Ukraine	111
Ecuador	35	Trinidad and Tob	70	Egypt	105	Yemen	111

These countries are ranked according to increasing order of efficiency. From the table, it is evident that South Africa has lowest efficiency (i.e. 0.2487) and countries like Armenia, Burundi, Benin, China(g), Cape Verde, Cyprus, Spain, Ethiopia, France, United Kingdom, Georgia, Greece, Croatia, Indonesia, Italy, Jamaica, Japan, Sri-Lanka, Morocco, Mali, Malta, Mozambique, Niger, Oman and Philippines have maximum efficiency which is 1.This implies that in this year South Africa is also not able to spend his money efficiently to improve health of his countrymen. On the other hand all countries who have maximum efficiency have implemented their health policy efficiently.

Frontier Production Analysis (for 1997)

Cobb-Douglas Stochastic Production Frontier Model with Time-Invariant Effect- $\ln(\text{health})_{it} = \alpha + \beta_1 \ln(\text{HEXP})_{it} + \beta_2 \ln(\text{HC3})_{it} + \beta_3 \ln(\text{GINI})_{it} + \beta_4 \ln(\text{POPDEN})_{it}$

$+ \beta_3 \ln(\text{PUBTHE})_{it} + v_{it} - u_{it}$

Or

$\ln(\text{health})_{it} = \alpha + \beta_1 \ln(a_1)_{it} + \beta_2 \ln(a_2)_{it} + \beta_3 \ln(a_3)_{it} + \beta_4 \ln(a_4)_{it} + \beta_3 \ln(a_5)_{it} + v_{it} -$

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Table 5.6.1 Maximum likelihood estimates

Variables	**Estimate**	**Std. Error**	**z value**	**Pr(>|z|)**
Intercept	3.8194664	0.0662905	57.6171	< 2.2e-16
log(a_1)	0.0702314	0.0061596	11.402	< 2.2e-16
log(a_2)	0.0778579	0.0121257	6.4209	1.36E-10
log(a_3)	-0.030723	0.0255309	-1.2034	0.2288
log(a_4)	0.0030233	0.0030329	0.9968	0.3188
log(a_5)	0.003152	0.0133422	0.2362	0.8132
Sigma Sq	0.0146711	0.0023238	6.3133	2.73E-10
Gamma	0.964752	0.0252959	38.1387	< 2.2e-16

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Log likelihood value: 175.388

Cross-sectional data

Total number of observations = 140

Mean efficiency: 0.9142405

The coefficient estimate of log(a_{01}) suggest that on an average a 1% increase in health expenditure per capita, expenditure per capita will increase the overall health performance by 0.070%. Similarly, price of purchased funds is 0.581%.

The coefficient estimate of log(a_{02}) suggest that on an average, a 1% increase in educational attainment by countries results in a 0.077% increase in the overall health performance.

Table.5.6.2.Ranking of countries on the basis of their performances (Stochastic Production Frontier efficiency with Time-Invariant Effect) for Health expenditure in the year 1997

Country	Rank	Country	Rank	Country	Rank	Country	Rank
Central African	1	Togo	36	Sweden	71	Lithuania	106
South Africa	2	Uganda	37	Slovenia	72	Cape Verde	107
Botswana	3	Nepal	38	Netherlands	73	Venezuela	108
Namibia	4	Argentina	39	Kuwait	74	Croatia	109
Myanmar	5	Gambia	40	Barbados	75	Comoros	110
Nigeria	6	El Salvador	41	Austria	76	Tunisia	111
Malawi	7	Haiti	42	Australia	77	Thailand	112
Zambia	8	Bolivia	43	Finland	78	Costa Rica	113
Lesotho	9	Panama	44	Bahrain	79	Georgia	114
Swaziland	10	Kenya	45	Fiji	80	Spain	115
Ethiopia	11	Qatar	46	Sudan	81	Poland	116
Mozambique	12	Iraq	47	Mexico	82	Greece	117

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Congo	13	Uruguay	48	Italy	83	Jamaica	118
Guinea-Bissau	14	Tonga	49	Uzbekistan	84	Yemen	119
Mauritania	15	Denmark	50	Armenia	85	Malta	120
Cameroon	16	Iran (Islamic Re	51	Belarus	86	Singapore	121
Rwanda	17	Pakistan	52	Syrian Arab Repu	87	Nicaragua	122
Equatorial Guine	18	Republic of Kore	53	Iceland	88	Saudi Arabia	123
Maldives	19	Germany	54	Japan	89	Egypt	124
Niger	20	Slovakia	55	Republic of Mold	90	Cyprus	125
Zimbabwe	21	Burundi	56	France	91	Colombia	126
Brazil	22	Switzerland	57	Czech Republic	92	Ukraine	127
Bahamas	23	Guyana	58	United Arab Emir	93	Chile	128
Viet Nam	24	Mauritius	59	Trinidad and Tob	94	Dominican Republ	129
Mali	25	Burkina Faso	60	Estonia	95	Kazakhstan	130
Peru	26	Latvia	61	Romania	96	Paraguay	131
Lebanon	27	Israel	62	Hungary	97	Benin	132
United States of	28	Ecuador	63	Turkey	98	Indonesia	133
Tajikistan	29	Canada	64	Norway	99	Guatemala	134
Russian Federati	30	Bulgaria	65	Jordan	100	Senegal	135
Turkmenistan	31	Luxembourg	66	Portugal	101	Malaysia	136
Cote d'Ivoire	32	Belgium	67	Ireland	102	Sri Lanka	137
China (g)	33	India	68	Bangladesh	103	Oman	138
Honduras	34	New Zealand	69	Samoa	104	Morocco	139
United Republic	35	Ghana	70	United Kingdom	105	Philippines	140

