Health Economics

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Week – 10

Lecture 47- Concepts of Productivity and Efficiency

Welcome friends once again to our NPTEL MOOC module on Health Economics. After covering the unit on the economic evaluation of healthcare, it is time indeed for us to explain how efficient our healthcare system is. Hence, this particular unit is targeted accordingly, and we have carried out the contents on health efficiency. We are in the big number 10, which is why it is called unit 10. In the very first lecture, we will discuss the concepts of productivity and efficiency as part of health efficiency.

So, here are the goals. The first goal of this particular lecture is to understand productivity and efficiency. The basic models of healthcare efficiency, demand efficiency in healthcare, and problems in selecting models in healthcare. I will just give you the background of the productivity and efficiency analysis.

We start with an example. One is like if you have, there is a shoe factory that uses various materials, including labor and capital, to produce shoes. Hence, we can clearly differentiate the input and output in this context. Output is, of course, since we are restricted to shoe factories, so the output is shoe production, and input is materials and raw materials, labor and capital, etc. How do we measure the performance of the shoe factory? This is either by productivity ratio or performance ratio, or rate of performance and performance indicators.

First, by productivity ratio, we mean that the ratio of output to input is checked. A larger value of the ratio indicates better performance, whereas performance is a relative concept. When we say performance, productivity is also, of course, a quantity unit or in terms of ratio, whereas performance is a relative concept that can only compare the performance of one year to another or the performance of one factory to another. It is not just a performance by itself is standing clear. The term productivity and efficiency are often used interchangeably, but they are not precisely the same thing.

$$P_o = \frac{Output_o}{Input_o}$$

$$Efficiency = \frac{Productivity\ of\ firm}{Maximum\ productivity}$$

The productivity of a producer is the ratio of its output to the inputs of an organization. Here, organization means it is output by input; output O stands for organization. So, the ratio indeed defines productivity, whereas, with efficiency, we actually compare the observed and optimal values of its output and inputs. So, the productivity of a particular firm is compared to the firm having its maximum productivity. So, where that particular unit, maybe a DMU unit or maybe a particular firm in the competition, is standing differently than others, it is basically a comparison with their maximum productivity in this context.

So, efficiency is defined as maximum productivity in the denominator and productivity of that particular firm in the numerator. Hence, we can understand whether that firm is performing better than others. We have also given an example here; you can just mark the difference. Let us assume a single input and output firm. There are different firms we have listed (below table), and they are usually called DMUs, Decision Making Units. And these are at this moment, we have kept 5, and their individual input and output are mentioned in the next columns as X and Y.

Firms/ DMUs	Input (X)	Output (Y)	Productivity (P_O=y/x)	Efficiency $E_O = P_O/P_{maximum}$
A	5	2	0.4	1
B	30	6	0.2	0.5
C	10	3	0.3	0.75
D	20	2	0.1	0.25
E	20	6	0.3	0.75

Hence, the productivity calculated for the first firm is calculated as 2 by 5, and so it is 0.4 and similarly 6 by 30, etcetera. That is simply called output by input and understanding efficiency. As we have already mentioned, it is the particular score out of the maximum score among the DMU units, firms, or competitors. Here you can easily see the maximum is here; this is 0.4.

So, that means we are going to keep the denominator at 0.4. The numerator is the individual firm 0.4. So, this is 0.2 divided by 0.4, it is 0.5. So, by this approach, you can clarify the difference between the simple difference between productivity and efficiency. You can easily infer a number of things.

This firm A is coming out to be the best one in terms of its efficiency. Since the efficiency score is 1 and the best relative unit of measurement of efficiency is considered to be 1. And so others are relatively important, like 0.75. Is there another too? They are even better than others; for example, C is better than B, and firm E is better than D and B, etc. So, the value of the efficiency score matters when comparing whether they are efficient enough or not.

Productivity and efficiency by definition by concepts Once again, we have started explaining productivity as the ratio of output to input, and usually, this is considered to be an absolute concept, whereas efficiency is a score that is actually derived relatively. We are finding a comparable relative value. The productivity of a firm is compared to the firm having maximum productivity in terms of efficiency and observed output is compared to the maximum potential output obtainable from the input. We also compare the observed input to the minimum potential input to produce the output. Here, we can also compare the minimum observed input to the minimum potential input. In the case of output, we are comparing the maximum output to the individual observed output.

