Arab American University – Jenin

Deanship of Graduate Studies

Using Data Envelopment Analysis in Higher Education in Palestine

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This thesis was submitted

in partial fulfillment of the requirements for the degree of

Master of Science

in

Applied Mathematics

August 2012

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Dedication

I dedicate this work to my parents, wife, brothers, and to my beloved daughter.

Acknowledgment

First of all, I want to thank God for all his graces on me and for giving me the ability to finish this work.

It is an honor for me to work with my supervisor Dr. Elias Dabeet. To him I owe my deepest gratitude.

It is my pleasure to thank those who made this thesis possible. My parents, wife, brothers, family and friends, without their support this work could not have been finished.

I would like to express my gratitude to Dr. Iyad Suwan for his valuable remarks and continuous support.

I would like to thank the examination committee for their valuable feedback in order to have this work brought out with the best standards.

I am indebted to many of my colleagues who supported me: Shade, Firas, Marwan, Samer, Helmi, Nizar, and all my friends. Also I will never forget the support of my students.

Finally, my great gratitude to the Mathematics Department at Arab American University-Jenin.

Contents

Abstract

Higher education is one of the most important sectors in any country because of its impact on economy, healthcare, community and other sectors. The motivation for this thesis is the lack of researches in measuring the efficiency and performance of institutions of higher education in Palestine.

In this thesis, Data envelopment analysis was used as a non- parametric method to measure the efficiency and assess the performance of the traditional universities in Palestine in the period 2006/2010. Results were compared with the well-known linear regression analysis which is a parametric method. The basic Charne, Cooper and Rodes (CCR) model and Malmiquist index analysis of data envelopment analysis along with a standard regression analysis were used in order to achieve the goal.

The results revealed that the most developed universities in Palestine in the period 2006/2010 according to the productivity growth were Gaza's traditional universities as Al- Aqsa University / Gaza comes first with productivity growth of (24.8%), Islamic University / Gaza comes second with a productivity growth of (23.8%) and Al- Azhar University / Gaza were in fourth place with a productivity growth of (12.1%). The West bank traditional universities had just one university in the top four which was the Arab American University as it comes third with productivity growth of (16.3%) .

The traditional universities in Palestine in general showed a growth in many aspects as the data shows promising evolution in the next few years. Tending to higher education is also growing in Palestine and has a promising future.

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الملخص

قطاع التعليم العالي يعتبر من اهم القطاعات بالنسبه لاي دوله بسبب تاثيره على الاقتصاد والصحه والمجتمع وكثير من القطاعات الاخرى. الدافع وراء عمل هذه الاطروحه هو فقر الساحه الفلسطينيه لهذا النوع من الابحاث التي تختص بقياس الفعاليه وتقييم اداء وعمل مؤسسات التعليم العالي في فلسطين.

في هذه الاطروحه استخدمت تحليل تغليف البيانات وهي طريقه غير معلمية لقياس فعاليه وتقييم اداء الجامعات الفلسطينيه التقليديه في الفترة الزمنيه بين عام 2006 وعام 2010 ودعمت نتائج التحليل باستخدام طريقه معلمية وهي تحليل الانحدار البسيط. استخدمت نموذجين من نماذج تحليل تغليف البيانات وهما : النموذج الاساسي لكارنز كوبر ورودزوالنموذج الاخر هو مؤشر مالمكويست، بالاضافه الى تحليل الارتباط المعياري للوصول الى المطلوب.

النتائج اظهرت ان الجامعات الاكثر تطورا في الفترة الزمنيه بالنسبه لمقياس التطور كانت جامعات قطاع غزة حيث حصلت جامعه الاقصى على المرتبه الاولى بنسبه تطور بلغت 24.8% وتبعتها كل من الجامعه الاسلاميه بنسبه تطور 23.8% في المرتبه الثانيه وجامعه الأزهر في المرتبه الرابعه بنسبة تطور 12.1%. الجامعة العربيه الامريكية حصلت على المرتبه الثالثة بنسبة تطور 16.3% وهي الجامعة الوحيدة في الضفة الغربية التي نافست على المراتب الاربعه الأولى بنسب التطور.

بشكل عام الجامعات الفلسطينية اظهرت تطورا ملحوظا في الفترة الزمنيه 2010/2006 في مجالات مختلفه وذلك يبشر بتطور جيد على مستوى المستقبل القريب.

Chapter 1

Introduction

Efficiency is a ratio that measures the good use of Resources of any organization to reach its maximum capability with the least cast. There are two types of methods for measuring comparative efficiency: parametric and non-parametric methods. The parametric methods typically hypothesize a functional form and use the data to estimate the parameters of that function. The estimated function is then used to arrive at estimates of the efficiencies of units. The non-parametric methods, among those known as Data Envelopment Analysis (DEA), create virtual units to act as benchmarks for measuring comparative efficiency [13].

The DEA is a new and a very important research topic that is concerned in finding the efficiency of a set of entries which converts multiple inputs into multiple outputs. The DEA originally goes back to the early 1950's after World War Π as researchers extended operations research to economics. In 1978, the DEA fever exploded after the well-known paper by A. Charne, W.W. Cooper and E. Rodes [10].

The literature and applications of DEA have been important tools in order to give certain explanations in many aspects of the economy, education, health sector, banking and more aspects of life. The last two decades encountered a significant development in the use of DEA, which has been developed rapidly to be able to give solutions in different fields. After the first model which is the basic Charne, Cooper and Rodes (CCR) model was published by A. Charne, W.W. Cooper and E. Rodes [10], many models were developed by those and other researchers. Many researches concerning the DEA models and their applications were published in the next years [1-36].

The grow usage of DEA goes to the simplicity of the models that researchers induced compared to the complex nature of the statistical models in this field. DEA models were used by many researchers to examine the efficiency in many areas. In banking researchers used DEA models to find the efficiency, performance, scores and ranking [3, 4, 9, 12, 16, 25, and 26]. In health and education, DEA models were very useful and encouraging to find out much critical information that can be used to solve some of the most important issues in both areas [1, 5, 15, 22, 24, and 27].

R. D. Banker, A. Charne and W.W. Cooper (1984) [6] described some models for estimating technical and scale inefficiencies in DEA. In 1996 A. Charne, J. J. Rousseau and J. H. Semple [11] defined a new technique for assessing the sensitivity and stability of efficiency classifications in Data Envelopment Analysis which was developed for the ratio (CCR) model. The DEA models were considering non negativity constraint until A.Emrouznejad, Ab.Anouze and E. Thanassoulis(2010) [17] paper was published. They propose a semi-oriented radial measure, which permits the presence of variables which can take both negative and positive values. The model was applied to data on a processing system to compare the results with those yielded by two alternative methods for dealing with negative data in DEA, and they claimed that this new model will have more advantages in use than the modified slacks-based model that was developed by J.A. Sharp, W.B. Liu and W. Meng(2006) [28], and the range directional model which was published in 2004 by M.C. Portela, E. Thanassoulis and G. Simpson [25].

Education is one of the most important fields that effect the growth of any community. Governments around the world focus on developing educational institutions in different ways due to the important role that education plays in the growth and evolution of its different sectors. Data envelopment analysis applications

used to find the efficiency, productivity and growth in educational institutions mainly in higher education sector. Most of researchers were convinced that investing in higher education is a good thing for the economy and society. Higher education institutions as universities, colleges and research centers graduating highly trained individuals affect the whole community's life style.

A. Aristovnik, and A. Obadic (2011) evaluate the efficiency of higher education in Croatia and Slovenia [5]. Z. Daghbashyan(2011) investigates the economic efficiency of higher education institutions (HEI) in Sweden [15]. Also some researchers used the DEA models to evaluate efficiency inside one higher educational institution. As an example, M. M. Rayeni and F.H. Saljooghi(2010) used DEA models on twenty-one education departments of the Islamic Azad University- Zahedan branch in Iran in 2008-2009 [27] .

The lack of use of DEA applications in Palestine motivated us to work in this important and useful aspect. Higher education in Palestine needs more attention in order to achieve a breakthrough in economic, health and agriculture. In this thesis we studied the efficiency and productivity of the traditional universities in Palestine in the period of 2006/2010. We use DEA models along with regression analysis and compare them with each other to assign the more efficient way to reach our purpose.