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These countries are ranked according to increasing order of efficiency. From the table, it is evident that in the year 1997, Central African has lowest efficiency (i.e. 0.7215371) and Philippines has highest efficiency (i.e. 0.9909982). On the other hand all countries who have high efficiency like Paraguay, Benin, Indonesia, Guatemala, Senegal, Malaysia, Sri-Lanka, Oman, Morocco and Philippines have implemented their health policy efficiently. For this year the efficiency of Ireland is much better than the year 1993 that means over a five year gap the health situation of Ireland is improve. In spite of the weather condition of Ireland is not good, it implement their health policy in right way.

Conclusion:-

Efficiency gains can be measured in two ways: either by increasing health outcomes, while keeping inputs at current levels (output-orientation), or by decreasing inputs, while keeping health outcomes at current levels (input- orientation). For countries with life expectancy at or above 80 years of age, input orientation appears to be the more relevant criterion, because of the low returns in terms of added years of life expectancy that can be gained by increasing resource use. Among countries with high life expectancy there are wide variations in per capita health care expenditure, which end up having only marginal effects on health outcomes.

By data envelopment analysis:

In 1993, average efficiency of all country is **0.735** and in 1997, average efficiency is **0.752**. That means over the gap of five year average efficiency increases.

Estimated efficiency varies from 0.25 to exactly 1, implying that although some countries may be close to their potential, others are not reaching anywhere near maximum levels of health. It is evident that efficiency is positively related to health expenditure per capita, especially at low expenditure. It can be seen that South Africa, Swaziland, Botswana and Congo have the low efficiency scores in both year 1993 and 1997.After the gap of five years these countries have not improved their performance and South Africa still has lowest efficiency. In year 1993, Armenia, Benin, Chile, China(g), Colombia, Cape Verde, Spain, Ethiopia, France, Georgia, Greece, Croatia, Indonesia, Italy, Jamaica, Japan, Kazakhstan, Sri-Lanka, Morocco, Mali, Malta, Mozambique, Niger, Oman, Philippines, Poland, Senegal, Singapore, Ukraine and Yemen are group of countries with highest efficiency scores. In 1997, Armenia, Burundi, Benin, China (g), Cape Verde, Cyprus, Spain, Ethiopia, France, United Kingdom, Georgia, Greece, Croatia, Indonesia, Italy, Jamaica, Japan, Sri-Lanka, Morocco, Mali, Malta, Mozambique,

Niger, Oman and Philippines have maximum efficiency. Scores for the remaining countries are generally around the inter-quartile range, depending on the model.

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Countries which show decrease in their performance need modification in their policies. Here, South Africa need a special mention because his efficiency score is lowest for 1993 as well as for 1997.Although having a increment in his health expenditure over the gap of five years, his performance still poor and it has lowest rank.

By Stochastic Production Frontier Analysis:

In this method, average efficiency of overall country is **0.8094321** in year 1993 and in1997, the value of average efficiency is **0.9142405**.Here also over the gap of five year efficiency increases. By Frontier modeling, we conclude that on an average a 1% increase in health expenditure per capita, expenditure per capita will increase the overall health performance by 0.070%. Similarly, on an average, a 1% increase in educational attainment by countries results in a 0.077% increase in the overall health performance in 1997.This means that by increasing expenditure per capita and educational attainment, they can improve the overall health condition of countries.

Here estimated efficiency varies from 0.011 to 0.99 (*i.e.* approx. 1), implying that although some countries may be close to maximum efficiency. It can be seen that the Ireland have the lowest efficiency scores in 1993 but after the gap of five years Ireland has improved their performance and gain much better efficiency scores. Myanmar, Nigeria, Namibia, Central African, Congo and Botswana although scoring marginally better than Ireland are underperformers in 1993 and over the gap of five year these countries have not improved their performance. In 2008, Colombia has highest efficiency score but in 2013, Philippines have maximum efficiency. Scores for the remaining countries are generally around the inter-quartile range, depending on the model.

Our efficiency scores compare current population health levels with the maximum possible for observed levels of health expenditure and education in a country. This does not mean that 100% efficiency can be reached immediately. There will be time lags between some actions and their outcomes, and efficiency in many low performing countries is hampered by civil unrest or a high prevalence of HIV and AIDS.

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