In some cases, the combination of these two can also be considered to identify the efficiency score. The literature on frontier production and cost production and the calculation of the efficiency measures began with the two important writers, Debreu in 1951 and Farrell in 1957. So, we refer to their work on frontier production and cost function, especially the calculation of efficiency. Farrell, in writing, suggested that one could usefully analyze technical efficiency in terms of realized deviations from an idealized frontier isoquant, which is usually measured through radial measures. We will discuss this in our next lecture.

Different findings were made by different authors on the application of efficiency and productivity analysis. Oum and Yu's 2004 paper explained the airports. Then, Buck and Linna 2003 and Buck 2002 paper applied the efficiency and productivity analysis for dentistry and hospitals, community and rural healthcare, and bank branches. There are some works from the WHO, nursing homes, etc. There are different papers we have cited that interest you. I think you can go through them, and they will be useful.

Why is it necessary? Efficiency analysis in healthcare: Why is it required? You can also take the word as demand for efficiency analysis. There are some indicators that will clarify why efficiency analysis is so urgent and so needed, not just for the researcher but also for the policymakers, even the producing unit or the supply units, etcetera. We will start by explaining the policymakers' perspective here. So, efficiency has become a central objective of the policymakers. They assured that such expenditure was in line with citizens' preferences when considering the efficiency scores of each public provisioning healthcare unit.

When we see that expenditure is in line with the citizen's requirements, then it is perfectly fine that the efficiency score will actually give us a direction in terms of further policy making. So, as I just said, it is as per the citizen's preferences, and expenditures are viable and justified, particularly when many sources of finance, such as tax revenues, are under acute pressure. Another indicator of efficiency analysis and its need is cost-effectiveness. How minimum cost we require, whether that minimum cost allocated to deal with the citizen services are actually finding the best output is indeed required. This cost-effective analysis is analogous to the economics concept of cost-effectiveness and is also referred to as accountants' concepts of value for money.

Another one is called potential customers' needs. The potential customers for measures of efficiency include governments, regulators, healthcare purchases and healthcare providers, and the public. So far as supply-side directions are concerned, health technologies are changing rapidly, and there are pressures to introduce new technologies that are often irresistible and uncertainty about the cost-effectiveness as well so far as supply-side perspectives are concerned in provisioning services public. So, if efficiency scores are really justified enough, it would indeed be good to supply that product, especially in healthcare. The demand side perspective, as well as the aging population, poses particular challenges, typical challenges for the design of healthcare systems.

Some healthcare systems might require modifications, and since society is aging day by day, a number of developed countries have already experienced the problem of aging, and there are natural occurrences of diseases that require further attention from the supply side. Hence, the demand side matters since it poses certain requirements. Expectations are becoming even more challenging and difficult to deal with. Healthcare purchasers, what type of purchasers are important? Those who are purchasers of healthcare have a serious information difficulty when negotiating contracts with providers. People find it difficult to judge whether providers are offering good value for money.

Purchasers to understand better the performance of their local providers relative to the best practice and intuition, an element of yardstick competition in the purchasing function as mentioned in this work. So, we are now discussing some important starting points for productivity and efficiency analysis. One is called DMUs (Decision-Making Units). You can read as DMU. We have also mentioned here the focus of efficiency analysis is an organizational locus of production, often referred to as a decision-making unit.

It is used to describe the production entity that turns input into output. For example, hospitals, firms, industries, power plants, banks, etc. These are used to be considered as the DMU units for analysis. As we have mentioned in healthcare, examples of DMU can include the entire health system; we can analyze this, purchasing organizations, whoever is purchasing healthcare products, hospitals, physician practices, and individual physicians

as well. How far these are actually competing with each other and how far their productivity is reflected better whether it is still needed or not, DMU units are relevant for analysis.

What is the basic structure of the productivity and efficiency analysis? Here, we have presented a very naive model of organizational performance from the authors (below). We have cited the authors at the end. As our readings, important readings. So, start with the cost to the output as the benefit out of the cost. The cost might include different sets of inputs, and they combined to deal with a variable called cost that might actually carry certain weights and maybe be defined through the index based on these.

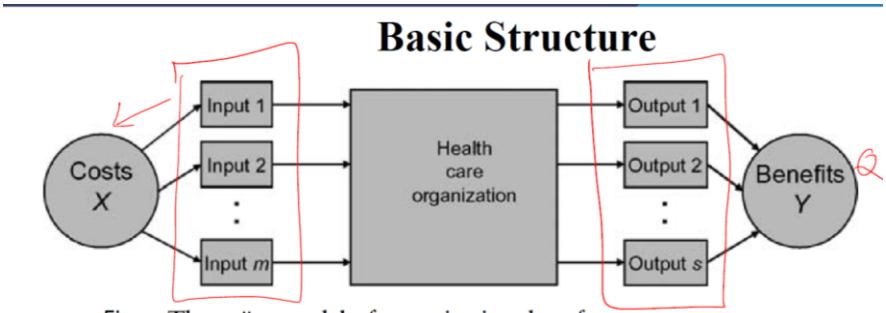

Fig:- The naïve model of organisational performance.

