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PRODUCTIVITY ANALYSIS IN IRAQI HOSPITALS

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ABSTRACT
Analyzing productivity and efficiency in Iraqi hospitals using non-parametric frontier technique is important issue. Two indices approach are used: first, Malmquist productivity index (MPI), with output orientation, and the second is a Luenberger productivity indicator (LPI) that can measure by both input reduction and output expansion. A sample of three hospitals in (Baghdad) district are taken to evaluate the productivity progress and its decomposition efficiency change and technological change, over two year period (2014-2015). The results reveled all hospitals in the study had a productivity improvement during study period.

INTRODUCTION
Productivity analysis in recent years become one of the more significant issues generally for health and especially for hospitals. We need to study the productivity evaluation to determine the extent of progress in the effectiveness of systems to keep pace with development and healthy growth. For the purpose of employment of the available possibilities to fit users, which can also be the independence of the service level, in particular the economic factor has become the main engine of evolution. Generally, there are some definitions of productivity: first, the Productivity is output/input, in other terms is measure of efficiency; second, the productivity refers to broader concept that makes the organization have a better function; and another definition states that productivity is composition of both, effectiveness and efficiency [1]. The productivity and efficiency may be analyzed using different measurements techniques as shown in Figure (1). The researchers mostly focused on productivity change in health sector typically using the Malmquist productivity index (MPI) or Luenberger productivity indicator (LPI) with adopting the (DEA) to frontier estimation. In this study we apply the two indexes (LPI) and (MPI) through the application of (DEA) to estimate the change in productivity and its composition: efficiency change and technological change for hospitals. There are some comparisons between these two indices, are clarified briefly by (Boussemart and Briec et al.) [2]. The main differences between these indices are: (i) The (MPI) based on ratio in its measurement form, while the LPI based on differences. (ii) The (MPI) can be specialized with either input oriented or output oriented approaches in determine the productivity change, while the LPI technique can specialized with both input reduction and output expansion in the same time (because it is based on directional distances function (DDF)).

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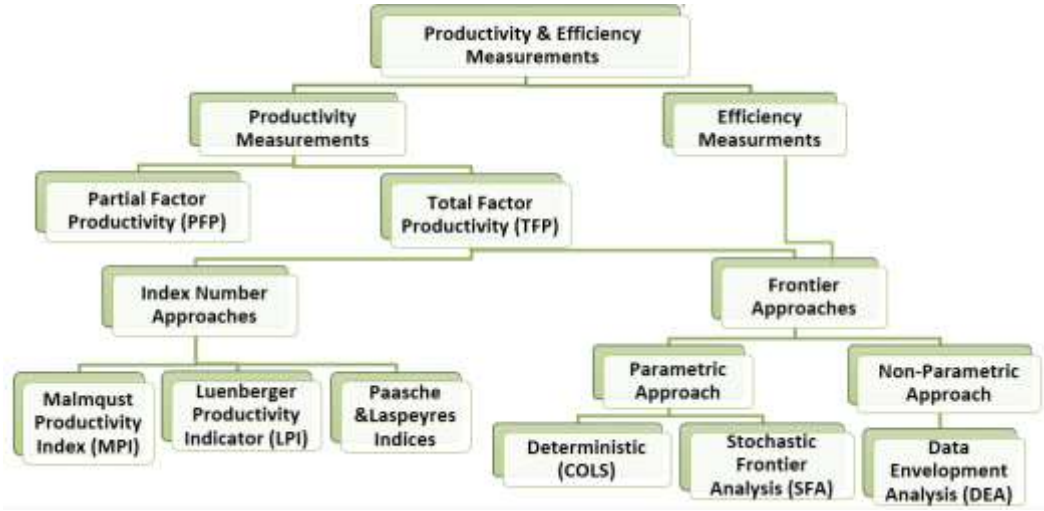

Figure 1. Measurement Techniques for Efficiency & Productivity Analysis [3].