In chapter two of this thesis, we presented some of the most important DEA models that are very useful in the field of efficiency testing. We consider the basic CCR model presented by A. Charne, W.W. Cooper and E. Rodes(1978) [10], a slack-based measure of efficiency (SBM) model which was introduced by Tone (1997) and other important models [32].

Literature review for some of the previous studies that implicated various types of DEA models into action were presented in chapter three. Data, variables and method for the study were presented in chapter four.

In chapter five, the data were analyzed by two different DEA models which are: basic CCR model and a malmiquist index model. Traditional statistical analysis consisted of standard regression analysis and correlation analyses were used to analyze the data set. Results for each model are presented in each section.

Chapter six discusses the results that emerged from the data analysis and compared them with results from previous studies showing the strengths and weaknesses of the analysis. Conclusions and recommendations were presented in chapter seven.

Chapter 2

Theoretical framework

This chapter consists of five sections. In the first section a definition for the DEA will be presented. In the last four sections we will present some of the DEA models, some of them will be used in the analysis in this thesis.

2.1 What is DEA?

According to S. Talluri [29], Data Envelopment Analysis is a tool to test and improve the performance of manufacturing and service operations. It was applied in evaluating the performance to many types of economic institutions, health care industry, high and secondary educational institutions, banking and even in military farms. In fact, DEA is a multi-factor productivity analysis model for measuring the relative efficiencies of a homogenous set of decision making units (DMUs). It uses mainly the principle of output to input ratio measures. It starts with the simple ratio:

$$\frac{output}{input}$$ ([13] page 1)

This ratio was used to measure the efficiency. The same was proposed by the productivity as it is used to evaluate employee performance.

In DEA the organization under study is called a DMU (decision making unit). A group of DMUs is used to evaluate each other with each DMU having a certain degree of managerial freedom in decision making.

Definition2.1.1 ([13]): Suppose there are n DMU_s: DMU_1, DMU_2, ..., and DMU_n. Some common input and output items for each of these j = l, ..., n DMU_s . Suppose m input items and s output items are selected. Let the input and output data for DMU_j be

{x_{ij}, x_{2j},…, x_{mj}) and (y_{1j}, y_{2j},…, y_{sj}), respectively. The input data matrix X and the output data matrix Y can be written in matrix form as follows:

$$X = \begin{pmatrix} x_{11} & x_{12} \cdots & x_{1n} \\ x_{21} & x_{22} \cdots & x_{2n} \\ \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & x_{mn} \end{pmatrix}$$

$$Y = \begin{pmatrix} y_{11} & y_{12} \cdots & y_{1n} \\ y_{21} & y_{22} \cdots & y_{2n} \\ \vdots & \vdots & \vdots \\ y_{s1} & y_{s2} & y_{sn} \end{pmatrix}$$

Where X is an (m × n) matrix and Y an (s × n) matrix. ([13] Page22)

DEA has developed rapidly to have a large number of models that is used in various types of applications in every aspect.

DEA utilizes mathematical programming which can handle large numbers of variables and relations constraints. It makes it easier to deal with complex problems. The extensive body of theory and methodology available from mathematical programming can be brought to bear in guiding analyses and interpretations. Much of this is now available in the literature on research in DEA and a lot of this has now been incorporated in commercially available computer codes that have been developed for use with DEA [14].

2.2 The CCR model

CCR model is the basic model that many of the models depends on to maximize the output of original DMUs by solving a linear programing problem. In CCR model we need to find the efficiency for each DMU. Let the DMU_j to be evaluated on any trial be designated as DMU_{jo} where o ranges over 1, 2,..., n . solve the linear programing problem to obtain the values for the inputs weights (v_i) as i= 1,2,3, ….,m and the output weights (u_r) as r=1,2,3,…., s :

$$\text{Max}_{v,u}\ \theta = u_1y_{10} + \ldots\ldots + u_sy_{s0}$$

Subject to:

$$v_1x_{10} + v_2x_{20} + \ldots\ldots + v_mx_{m0} = 1$$

$$u_1y_{1j} + \ldots\ldots + u_sy_{sj} \leq v_1x_{1j} + \ldots\ldots + v_mx_{mj} \qquad (j = 1, 2, 3, \ldots, n)$$

$$v_1, v_2, v_3, \ldots\ldots, v_m \geq 0$$

$$u_1, u_2, u_3, \ldots\ldots, u_s \geq 0 \qquad ([10])$$

The next definition explains the feasible solution for the linear programing system.

Difinition2.2.1 ([13] Page 24): let θ^* be the feasible solution for the linear programing system. DMU_0 is CCR-efficient if $\theta^* = 1$ and there exists at least one optimal (v, u*) with V* > 0 and u* > 0. Otherwise, DMU_0 is CCR-inefficient.*

This means that DMU_0 is inefficient if $\theta^* < 1$ or when either v*, u* equals zero for every optimal solution of the linear programing system.

E_0 is called the reference set to the DMU_0 When a subset E_0 of E_0' as

$$E_0' = \{ j : \sum_{r=1}^{s} u_r^* y_{rj} = \sum_{i=1}^{m} v_i^* x_{ij} \}$$

The existence of this set forces the DMU_0 to be inefficient.

Example 2.2.1: Let's choose 10 traditional Universities in Palestine which we label A to H at the head of each column in Table 2.2.1.

Table 2.2.1

Example 2.2.1: 10 traditional universities in Palestine in 2010

University (DMU)	Enrolled students (input)	Graduated students (output)
Al Azhar University / Gaza	2901	1398
Islamic University / Gaza	4321	3991
Al Aqsa University / Gaza	3084	2538
Hebron University	1558	867
Palestine Polytechnic University	880	445
Bethlehem University	865	667
Al Quds University	3219	1462
Birzeit University	1806	1088
An-Najah University	4465	2677
Arab American University	1522	612

We will find the efficiency for every DMU by solving the corresponding linear programing problem.

For Al Azhar University / Gaza we can find the efficiency by solving:

Max $\theta = u$

s. t $2901v = 1$

$1398\ u \leq 2901v$

$3991\ u \leq 4321\ v$

$2538\ u \leq 3084\ v$

$867\ u \leq 1558\ v$

$445\ u \leq 880\ v$

$667\ u \leq 865\ v$

$1462\ u \leq 3219\ v$

$1088\ u \leq 1806\ v$

$2766\ u \leq 4465\ v$

$612\ u \leq 1522\ v$

And $u, v \geq 0$

The optimal solution in this case (one input, one output) is:

$\theta^* = 0.522$.

So the efficiency for Al Azhar University / Gaza is $\theta^* = 0.522$ and the reference set E_0 = {Islamic University / Gaza} as it constrains above gave us an equality for both sides. We can interpret the efficiency for the remaining Universities in the same way that we used with Al Azhar University / Gaza so the final solution for them will be as in table 2.2.2.

Table 2.2.2

Reference sets

DMU	CCR (θ^*)	Reference set
Al Azhar University / Gaza	0.522	Islamic University / Gaza
Islamic University / Gaza	1	Islamic University / Gaza
Al Aqsa University / Gaza	0.891	Islamic University / Gaza
Hebron University	0.602	Islamic University / Gaza
Palestine Polytechnic University	0.547	Islamic University / Gaza
Bethlehem University	0.835	Islamic University / Gaza
Al Quds University	0.492	Islamic University / Gaza
Birzeit University	0.652	Islamic University / Gaza
An-Najah University	0.649	Islamic University / Gaza
Arab American University	0.435	Islamic University / Gaza

As shown in table 2.2.2 we can see clearly that Islamic University / Gaza is the reffencing store with respect to other Universities shown above so it is the efficient University between all and every other University .

We can modify the CCR model to make a new CCR model that maximizes the output with whatever inputs the DMUs have. This modified model is called output-oriented model the linear programing problem (LP_0) will be:

$Max_{u,v}$ U

Subject to:

$x_0 - X V \geq 0$

$Uy_0 - YV \geq 0$

$V \geq 0$

As X is the input matrix, Y the output matrix, V= (v_1 v_2 v_3 ….. v_m) and

U = (u_1 u_2 u_3…. u_s) .