That will translate into cost function. Similarly, there are different indicators of output in the healthcare system, such as doctor-to-patient ratio, healthcare facilities, etc. They are all part of maybe the structure whereas, when I say the output of healthcare, maybe the number of treated persons over the time period, maybe an output, maybe a number of the cost minimization, maybe an output, and maybe a number of persons who have responded better feedback out of their consultations. If that can be numerically presented, it can also be considered an output. On the input side, there are a number of ways where we understand healthcare input, maybe the doctor-patient ratio or maybe hospital beds, etc., out of proportion. There are various ways by which we can understand the organizational setup to understand the production and efficiency analysis. So, the organization consumes a series of M physical resources of inputs and is valued in total as X by society. Some transformation processes take place, such as the production of S output with society values in aggregate as Y. Therefore, when we say there are different indicators that are affecting the cost, we are referring to either input, here is our input, or this is our output. And combinedly, we can derive one variable through their respective weight.

So, since there are multiple output possibilities, we have to carry the relative weights. So, here it is W_S, and the weights are basically their relative importance so far as the additional output is concerned, and this is presented here. This is our output combined. The indexed value of the output is precisely the function of the individual outputs. So, and their relative weights at the i-th unit, this may be your i, S is your i, and i stands for if there are S number of units you can go through accordingly, and o stands for the organization.

$$Y = \sum_{s=1}^{S} W_s Y_{sO}$$

Where,
Y= Aggregate value of outputs of organization O
W_s = Weight attached to output s^{th}
Y_{sO} = Value of output s^{th} of organization O

$$X = \sum_{m=1}^{M} W_m X_{mo}$$

Where,
X= Aggregate value of inputs of organization O
W_m = Weight attached to input m^{th}
X_{mO} = Value of input m^{th} of organization O

Hence, we can calculate a single variable that will be represented as output, and there are multiple inputs as well. Similarly, we have to carry their individual relative weight, and here, M stands for the i-th unit or j-th unit of inputs, and accordingly, we derive their indexed representative variable X. If we have information on the magnitude of W and W_S that is for the output and W_M for the inputs, we can readily compute the efficiency as the ratio Y upon X. In competitive markets, both W_S and W_M might be readily observed as prices. Overall efficiency is measured by applying weight vectors, which are weight vectors here W_S and W_M, respectively, for output and inputs.

$$eff_O = \frac{\sum_{s=1}^{S} W_s Y_{sO}}{\sum_{m=1}^{M} W_m X_{mo}}$$

**Notations are as explained above*

Hence, the efficiency score is the output vector to the input and the output value to the input value after converting it into an index. So, we already discussed in competitive markets both WS and WM might be readily observed as prices as we already discussed. So, in the health domain, prices are observed, particularly on the output side, and for weight, those two respective weight analytic techniques can be developed to find out that the production of most healthcare outputs rarely conforms to a production line type technology where a set of clearly identifiable inputs are used to produce a standard type of output. Model-building principles in healthcare have many issues, such as what is the appropriate unit of analysis, what are the outputs of healthcare, then what value should be attached to the outputs, what inputs are used in the production of this output, and how should this be valued. Some environmental constraints could also be discussed.

So, at this moment, we are emphasizing that a unit of analysis is an important indicator. There are three criteria to guide the choice of the unit of analysis. We start by emphasizing that the unit of analysis should capture the entire production process of interest, which may entail defining artificial units of analysis as well. There should be the DMUs, decision-making units that are a function; the function is to convert inputs to outputs, and the DMUs have discretion about the technological process by which this conversion takes place. The

units comprising the analytical sample should be comparable and seek to produce the same set of output.

So, what are the outputs in the healthcare sector or the unit we are discussing? In competitive industries, the physical output is basically a traded product, maybe your washing machine, cooler, etc. It varies enormously in terms of various dimensions of quality such as reliability, look or temperature range, etcetera. In many parts of the economy, prices do not exist. Outputs are also difficult to define. This is true for many of the goods and services to which government spending is devoted, as mentioned by Atkinson's paper in 2005.