LITERATURE REVIEW

There are many researches of efficiency analysis and productivity change of hospitals using different measurement approaches and developed in different countries. Baros and De Menzes et al. (2007) [4] used (LPI) technique, to evaluate the productivity change of Portuguese hospitals over seven periods from (1997 to 2004). Afonsso and Fernands (2008) [5] also estimate the change in productivity of (68) Portuguese public hospitals over five periods from (2000 to 2005), but by applying DEA approach with (MPI). Kierigia et al. (2008) [6] evaluates the productivity change using (MPI) of 28 public hospital in Angola, over three period time (2000-2002), he found that on average, the productivity of hospitals in Angola increased about 4.5% over the period of study years. Chowdhury and Zelenyuk et al. (2010) [7] use the (MPI) technique with (DEA) to estimate the productivity and technological change of Ontario hospitals of sample data (2003-2006), they found that productivity progress occurred in most through improvement in technology and in spite of declining efficiency. Tlotlgo and Nonvigon et al (2010) [8] applied the DEA based MPI to a sample of (21) non- teaching hospitals in the Republic of Botswana over the period from 2006 to 2008. Torabeipour and Najarzadeih et al (2014) [9]measured the productivity change of (12) teaching and non-teaching hospitals in Ahvaz County, over period from (2007 to 2010), using the (DEA) technique and MPI, they found there are not a considerable difference in average productivity changes among non-teaching and teaching hospitals except in year (2009).

Chenga and Taoi et al. (2015) [10] estimate the productivity change using MPI of (114) sample county hospitals in Henan province, China, over periods from 2010 to 2012, they found the hospitals experienced productivity progress during the study period.

METHODOLOGY

Malmquist Productivity Index (MPI)

The (MPI) approach introduced by, (Caves et al.) [11], to estimate the productivity change between two points in terms of ratios of distance function. It's a conventional technique to evaluate the productivity progress, which it is mostly used in evaluating the productivity change in healthcare sector. There are two measurements approach to estimate the frontier: DEA, and Stochastic Frontier Analysis SFA [12]. DEA is mostly used approach, as it requires fewer assumptions than (SFA), concerning the configuration of the production technology [5].
Following to (Fare et al.) [12], the output oriented MPI change between period (*t)* and period (*t+1)* is given by:

$$M_0(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{d_o^{t+1}(y_{t+1}, x_{t+1})}{d_o^t(y_t, x_t)} \times \left[\frac{d_o^t(y_{t+1}, x_{t+1})}{d_o^{t+1}(y_{t+1}, x_{t+1})} \times \frac{d_o^t(y_t, x_t)}{d_o^{t+1}(y_t, x_t)} \right]^{1/2} \quad (1)$$

Where, $M_0(y_t, x_t, y_{t+1}, x_{t+1})$ represents Total Factor Productivity change, and $d_o^t(y_t, x_t), d_o^t(y_{t+1}, x_{t+1}),$

$d_o^{t+1}(y_t, x_t), d_o^{t+1}(y_{t+1}, x_{t+1})$, are represent the distance function values, which will be described in models (1), (2), (3), and (4).

The current hospital is represented by (o). If a value of M_o>1 it indicates growth in productivity from period *(t)* to period *(t+1)*, while if a value of M_o<1 it indicates a decline in productivity.

The MPI decomposed in to two components: efficiency change and technological change. Where, the first ratio outside the brackets in equation (1) indicates to efficiency change and the second ratios indicates to technological change. So that, the efficiency change and technological change can be evaluated as:

$$\text{Efficiency change (EFFCH)} = \frac{d_o^{t+1}(y_{t+1}, x_{t+1})}{d_o^t(y_t, x_t)} \quad (2)$$

$$\text{Technological change (TECH)} = \left[\frac{d_o^t(y_{t+1}, x_{t+1})}{d_o^{t+1}(y_{t+1}, x_{t+1})} \times \frac{d_o^t(y_t, x_t)}{d_o^{t+1}(y_t, x_t)}\right]^{1/2} \quad (3)$$

In this study, the MPI measured by using non-parametric frontier technique (DEA), and assume constant return to scale (CRS) output oriented approach. Thus, to compute the distance functions appeared in equation (1), four linear programing models are needed to solve for each hospital as shown in Figure (2).