In the above model we used the linear programing system to maximize outputs while using no more than the observed amount of any input. This model is very useful in our field of study which is higher education.

When we transform the above system by Defining $\lambda = \frac{V}{U}$, $\theta = \frac{1}{U}$ then the linear programing problem will be:

$Max_{u,v} \frac{1}{\theta}$

Subject to:

$\theta x_0 - X \lambda \geq 0$

$y_0 - Y \lambda \geq 0$

$\lambda \geq 0$

Which we can call the input oriented CCR model. This model minimizes the inputs as it maximizes the term $\frac{1}{\theta}$ while the outputs will remain fixed. It represents the dual problem for the output oriented CCR model. ([13] Page 58)

The next model is a CCR model that attempts to maximize outputs while using no more than the observed amount of any input. This model is another modified model (dual problem) for the output-oriented model, formulated as (LPO_0):

$Min_{p,q}$ $p\ x_0$

Subject to:

$q\ y_0 = 1$

$-\ p\ X + q\ Y \leq 0$

$p \geq 0\ ,\ q \geq 0$ ([13] page 60)

The next theorem shows the feasible solution for (LPO_0):

Theorem 2.2.1 ([10] Page 24):Let an optimal solution of [LP_o) be (v, u*), then an optimal solution of the output-oriented model (LPO_o) is obtained from*

$p^*=v^*/\Theta^*$, $q^*=u^*/\Theta^*$. *([13] page 60)*

2.3 A slack- based measure of efficiency (SBM)

The SBM model was introduced by Tone (1997) ([32]) it has mainly two important properties:

1- It is units invariant as the measure is invariant with respect to the unit of measurement of each input and output item.
2- The measure is monotone decreasing in each input and output slack. ([13] page 100]

Tone ([32, 33]) defined the SBM by the fractional programing problem with λ,s^- and s^+ as s^- and s^+ is defined as input excess and output short fill, m is number of inputs, s is number of outputs and λ is column vector:

$$\text{Min}_{\lambda,s^-\,s^+}\ \rho = \frac{1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{i0}}}{1-\frac{1}{s}\sum_{r=1}^{s}\frac{s_i^+}{y_{i0}}}$$

Subject to:

$$x_0 = X\lambda + s^-$$

$$y_0 = Y\lambda - s^+$$

$$\lambda \geq 0\ ,\ s^- \geq 0\ ,\ s^+ \geq 0$$

In this model to reach a solution we assume that $X \geq 0$. We delete the term s^-_i/x_{i0} if $x_{i0} = 0$ and we replace it by a very small positive number.

We can interpret the formula corresponding to ρ above to be:

$$\rho = \left(\frac{1}{m}\sum_{i=1}^{m}\frac{x_{i0}-s_i^-}{x_{i0}}\right)\left(\frac{1}{s}\sum_{r=1}^{s}\frac{y_{i0}-s_i^+}{y_{i0}}\right)^{-1}$$

Theorem 2.3.1([32]): If DMU A dominates DMU B so that $x_A \leq x_B$ and $y_A \leq y_B$ then $\rho^*_A \geq \rho^*_B$.

The SBM model can be transformed to the next linear programing problem by introducing appositive scalar variable t:

$$\text{Min}_{\,t,\,\lambda,s^-,s^+} \quad \tau = t - \frac{1}{m}\sum_{i=1}^{m}\frac{ts_i^-}{x_{i0}}$$

Subject to:

$$1 = t + \frac{1}{s}\sum_{r=1}^{s}\frac{ts_i^+}{y_{r0}}$$

$$x_0 = X\lambda + s^-$$

$$y_0 = Y\lambda - s^+$$

$$\lambda \geq 0\ ,\ s^- \geq 0\ ,\ s^+ \geq 0\ ,\ t \geq 0$$

Now define $S^- = ts^-$, $S^+ = ts^+$, and $\Lambda = t\lambda$.

Then the linear programing model becomes:

$$\text{Min}_{t,\ \Lambda, s^-, s^+}\ \tau = t - \frac{1}{m}\sum_{i=1}^{m}\frac{S_i^-}{x_{i0}}$$

Subject to:

$$1 = t + \frac{1}{s}\sum_{r=1}^{s}\frac{S_i^+}{y_{i0}}$$

$$tx_0 = X\,\Lambda + S^-$$

$$ty_0 = Y\,\Lambda - S^+$$

$$\Lambda \geq 0,\ s- \geq 0,\ s+ \geq 0,\ t \geq 0$$

The optimal solution of SBM is:

$P^* = \tau^*$, $\lambda^* = \Lambda^*/ t^*$, $s^{+*} = S^{+*}/ t^*$. ([13] Pages 97-102)

Definition 2.3.1 ([13] page 102): A DMU (x_0, y_0) is SBM-efficient if and only if P = 1.*

In this model the reference set R_0 is defined by:

$R_0 = \{j \mid \lambda^*_j \geq 0\}$ where $j \in \{1, 2, 3, \ldots, n\}$.

2.4 Cone- ratio method

The cone- ratio method is another model used to find the efficiency of firms and organizations after making restrictions on some of the multipliers that affects the efficiency. Let's restrict the weight v to be in the polyhedral convex cone spanned by the k admissible nonnegative direction vectors (a_j) (j = 1, 2, …. , k).

V can be interpreted now as:

$V=\sum_{j=1}^{k} \propto_j a_j$ with $\propto_j \geq 0 \quad (\forall j)$

$= A^T \propto$

Where $A^T = (a_1 , a_2 , \ldots, a_k) \in R^n$ and $\propto^T = (\propto_1, \propto_2, \ldots., \propto_k)$

The same restrictions will be used on the feasible region of the output weight u. we restrict the feasible region in the polyhedral convex cone U spanned by the I admissible nonnegative direction vectors b_j (1, 2, …., l) .

U will be defined as:

$U =\sum_{j=1}^{l} \beta_j b_j$ with $\beta_j \geq 0$ (∀j)

$= B^T \beta$

Where $B^T = (b_1, b_2, \ldots, b_j) \in R^n$ and $\beta^T = (\beta_1, \beta_2, \ldots., \beta_j)$ ([13] page 186)

The linear programing problem for cone- ratio will be given as:

$\text{Max}_{\propto, \beta} \beta (By_0)$

Subject to:

$\propto (A x_0) = 1$

$-\propto (AX) + \beta (BY) \leq 0$

$\propto \geq 0$

$\beta \geq 0$ ([13] page 188)

It's clear that the polyhedral cone-ratio method has the same way of finding the efficiency like the basic CCR model except that the cone-ratio method evaluates the DMUs by the transformed positive data $\bar{X}, \bar{Y}$ as:

$\bar{X} = AX \in R^{k \times n}$ And $\bar{Y} = BY \in R^{l \times n}$

2.5 Malmquist index model

It is an index representing total factor productivity growth of a DMU. It can describe the regress or progress in efficiency along with frontier technology between two periods of time. We can define it by understanding two concepts:

1- Catch up: it defines the degree of how DMU improves or worsens its efficiency.
2- Frontier shift: it reflects the change in the efficient frontiers between the two time periods.

Malmquist index deals with n DMUs (x_j, y_j) as j= 1, 2, 3, …., n . Each DMU have m inputs denoted by a vector $x_j \in R^m$ and q outputs denoted by a vector $y_j \in R^q$ over the periods 1 and 2 .

We assume that $x_j > 0$ and $y_j > 0$ ($\forall$j)

The production possibility set $(X, Y)^t$ as t= 1and 2 spanned by (x_j , y_j) as j = 1, 2, …., n is defined by :

$$(X, Y)^t = \{(x, y) \mid x \geq \sum_{j=1}^{n} \lambda_j x_j^+, 0 \leq y \leq \sum_{j=1}^{n} \lambda_j y_j^+, L \leq e\lambda \leq U, \lambda \geq o\}$$ ([13] Page 328)

Where e is the raw vector with all elements equal to one , $\lambda \epsilon$ R^n is the intensity vector and L,U are the lower and upper bounds for the sum of the intensities as (L, U) = { (0, ∞), (1,1) (1, ∞), (0, 1) }. ([13] Page 328)

The production possibility set $(X, Y)^t$ is characterized by frontiers that are composed of $(x, y) \in (X,Y)^t$, so it is not possible to improve any element of input x or any element of output y without making the input or output go worse.