The health sector, in particular, is where the government's role is pivotal and very important. So, defining outputs is indeed problematic in the healthcare sector. Healthcare is rarely demanded for its own sake. It is indeed derived from the belief that healthcare will make a positive contribution to the health status, and hence, there will be better consequences for society. Output of healthcare is considered in two broad categories: one is additional health conferred on the patient and broader patient satisfaction over and above the relative to the health effect.

An efficiency model is developed according to the purpose of the analysis, maybe for the short run, narrow short run, or long run period where we are supposed to disaggregate the analysis using the existing resources, whatever are available, and disaggregate inputs to reflect the resources currently at the disposal of the management. Whereas in the long run cases, longer-term analysis, that is, the less constrained analysis and a single measure of the total cost, an adequate indicator of physical organization inputs, etc., are relevant. Coming to another important point of analysis of productivity and efficiency and their constraints, one of the constraints we mentioned is environmental constraints that restrict comparison only to organizations within a similarly constrained environment. In these models, the constraint explicitly is analogous to factors in the production process, and this undertakes risk adjustment as well. How do we accommodate these influences and environmental constraints? Sometimes, authors suggest that in cluster analysis, we need to compare the like with like or similar family categories and incorporate environmental factors in the model, treating them as exogenous input that is analogous to the labor or capital that you have considered.

And so far as risk adjustment is concerned, we need to adjust organizational outputs for differences in circumstances before they are deployed in the efficiency model. So, after saying so, we need to address some practical challenges as well as part of our conceptions on productivity and efficiency analysis. There is a serious lack of information and some indicators related to performance. Time series are often short and interrupted by structural changes, missing data for some organizations, and sample sizes may also create some

disturbances that might be too small to draw influences. So, overall, as I have already said, we are starting with an organization, and we will be comparing its output with its inputs.

This is our standard basic model (given below). However, there are so many factors we need to take into account, like the t-1 period to t+1 period of endowment, exogenous inputs, and some system constraints that may be there, like policy constraints, physical constraints, etcetera. Their joint output by output as well as integrated care research teaching, etcetera, and external inputs such as productivity and independence of the system should also be somewhere included in the analysis. Therefore, we have cautioned that potentially high sensitivity of the results to model specification and data errors is important, with great attention to sensitivity analysis or experimentation with different model specifications and caution withdrawing definitive judgments on the efficiency of individual organizations. It has to be noted that it will never be feasible to accommodate all the issues summarizing the above figure into the efficiency analysis, and we should be aware of which factors are most likely to affect the model for consideration. So, these are all the very foundations of productivity and efficiency analysis.

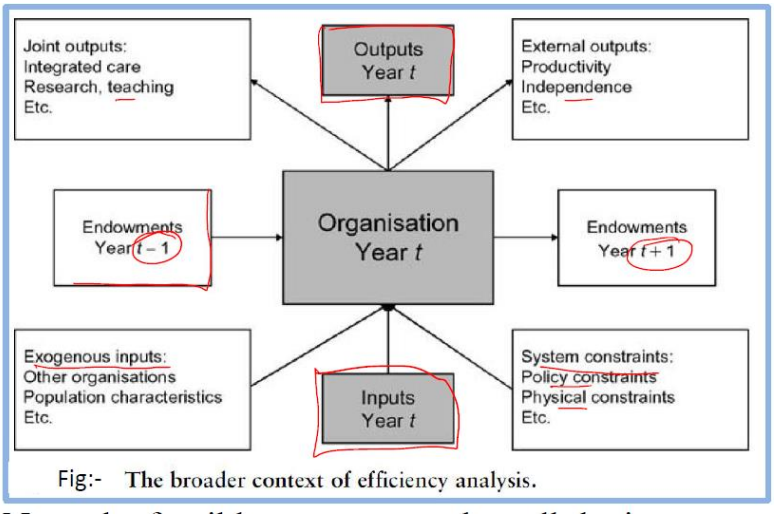

Fig:- The broader context of efficiency analysis.

In our subsequent lectures, we will be emphasizing this in detail. In between, I think these three readings are important. We have also cited their chapters you can follow, and I think it is suggested to you that only you be able to address all the questions in the exam. And what are their details? We will also go by a detailed schematic presentation of the entire possibility of productivity and efficiency. We will certainly emphasize the DEAP software, and we will emphasize different conceptions of measurement, data envelopment analysis, input and output-oriented DEA, constant returns to scale DEA model, and variable returns to scale model and scale efficiency.

So, in our next lecture, we will emphasize how far this is going to change variable returns and scale efficiency, etc. With this, I must thank you and expect you to be present in our next lecture. Thank you.