$$\{d_o^t(y_t, x_t)\}^{-1} = \text{Max } \theta_h \quad s.t. \sum_{h=1}^{H} \lambda_h x_{it}^h \le x_{it}^o \quad \sum_{h=1}^{H} \lambda_h y_{jt}^h \ge y_{jt}^o \theta_h \quad \lambda_h \ge 0, \quad h = 1, \dots\dots\dots, H \quad \text{Model (1)}$$

$$\{d_o^t(y_{t+1}, x_{t+1})\}^{-1} = \text{Max } \theta_h \quad s.t. \sum_{h=1}^{H} \lambda_h x_{it}^h \le x_{i(t+1)}^o \quad \sum_{h=1}^{H} \lambda_h y_{jt}^h \ge y_{j(t+1)}^o \theta_h \quad \lambda_h \ge 0, \quad h = 1, \dots\dots\dots, H \quad \text{Model (2)}$$

$$\{d_o^{t+1}(y_t, x_t)\}^{-1} = \text{Max } \theta_h \quad s.t. \sum_{h=1}^{H} \lambda_h x_{i(t+1)}^h \le x_{it}^o \quad \sum_{h=1}^{H} \lambda_h y_{j(t+1)}^h \ge y_{jt}^o \theta_h \quad \lambda_h \ge 0, \quad h = 1, \dots\dots\dots, H \quad \text{Model (3)}$$

$$\{d_o^{t+1}(y_{t+1}, x_{t+1})\}^{-1} = \text{Max } \theta_h \quad s.t. \sum_{h=1}^{H} \lambda_h x_{i(t+1)}^h \le x_{i(t+1)}^o \quad \sum_{h=1}^{H} \lambda_h y_{j(t+1)}^h \ge y_{j(t+1)}^o \theta_h \quad \lambda_h \ge 0, \quad h = 1, \dots\dots\dots, H \quad \text{Model (4)}$$

Figure 2. Four LP models in MPI index

Where, $d_o^t(y_{t+1}, x_{t+1})$ represents distance from the period *(t+1)* and the period *(t)* technology, θ_h is the factor by which an output set y_{jt}^o is adjusted to achieve the maximum output level y_{jt}^h in county hospital (h), λ is variables weights, x_{it}^h, $x_{i(t+1)}^h$ are quantities of input i for DMU_h in periods t and (t+1) respectively, $y_{jt}^h, y_{j(t+1)}^h$ are quantities of output j for DMU_h in period t and (t+1) respectively.

Luenberger Productivity Indicator (LPI)

The (LPI) is based on the Directional Distance Function (DDF). The (DDF) evaluates the smallest changes in a given direction in input & output, which are needful for a firm to reach the "Production Frontier". The (DDF) determines, a shortcut in (one direction), which, permits an observed (production unit) to reach the "Production Frontier". Its main advantage lies in its capability to simultaneous take account of inputs and outputs. The Luenberger productivity indicator defined as following [13]:

$$L(z_t, z_{t+1}) = D_t(z_t, g) - D_{t+1}(z_{t+1}, g)] + \frac{1}{2}[D_{t+1}(z_{t+1}, g) - D_t(z_{t+1}, g) + D_{t+1}(z_t, g) - D_t(z_t, g)] \quad (4)$$

where, L (z_t, z_{t+1}) is LPI value, $[D_{t+1}(z_{t+1}, g),\ D_t(z_{t+1}, g),\ D_{t+1}(z_t, g),\ D_t(z_t, g)]$, are indicate the values of (DDF) for the input &output vector for the technology in period (t+1) and period (t), that will be described in models (5), (6), (7) and (8) in figure (3).