The catch up effect from period 1 to period 2 is measured by:

$$\text{Catch up} = \frac{efficiency \quad of \ (x_0, y_0)^2 with \quad respect \quad to \quad period\, 2 \quad frontier}{efficiency \quad of \ (x_0, y_0)^1 with \quad respect \quad to \quad period\, 1 \quad frontier}$$

([13] Page 329)

It can be expressed by:

$$C = \frac{\delta^2((x_0, y_0)^2)}{\delta^1((x_0, y_0)^1)} \quad \text{As } \delta \text{: distance.} \qquad \text{([14] Page 217)}$$

catch up >1 indicates progress in the relative efficiency from period one to period 2 and means the DMU improved productivity between those two periods while if catch up ≤ 1 then no change in efficiency when catch up =1 and regress in efficiency for the DMU when its less than one .

The catch up effect is determined by the efficiencies being measured by the distances from the respective frontiers expressed as:

Frontier shift $\Phi = \sqrt{\Phi_1 \Phi_2}$ ([13] Page330)

We can represent it as:

$$F = \left[\frac{\delta^1((x_0, y_0)^1)}{\delta^2((x_0, y_0)^1)} \times \frac{\delta^1((x_0, y_0)^2)}{\delta^2((x_0, y_0)^2)} \right]^{\frac{1}{2}}$$ ([14] Page 217)

When frontier shift >1 then there is a progress in the frontier technology around DMU_0 between the two periods. When the frontier shift = 1 then there is no change in the frontier technology and also when it's less than 1 then there is a regress in the frontier technology.

Malmiquist index is the product of the catch up and frontier shift so Malmiquist index will be expressed in the formula:

$$MI = \frac{\delta^2((x_0, y_0)^2)}{\delta^1((x_0, y_0)^1)} \times \left[\frac{\delta^1((x_0, y_0)^1)}{\delta^2((x_0, y_0)^1)} \times \frac{\delta^1((x_0, y_0)^2)}{\delta^2((x_0, y_0)^2)} \right]^{\frac{1}{2}}$$

$$= \left[\frac{\delta^1((x_0, y_0)^1)}{\delta^2((x_0, y_0)^1)} \times \frac{\delta^1((x_0, y_0)^2)}{\delta^2((x_0, y_0)^2)} \times \left(\frac{\delta^2((x_0, y_0)^2)}{\delta^1((x_0, y_0)^1)} \right)^2 \right]^{\frac{1}{2}}$$

$$= \left[\frac{\delta^1((x_0, y_0)^1)}{\delta^2((x_0, y_0)^1)} \times \frac{\delta^1((x_0, y_0)^2)}{\delta^2((x_0, y_0)^2)} \times \frac{\delta^2((x_0, y_0)^2)}{\delta^1((x_0, y_0)^1)} \times \frac{\delta^2((x_0, y_0)^2)}{\delta^1((x_0, y_0)^1)} \right]^{\frac{1}{2}}$$

Hence

$$MI = \left[\frac{\delta^2((x_0, y_0)^2)}{\delta^2((x_0, y_0)^1)} \times \frac{\delta^1((x_0, y_0)^2)}{\delta^1((x_0, y_0)^1} \right]^{\frac{1}{2}}$$

Remarks ([13] page 331, [14] page 217 and [26]):

1- MI>1 indicates that there is improvement in the total productivity of DMU_0 from the first period in to the second period meaning that the efficiency has improved between the two periods.
2- MI=1 indicates no change in the total productivity so the efficiency didn't improve from the first period into the second period.
3- MI<1 indicates that the total productivity for the original DMU_0 regressed from the first period in to the second and so the efficiency also decreased going throw these periods.
4- The MI depends on the distance function which indicates non negativity axioms.

The most powerful interpretation of the malmiquist index was introduced by Tone (2001) [33]. It uses the slacks-based non radial and oriented DEA model and evaluates the efficiency of by examining (x_o,y_o) as s= 1,2 with respect to the evaluator set $(X,Y)^t$ as t = 1, 2. It was expressed by the linear programing problem:

$$\delta^t((x_0,y_0)^s) = \min_{\lambda,s^-} 1-\frac{1}{m}\sum_{j=1}^{m}\frac{s_j^-}{x_{j0}^s}$$

Subject to:

$$X_0^s = X^t\lambda + s^-$$

$$y_0^s \leq Y^t\lambda$$

$$L \leq e\lambda \leq U$$

$$\lambda \geq 0$$

Where the vector $s^- \in R^m$ denotes inputs slacks. ([14] Page 210)

Chapter 3

Literature review

In this chapter a selected sample of previous studies that used DEA different models in deferent fields will be presented.

D.Angeliidis and K.lyroudi(2006) used DEA to evaluate the efficiency in the Italian banking industry. The non-parametric method that they used is Malmiqust index for the period of 2000-2001 to examine the productivity of 100 of the larger Italian banks. They used a group of inputs and outputs according to the value added method. Neural networks regression analysis in addition to the OLS traditional approach were used to determine the best approach that minimizes the error between estimated and actual values. The productivity was measured by the Malmquist index and was found to be equal to 1.035, which means that total productivity increased by 3.5%. Its two components, the technological change index was found equal to 0.559 and the technical efficiency change index was equal to 1.853 [5].

Z.Yang (2009) presented an evaluation of 240 branches of one big Canadian bank in Toronto using DEA. As methodology, he used the production approach and the financial intermediation approach. The BCC model that was used in the paper was utilized in order to consider the size effect. He founded that the variations among the branches were very big and the total efficient branches were 113 from the total number of branches (240). Special emphasis was placed on how to present the DEA results to management so as to provide more guidance to them on what to manage and how to accomplish the changes in this paper [35].

J. Akazili1, M. Adjuik1, C. Jehu-Appiah2 and E. Zere3 (2008) used DEA to measure the extent of technical efficiency of 89 randomly sampled public health centers in Ghana. They aimed to determine the degree of efficiency of health centers and recommend performance targets for the inefficient facilities. The inputs that they used are Number of non-clinical staff including laborers, Number of clinical staff and Number of beds and cots. Outputs were General outpatient visits, Number of antenatal care visits, Number of deliveries, Number of children immunized and Number of family planning visits. Inputs and outputs were chosen very carefully as they may affect the distribution of technical efficiency. The study showed that 65% of health centers were technically inefficient and were using resources that they did not need[1].

B. Casu, C. Girardone, P. Molyneux (2004) presents productivity change in over 2000 European banks from 1994 throw 2000.they used the Malmquist index as anon parametric approach and compared it with a decomposition of cost changes as the parametric approach. The results using the two approaches were close and don't have much change as the same efficiency estimates were interpreted. Both parametric and non-parametric estimations suggest a clear productivity growth in the Italian and Spanish banking sectors, whereas results are mixed for French and German banking section. They concluded that the competing methodologies do not yield markedly different results in terms of identifying the main components of productivity growth[9].

R. Tóth(2009) aimed that the higher education reform process both in Hungary and in the European countries is establishing a competitive, qualitative higher education with efficiently operating institutions. He used DEA models to compare the efficiency of higher education systems and to examine whether their efficiency is

influenced by the extent of the contribution of the state and the private sector or socio-economic factors like GDP per capita and education level of parents. One input and two output variables for comparing the European higher education systems were used in his paper. He used the CCR model with output – orientation with 29 DMUs. The paper found that the GDP per capita has the most considerable influence on what results the countries achieve in higher education relative to their inputs, and the degree of the state contribution is negatively correlated to the efficiency measure and then concluded that the rise of the private contribution to the expenses of higher education is a more effective tool of the enhancement of efficiency in the poorer countries than in the richer ones [34].

A. Aristovnik and A. Obadic(2011) applied three models of DEA to assess the relative technical efficiency of higher education across countries, with a particular focus on Croatia and Slovenia. They used a set of three inputs along with seven outputs on a thirty seven country (DMU). They divided the set of inputs and outputs into three groups then they used the CCR output-oriented model in order to achieve their goal. The papers results suggest the significant inefficiency of higher education spending in Croatia. On the other hand, the higher education system in Slovenia is shown to have a much higher level of efficiency compared to Croatia as well as many other comparable countries. They emphasized that when using a non-parametric approach differences across countries are not statistically assessed which may be considered a further limitation of the results [5].

In M. M. Rayeni and F.H. Saljooghi(2010) DEA was used to assess a set of twenty- one education departments of the Islamic Azad University- Zahedan branch in Iran in 2008-2009 academic years. They used Interval efficiency in the performance assessment and to have a more accurate ranking. They also used

optimism coefficient as a new method in ranking. One of the most significant advantages of this method is the compatibility and stability of which in ranking, also efficient departments is generally reduced and regarding the optimism coefficient as they stated in the paper [27].

Z. Daghbashyan(2011) investigated the economic efficiency of higher education institutions in Sweden to determine the factors that cause efficiency differences. In the paper Stochastic frontier analysis is utilized to estimate the economic efficiency of 30 Higher Education Institutions for the academic years 2001-2005 using both pooled and panel data approaches. He used a set of11 inputs categorized in to four groups: Input Price, Student characteristics, Staff characteristics and cost. Six outputs were used along with the inputs in order to achieve his goal. The results of the analysis suggested that Swedish Higher Education Institutions differ in their cost efficiency. He found that the estimated efficiency of most universities is above the mean and only 6 Higher Education Institutions have got efficiency estimates below the average. The results also suggest that the efficiency of Swedish Higher Education Institutions did not change much within the period discussed [15].

E. Martin (2003) used a large set of inputs and outputs and classified them in to five groups, three groups representing inputs and two representing outputs. The objective was to assess the performance of the 52 departments in Zaragoza University in Spain in the year 1999. He classified the sets of inputs and outputs in to four models with different combinations of inputs and outputs. To analyze the data he used the data envelopment analysis CCR model on the four models. He concluded that most of the inefficient departments are near the aim value. The reason of such a high number of efficient departments in his opinion is that the results were influenced by

the number of variables introduced in the models, the more variables introduced the more units will compute efficient [22].

V. Bosettia, M. Cassinellia,..(..etc) discussed a methodology to assess the performances of tourism management of local governments when economic and environmental aspects are considered as equally relevant. They used a set of 3 inputs and 2 outputs in the period 2001/2002. An output-oriented variable return to scale model has been used to compute the relative static efficiency and dynamic efficiency of each municipality of 194 Italian municipalities for the years 2001 and 2002. The results show that 8 DMUs were considered efficient. More studies are required according to the researchers [8].

J. Benneyan, M. Erkan Ceyhan and A. Sunnetciused data envelopment analysis studies to identify countries with the most efficient healthcare systems in terms of translating resources consumed into outputs produced in their paper " Data Envelopment Analysis of national healthcare systems and their relative efficiencies" in 2007. The analyses identify 27-65 countries on empirical performance frontiers based on six key dimensions of healthcare systems: clinical outcomes, health adjusted life years, access, equity, safety, and resources. They used a total of 5 inputs and 6 outputs in order to reach their goal. The United States, Canada, and New Zealand have very low DEA scores, whereas the UK and Australia both are on the best practice frontier (score = 1) [7].

N. Zhang, A. HU, and J.Zheng have simplified the health production efficiency model and adopts the narrow definition of efficiency as the relative

efficiency of a medical and health system in transforming input into output while treating part of the social environment variables as possible factors of influencing the efficiency. They used output-oriented BCC model and used DEA software EMS to calculate the technical efficiency of China's provincial health production in the years 1982, 1990 and 2000. They used asset of three inputs and one output on 30 hospitals in China. They used five different models according to influencing factors to be analyzed. Results showed that 4 hospitals were considered efficient in 1982 while 6 and 9 were efficient in 1990 and 2000 respectively which indicate that the number of provinces with relative technical efficiency increased gradually [36].

A.Ibiwoye presented a frontier efficiency method for handling multiple inputs and outputs. It uses real data from the insurance sector to demonstrate the merit of the frontier approach for assessing productivity and for policy formulation. The paper " Evaluating financial services productivity: a compression of ratios, index numbers and frontier methods" used DEA to evaluate the efficiency and productivity for 10 insurance companies in the period 2000/2005 in Nigeria. The 10 companies from which data were collected are leading companies in the market as their combined total share represents about 65% of the insurance market. Using CCR model eight companies were generally efficient with respect to technical and scale efficiency while two were found to be inefficient [19].

R. Malhotra, D.K. Malhotra, and H. Lermack analyzed the performance of seven North American Class I freight railroads in 2010 using DEA models. Five of them were considered efficient resulting the CCR model. They presented that Data envelopment analysis clearly brings out the firms that are operating more efficiently in

comparison to other firms in the industry, and points out the areas in which poorly performing firms need to improve [21].

P.L. Lam and A. Shiu used DEA to find the productivity performance of China's telecommunications sector before and after the reform in 1994. The study covers the period between 1975 and 2005for 39 Telecommunications Company. They used a set of three inputs and one output with the malmiqust index model. They founded that the average growth in TFP is 5.5% per annum during the period 1975 to 2005. The average TFP growth rate during the post-reform period (1994-2005) is 6.8%, which is much higher than the growth rate of 4.6% during the pre-reform period (1975-1993). By the decomposition of the TFP they founded that the TFP growth indicates that telecommunications companies in China have achieved a higher growth rate in technological change. They concluded that technological change is found to be the major source of TFP growth for China's telecommunications companies [20].

M. S. Gok,and B. Sezen investigated the efficiencies of hospitals in Turkey with respect to their own-erships for the years 2001 to 2006 in their paper "Analyzing the efficiencies of hospitals : an application of data envelopment analysis". The distribution of total number of hospitals in their data set is as follows: 2001- 477 hospitals; 2002 – 504 hospitals; 2003 – 526 hospitals; 2004 – 566 hospitals; 2005 – 569 hospitals, 2006 – 608 hospitals which includes all of Turkeys hospitals. They used a set of three inputs and ten outputs with the efficiency measurement system (EMS) was used to evaluate hospital efficiency. They used Malmquist Productivity Index can be used to measure the patterns of efficiency changes on the panel data. They concluded that most of the efficient hospitals were from the small cities and that

there is a negative correlation between the city population and the hospital efficiencies[18].

Chapter4

Methodology

This chapter consists of three sections discussing the methodology used in this thesis.

4.1 Data

The data has been collected from the Ministry of Higher Education annual publications. The detailed data were collected from the universities reports that are submitted by the Ministry of Higher Education for the years of 2006, 2008 and 2010. The final sample consisting of 11 DMUS that form all traditional universities in Palestine except Al- Quds Open University. Evaluating educational system is more difficult than evaluating efficiency for economic institutions such as benefit assessment to determine DMU performance or inputs and outputs economic value, because inputs and outputs generally stand in the education, research and human resources which the measurement of an assessment unit is very difficult. Inputs and outputs can be chosen in several ways and the efficiency of the educational institution can be measured according to the set of variables (inputs and outputs).

There are many variables that can be considered in any research seeking the efficiency of those institutions. In this research we considered the human resources approach to measure the efficiency of the traditional universities in Palestine. This approach was used by M. Rayeni and F. Saljooghi (2010) [27] as they measured the efficiency of the departments in Islamic Azad University. This is a useful approach as it measures the efficiency according to the most important assets to the universities as they cannot function probably without the existence of the right number of human resources.

4.2 Inputs and outputs

In this thesis we used a group of 7 inputs and 2 outputs. We selected them to have the most important inputs and outputs that we can find according to the principle that we choose to work on and the availability of the data. Choosing the suitable set of inputs and outputs is crucial to find the efficiency of the university. The inputs that we will consider in this thesis are : total number of applications applied to the university for bachelor degree, total number of applications applied to the university for master's degree, total newly undergraduate enrolled students, total newly graduate enrolled students, number of professors(Phd holders),number of teaching assistance, and number of Phd researchers. The outputs are: number of bachelor degree graduates and the number of master degree graduates.