$z_t = (x_t, y_t)$ denotes inputs and outputs in period (t), and g = $(-g_x, g_y)$ is the directional vector indicating that the inputs are to be contracted and the outputs increased simultaneously. A direction vector $g = (x, y)$ is used in this study, to measure the smallest changes in inputs and outputs, which is based on the proportional modulation of (inputs and outputs) simultaneously. Thus, the (DDF) is comparable to the (proportional distance function) that is used by (W. Briec) [14]. As in (MPI) approach, the nonparametric DEA model is used for frontier estimation [15]. So, to evaluate the productivity progress using LPI in equation (4), four maximization problems need to be solved; two for within-period distance functions $(D_t\ (z_t, g), D_{t+1}\ (z_{t+1}, g))$ and two for mixed-period distance functions $(D_t(z_{t+1}, g), D_{t+1}\ (z_t, g))$. As described in models (5), (6), (7) and (8) in figure (3).

$$D_t(z_t, g) = \text{Max}\ \beta \quad \text{s.t.} \quad \sum_{h=1}^{H} \lambda_h\, x_{it}^h \le x_{it}^o\,(1-\beta), \quad \sum_{h=1}^{H} \lambda_h\, y_{jt}^h \ge y_{jt}^o\,(1+\beta), \quad \lambda_h \ge 0,\ h = 1, \dots\dots\dots, H \qquad \text{Model (5)}$$

$$D_t(z_{t+1}, g) = \text{Max}\ \beta \quad \text{s.t.} \quad \sum_{h=1}^{H} \lambda_h\, x_{it}^h \le x_{i(t+1)}^o\,(1-\beta), \quad \sum_{h=1}^{H} \lambda_h\, y_{jt}^h \ge y_{j(t+1)}^o\,(1+\beta), \quad \lambda_h \ge 0,\ h = 1, \dots\dots\dots, H \qquad \text{Model (6)}$$

$$D_{t+1}(z_t, g) = \text{Max}\ \beta \quad \text{s.t.} \quad \sum_{h=1}^{H} \lambda_h\, x_{i(t+1)}^h \le x_{it}^o\,(1-\beta), \quad \sum_{h=1}^{H} \lambda_h\, y_{j(t+1)}^h \ge y_{jt}^o\,(1+\beta), \quad \lambda_h \ge 0,\ h = 1, \dots\dots\dots, H \qquad \text{Model (7)}$$

$$D_{t+1}(z_{t+1}, g) = \text{Max}\ \beta \quad \text{s.t.} \quad \sum_{h=1}^{H} \lambda_h\, x_{i(t+1)}^h \le x_{i(t+1)}^o\,(1-\beta), \quad \sum_{h=1}^{H} \lambda_h\, y_{j(t+1)}^h \ge y_{j(t+1)}^o\,(1+\beta), \quad \lambda_h \ge 0,\ h = 1, \dots\dots\dots, H \qquad \text{Model (8)}$$

Figure 3. Four LP models in LPI indicator

Productivity improvement in LPI is indicated by a positive value of the index, and productivity declines by negative value. The Luenberger indicator is also decomposed into efficiency change & technological change, as described in equations (5 & 6) respectively.

$$\text{EFFCH} = D_t\ (z_t, g) - D_{t+1}\ (z_{t+1}, g) \qquad (5)$$

$$\text{TECH} = \frac{1}{2}\ [D_{t+1}(z_{t+1}, g) - D_t(z_{t+1}, g) + D_{t+1}(z_t, g) - D_t(z_t, g)] \qquad (6)$$

Figure (4) illustrates the (LPI) structure. Where point (E) represents (z_t) and point (F) represents (z_{t+1}), in which A, B, C and D are points lie on the frontier:

$$\text{EFFCH} = [(A - E) - (D - F)] \qquad (7)$$

$$\text{TECH} = \frac{1}{2}\ [(D - C) + (B - A)] \qquad (8)$$

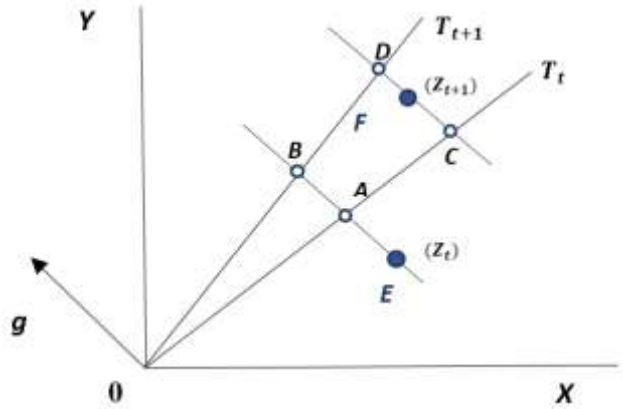

Figure 4. Luenberger Productivity Indicator (LPI) [4]

Therefore, the (EFFCH) determines how close the notation (E) is to the technology T_t , and the notation (F) to the technology T_{t+1}. (TECH) is the average distance between the technologies T_t and T_{t+1}.