4.3 Methods

We used three different methods, two of them are DEA models and the third is the traditional regression analysis. The first method that we used is the basic CCR model output- oriented. The output-oriented approach is the appropriate one for higher education because the principle of cost minimization is not applied according to the market conditions. We chose this model to find the efficiency for every university for each year (2006, 2008 and 2010) separately.

The second DEA model that we used is the Malmquist index of Total Factor Productivity (TFP) change. This model will measure the total productivity change as well as the efficiency change along the period (2006-2010). Using these two DEA models we can see the change of the efficiency and how it was affected during that time period. It will be easier to determine the ups and downs of the efficiency and what affected them along the time period. This way gives a more accurate judgment

on the growth or retardation of efficiency. Regression analysis will be used to examine the hypothesis whether there is a relation between the inputs and the efficiency of the traditional universities in Palestine.

We will use multiple software's to conduct the analysis for each model. DEA Excel Solver software will be used to conduct the analysis for the basic CCR model and we will verify our analysis by using DEA Solver Online software from the University of Hohenheim. Malmquist index of Total Factor Productivity (TFP) change analysis will be conducted by DEAP (v 2.1) software and we will verify our analysis by using KonSi DEA software. Regression analysis will be conducted by the reliable SPSS (v15) software.

Chapter5

Data analysis

In this chapter we will perform three kinds of analysis on the data set. The first section consists of a CCR model analysis and results for that analysis. Malmquist index analysis will be performed in the second section and the results will be presented. In the last section standard regression analysis will be applied on data in order to find the output. Three software programs will be used in order to get our results (DEA Excel Solver, DEAP (v 2.1), and SPSS**).**

5.1 Basic CCR model analyses

Using the DEA Excel Solver, the output oriented CCR model efficiency has been calculated for the traditional Universities in Palestine. The scores are shown in table 5.1.1 below:

Table 5.1.1

CCR efficiency score between 2006/ 2010

University	CCR efficiency 2006	CCR efficiency 2008	CCR efficiency 2010
Al- Azhar University / Gaza	0.8473	1.0000	0.9887
Islamic University / Gaza	1.0000	1.0000	1.0000
Al- Aqsa University / Gaza	1.0000	1.0000	1.0000
Hebron University	0.9716	0.899	1.0000
PalestinePolytechnic University	0.6769	0.5878	0.8916
Bethlehem University	1.0000	1.0000	1.0000
Al- Quds University	1.0000	1.0000	1.0000
Birzeit University	1.0000	1.0000	1.0000
An-Najah National University	1.0000	0.9841	1.0000
Arab American University	1.0000	1.0000	1.0000
PalestineTechnology University	1.0000	1.0000	1.0000

Table 5.1.1 shows that there are three Universities that scored less than the full score. These three universities are: Al- Azhar University which had a 0.8473 efficiency score, Hebron University which had a 0.9716 efficiency score and Palestine Polytechnic University which had a 0.6769 efficiency score. These three universities were considered inefficient as the efficiency score for each one of them are less than one. Islamic University, Al- Aqsa University, Bethlehem University, Al- Quds University, Birzeit University, An- Najah University, Arab American University and Palestine Technology (Khadory) had perfect score as they all have a CCR efficiency score one, this means that those universities were considered as efficient regarding to the basic CCR model.

In 2008 the efficiency score has been indorsed a little change as An- Najah University efficiency score became less than one efficiency score, at the same time Al- Azhar University efficiency score reached one in the same year.

Al- Azhar University, Islamic University, Al- Aqsa University, Bethlehem University, Al- Quds University, Birzeit University, Arab American University and Palestine Technology University were efficient as they all had a CCR efficiency score of one. Hebron University, Palestine Polytechnic University and An- Najah University had a CCR efficiency score less than one indicating that these universities were considered inefficient. Hebron University's efficiency score was 0.8990 shown in table 5.1.1 which is less than the efficiency score 0.9716 in 2006 for the same University. The efficiency scores indicates a general growth for all traditional universities in Palestine in 2010.two universities still considered inefficient but they had relatively high efficiency score.

The efficiency score of 0.9887 for Al- Azhar University which means that although the score is almost one but, Al- Azhar University still considered inefficient. Palestine Polytechnic University had a 0.8916 efficiency score showed in table 5.1.1 which indicates significant growth of efficiency according to the efficiency score of 0.5878 showed in 2008.

5.2 Malmquist index analysis

The malmiquist index (output oriented) efficiency change and total factor productivity (TFP) change has been calculated. A value of the index greater than one indicates positive TFP growth while a value less than one indicates TFP decline over the period. Productivity change is then decomposed into technological change (TC), and technical efficiency change (TEC), where TFP=TC×TEC.

The analysis overall shows a total productivity growth by (1.9%) as shown in table 5.2.1.

Table5.2.1
Malmquist index total productivity

EFFC	TC	TEC	TFP
1.021	1.015	1.004	1.019

The productivity growth seems to have been brought by the technological change (TC) which had a growth by (1.5%). The efficiency also shows a growth by (2.1%) in the period 2006/2010.

The results in table 5.2.2 and Figure 5.2.1 show a productivity growth for most of the universities. In practical for Al- Azhar University / Gaza (12.1%), Islamic University / Gaza (23.8%), Al- Aqsa University / Gaza (24.8%) and for Arab American University (16.3%). Productivity growth has been more modest for Birzeit University, An-Najah University and Palestine Technology University (7.3%, 2.5% and 4.8% respectively). In the same time, Hebron University, Palestine Polytechnic University, Bethlehem University and Al- Quds University (- 9.1%, - 4.7%, - 41% and – 22.8% respectively) had a drop in productivity.

Table 5.2.2
Malmquist index Efficiency change and Total factor productivity for individual Universities

University / Time period	2006/2008		2008/2010		2006/2010	
	EFFC	TFPC	EFFC	TFPC	EFFC	TFPC
Al- Azhar University / Gaza	1.180	1.083	0.989	1.159	1.080	1.121
Islamic University / Gaza	1.000	1.385	1.000	1.107	1.000	1.238
Al- Aqsa University / Gaza	1.000	1.092	1.000	1.427	1.000	1.248
Hebron University	0.925	1.076	1.112	0.768	1.015	0.909
Palestine Polytechnic University	0.868	1.094	1.517	0.829	1.148	0.953
Bethlehem University	1.000	0.672	1.000	0.518	1.000	0.590
Al- Quds University	1.000	0.691	1.000	0.861	1.000	0.772
Birzeit University	1.000	1.050	1.000	1.095	1.000	1.073
An-Najah University	0.984	1.165	1.016	0.903	1.000	1.025
Arab American University	1.000	1.214	1.000	1.112	1.000	1.163
Palestine Technology University	1.000	0.881	1.000	1.210	1.000	1.048