DATA AND RESULTS

A sample of three hospitals (Fatima Al-Zahra, Ibn Al-Balady, and Al-Elwaiya Children's) in (Baghdad) district are selected to evaluate the productivity progress and efficiency analysis. Based on the literature review and depending on the availability of data in statistical units of selected hospitals. Three inputs variables are identified: (i) Number of doctors, (ii) Number of nurses, (iii) Number of health personnel, and two outputs variables: (i) The Number of laboratory test, and (ii) Number of emergency visit.

Because of restriction and unavailability of data, the study models are deals with two years only (2014-2015). The inputs and outputs variables are described in Table (1) in term of mean, minimum and maximum of data.

Table 1. Descriptive Statistics of Data (2014-2015)

Variables	**Mean**	**Min.**	**Max.**
Inputs			
Number of Doctors	130	76	177
Number of Nurses	279	119	419
Number of Health Personnel	217	109	310
Outputs			
Number of Laboratory Tests	270,657	190,119	447,665
Number of Emergency Visits	35,893	21,669	48,535

The linear programing of each indices (MPI & LPI), models (1), (2), (3), (4) & (5), (6), (7), (8) respectively, are calculated using Microsoft® Excel solver. Then, the values of distance functions of MPI are subjected on equations (1), (2) and (3) to achieve the values of productivity change and its components in MPI approach. While the values of distance functions of LPI are subjected on equations (4), (5) and (6) to achieve the productivity progress and its components in LPI approach. The final results of productivity progress and its components in each approach are listed in Table (2).

Table 2. Productivity Progress of Hospitals using MPI &LPI (2014-2015)

Hospitals	**MPI**			**LPI**		
	Productivity	**Efficiency Change**	**Technological Change**	**Productivity Progress (L)**	**Efficiency Change**	**Technological Change**

	Progress (M)					
Ibn Al-Balady	1.501	1.323	1.135	0.169	0.139	0.030
Fatima Al-Zahra	1.307	1.184	1.104	0.128	0.081	0.047
Al-Elwaiya Children's	1.193	1	1.193	0.013	0	0.013

From Table (2), obtain the productivity progress of all hospitals are growth up in period 2014-2015, where the values of (productivity progress (M)) using MPI approach are larger than (1) in all hospitals, and using LPI approach the (productivity progress (L)) values are positive (+).

The productivity growth in Ibn Al-Balady hospital using MPI approach is (150.1%), and equal to (16.9%) by using LPI approach. In Fatima Al-Zahra hospital the productivity growth is equal to (130.7%) using MPI and (12.8%) using LPI. In Al-Elwaiya Children's hospital the amount of productivity growth is lesser than other pervious hospitals, where the (productivity progress (M)) value is equal to (119.3%) and (productivity progress (L)) value is equal to (1.319). Also, in Al-Elwaiya Children's hospital the technological change plays an important role in productivity progress than efficiency change (because the efficiency change value is equal to (1) in MPI approach and equal to zero in LPI approach, (make it has no effect on the productivity progress).

The efficiency change in Al-Elwaiya Children's hospital equal to (zero) in LPI approach and (one) in MPI approach, indicates to the hospital is relatively efficient in both years (2014 and 2015). While the efficiency change in Fatima Al-Zahra hospital is equal to (8.1%) in LPI and (118.4%) in MPI approach, which it lesser than the Ibn Al-Balady hospital efficiency change equal to (13.9%) in LPI and (132.3%) in MPI approach. Figures (5) & (6) describe the productivity progress of three hospitals using MPI and LPI respectively, over period (2014 – 2015).

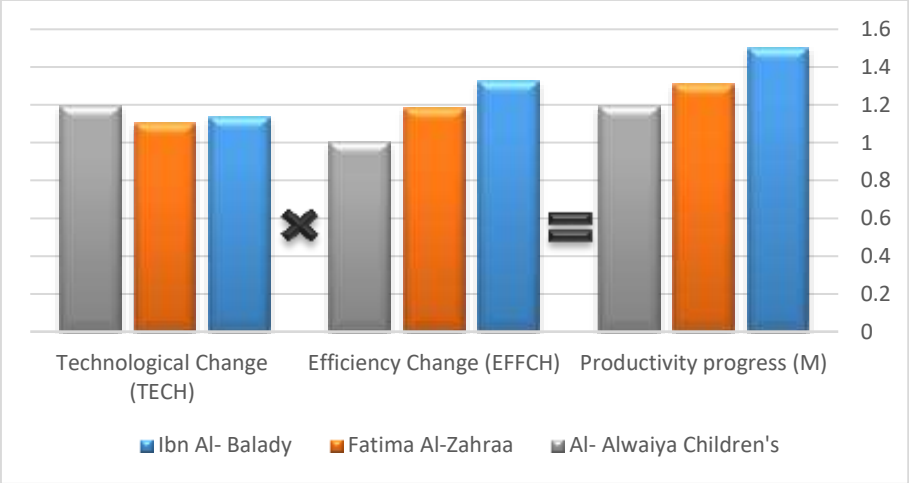

Figure 5. Productivity progress of hospitals over 2014-2015 using MPI

From Figure (5) see that Ibn Al-Balady hospital has a highest productivity improvement than other hospitals, while in technological change, Al-Elwaiya Children's hospital has a highest change than it peers.

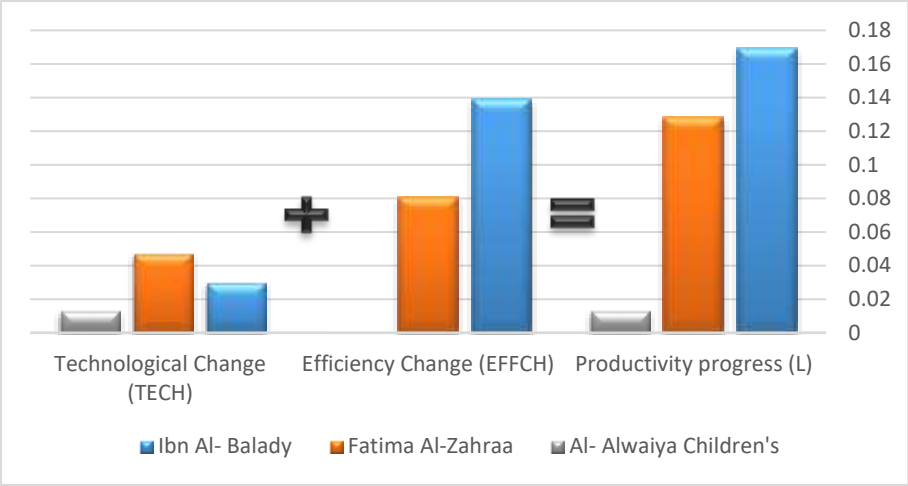

Figure 6. Productivity progress of hospitals over 2014-2014 using LPI

Figure (6) illustrates the progress of productivity in three hospitals using LPI, which the highest productivity progress and efficiency change are appeared in Ibn Al-Balady hospital. While the highest technological change appeared in Fatima Al-Zahra hospital.

CONCLUSION

In this study the data are collected from three hospitals in (Baghdad) district, over two years periods (2014-2015), by using two methods MPI and LPI to evaluate the amount of progress in productivity and its composition efficiency change and technological change.

The results show the productivity progress in three hospitals are in positive using LPI which indicates there are improvement in productivity in all hospitals through the period 2014-2015. Then from the efficiency change reveled the Al- Alwaiya Children's hospital is relatively efficient in both years of the study. Also, due to MPI and LPI approaches have a different measurement form, so, the achieved results are different, where the MPI based on ratios and the LPI base on differences. Finally, in term of future studies, more than three hospitals over more than one period time could be used to evaluates the productivity growth or declined over long time period, in which gives an insightful results about the productivity change to hospitals administrators.

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