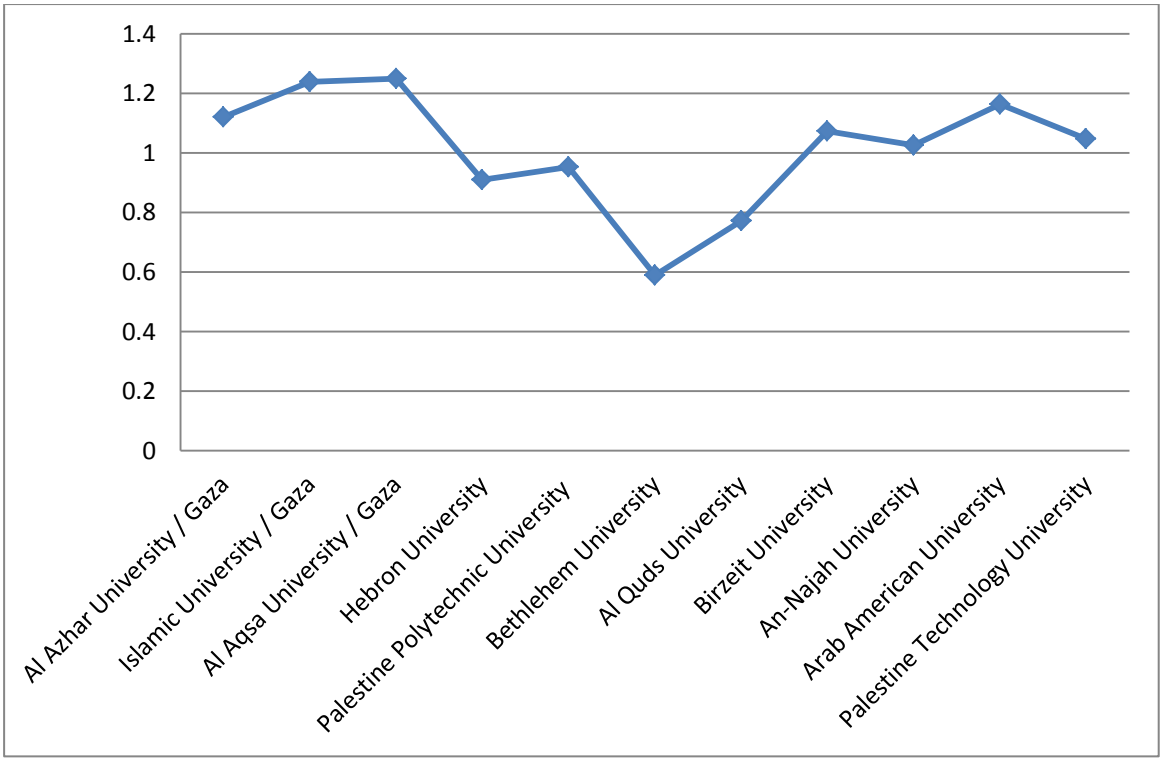

Figure 5.2.1
Malmquist index total factor productivity change 2006/2010

Al- Azhar University / Gaza, Hebron University and Palestine Polytechnic University have a significant growth in efficiency (8%, 1.5% and 14.8% respectively) in the period 2006/2010 which explains the change of efficiency that we noticed between the years 2006 and 2010 that we noticed using the basic CCR model in the previous section as we can see in table 5.1.1. Figures 5.2.2, 5.2.3 and 5.2.4 show that growth.

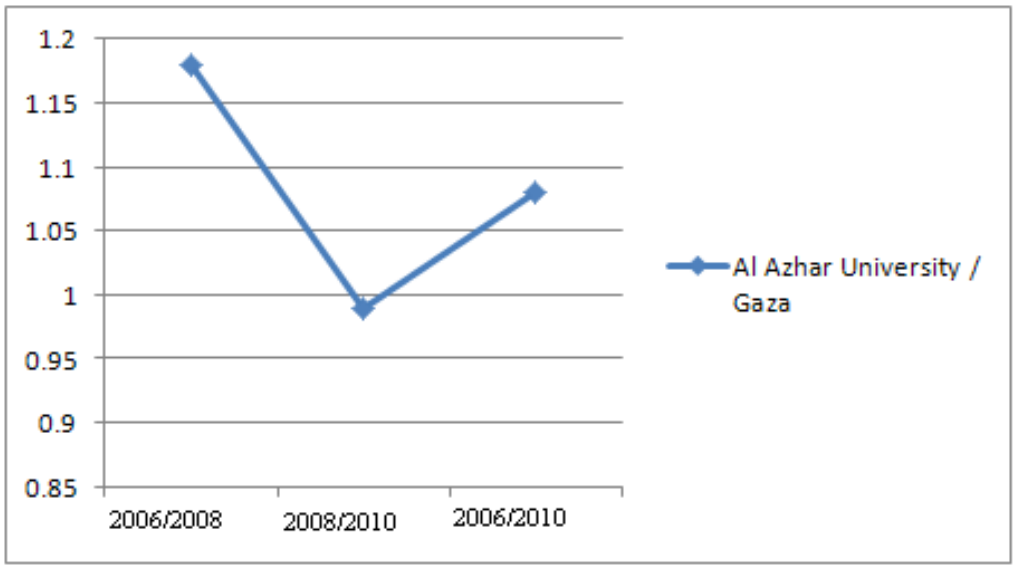

Figure 5.2.2
Efficiency change for Al-Azhar University / Gaza

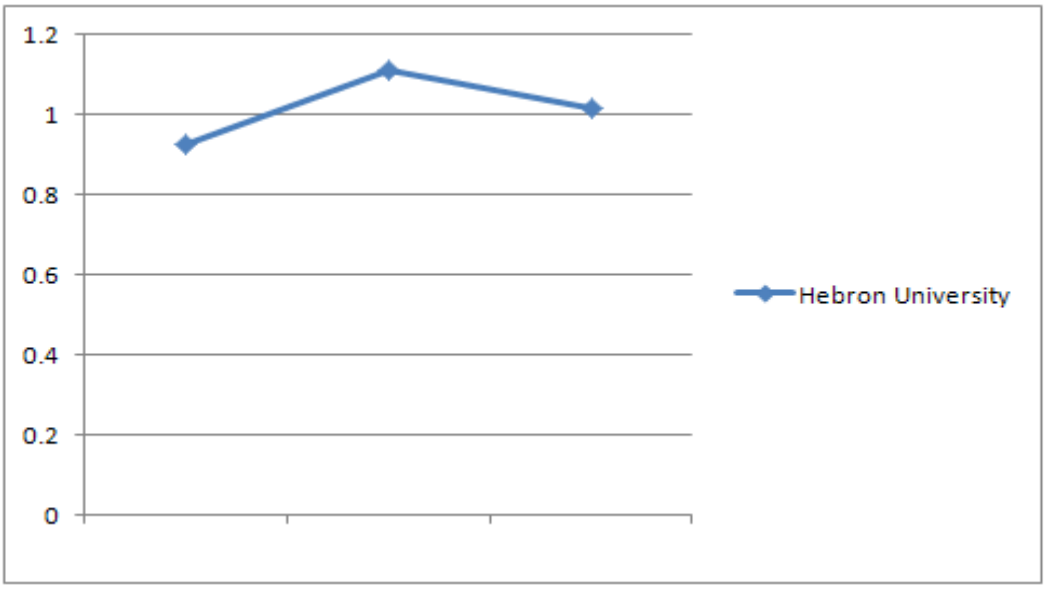

Figure 5.2.3
Efficiency change for Hebron University

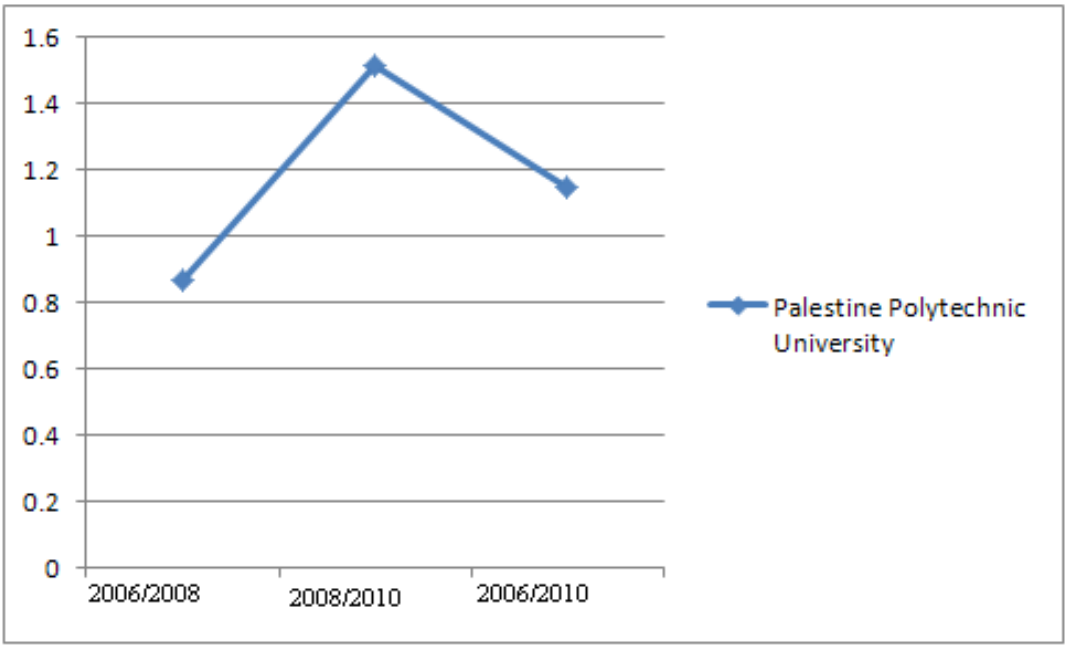

Figure 5.2.4
Efficiency change for Palestine Polytechnic University

5.3 Regression analysis

We chose the inputs for the DEA model as the independent variables in the standard regression analysis that we applied. The dependent variable that we considered is efficiency of the traditional universities in Palestine in the period 2006/2010. There was a problem with normality due to the dependent variable as we can notice from Figure 5.3.1.

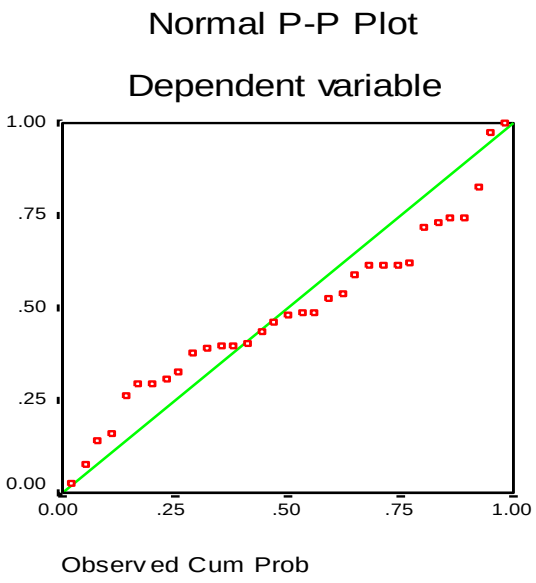

Figure 5.3.1
Normal P-P Plot for dependent variable

After transforming the data to be normal, the analysis results didn't improve so the transformation was neglected and we used the original data with the problem of normality. The independent variables also suffered problems with normality and linearity and after transforming them; neither changes nor improvements on the regression model were found. We used the original independent variables without transformation.

We used regression analysis to find the relationship between the efficiency of the traditional Universities in Palestine in the period 2006/2010 and the number of bachelor and master gradates. We wanted to study the effect of independent variables on the dependent variable and also we wanted to find the most effective independent variable.

The probability of the F statistic in the ANOVA table ($F(7, 25) = 25.587$, $p<0.001$) was less than or equal to the level of significance (0.05) as we can notice from table5.3.1. The null hypothesis that Multiple R was equal to zero was rejected. The

research hypothesis that there was a relationship between "efficiency of the traditional universities in Palestine in the period 2006/2010" and "inputs of the DEA model".

Table 5.3.1
F test

Model		Sum of squares	df	Mean square	F	Sig
1	Regression	27069449	7	3867064	25.587	Sig<0.001
	Residual	3778309	25	151132		
	total	30847758	32			

The Multiple R for the relationship between the combined set of independent variables and the dependent variable shown in table 5.3.2 was (0.937), which would be characterized as a very strong relationship using the rule of thumb that a correlation between 0.0 and 0.20 is very weak; 0.20 to 0.40 is weak; 0.40 to 0.60 is moderate; 0.60 to 0.80 is strong; and greater than 0.80 is very strong.

Table 5.3.2
R Square test (Model fit)

Model	R	R Square	Adjusted R Square
1	0.937	0.878	0.843

The predictor with the largest influence on the dependent variable was the statistically significant independent variable with the largest beta coefficient. According to table 5.3.3, the beta coefficient for "Total newly undergraduate enrolled students" (0.610) was higher than that of the other statistically significant independent variables.

Table 5.3.3
T test for individual independent variables

Model		Unstandardized coefficients		standardized coefficients	t	Sig
1		B	Std. Error	Beta		
	(Constant)	51.630	149.081		0.346	0.732
	application forums UND	0.110	0.115	0.216	0.712	0.483
	application forums for master	0.884	0.523	0.444	1.691	0.103
	enrolled new students UND	0.402	0.154	0.610	2.607	0.015
	enrolled new students master	-0.178	1.037	-0.041	-0.172	0.865
	Phd holders	-2.844	2.701	-0.280	-1.053	0.302
	Phd researcher	-26.625	36.375	-0.073	0.732	0.471
	teaching assistance/ master	1.478	1.868	0.133	-0.795	0.435

Based on the statistical test of the b coefficient (t = 2.607, sig=0.015) for the independent variable "Total newly undergraduate enrolled students ", the null hypothesis that the slope or b coefficient was equal to zero was rejected. The research hypothesis that there was a relationship between "Total newly undergraduate enrolled students " and " efficiency of the traditional Universities in Palestine in the period 2006/2010" was supported. The b coefficient for the relationship between the dependent variable " efficiency of the traditional Universities in Palestine in the period 2006/2010" and the independent variable " Total newly undergraduate enrolled students " was (0.402), which implies a direct relationship because the sign of the coefficient is positive. Higher numeric values for the independent variable " Total newly undergraduate enrolled students " are associated with higher numeric values for the dependent variable " efficiency of the traditional Universities in Palestine in the period 2006/2010"

The rest of the independent variables show no significant effect on the dependent variable as we can notice from table 5.3.3.

Table 5.3.4
Correlation analysis for the variables

	Input1	Input2	Input3	Input4	Input5	Input6	Input7	Output1	Output2
Input1	1	0.632	0.936	0.635	0.925	0.072	0.822	0.868	0.552
Input2	0.632	1	0.501	0.935	0.738	0.416	0.700	0.624	0.878
Input3	0.936	0.501	1	0.541	0.837	- 0.103	0.715	0.892	0.345
Input4	0.635	0.935	0.541	1	0.735	0.215	0.702	0.638	0.857
Input5	0.925	0.738	0.837	0.735	1	0.178	0.903	0.792	0.692
Input6	0.072	0.416	- 0.103	0.215	0.178	1	0.180	-0.049	0.553
Input7	0.822	0.700	0.715	0.702	0.903	0.180	1	0.710	0.725
Output1	0.868	0.624	0.892	0.638	0.792	-0.049	0.710	1	0.421
Output2	0.552	0.878	0.345	0.857	0.692	0.553	0.725	0.421	1

Correlation analyses were done for each pair of variables and it was shown in table 5.3.4. We did not find any evidence of very high correlation between any one input variable and any other (nor between output variables) and any one input variable having very low correlation with any of the output variables (nor between output variable and input variables) in table5.3.4. This is a reasonable validation of our DEA models. When finding very high or very low correlation between the one of the inputs and outputs, one of them needs to be excluded from the DEA model.

5.4 Results

The traditional universities in Palestine are divided into three groups by the basic CCR model analysis. The first group is the efficient group which consists of: Islamic University / Gaza, Al- Aqsa University / Gaza, Bethlehem University, Al-Quds University, Birzeit University, Arab American University and Palestine Technology University. Theses Universities were considered efficient at the year 2006 and remain efficient through the next two years2008 and 2010. The efficiency score for these Universities remained one at the three periods of time as shown in table 5.1.1 indicating that there were no significant change in efficiency during the years 2006,2008and 2010. This we can conform by Using Malmquist index analysis to find the efficiency change in the next section. The efficient Universities managed to use the human resources which indicated in the set of inputs and outputs used in this analysis in the pest way to reach this efficiency score. Number of students registered in the bachelor and masters programs in these Universities were consistent with the number of graduates from those programs.

The second group of analyzed University's showed some change in the efficiency. This group consisted of: Al Azhar University / Gaza, Hebron University and An-Najah University. These three universities showed an efficiency score which is almost one. Al Azhar University / Gaza efficiency score in 2006 was 0.8473 as shown in table 5.1.1. This efficiency score were improved in 2008 to reach the efficiency score one and again in 2010 the efficiency score dropped to 0.9887 in 2010. Hebron University scored 0.9716 efficiency in 2006 as shown in table 5.1.1. While in 2008 and 2010 the efficiency score were 0.899 and one consecutively. An-Najah University efficiency score were one in 2006 then dropped to 0.9841 in 2008 and reached one again in 2010. The efficiency that recorded for the three universities at

those years is nearly one at the most of the time so we cannot say that those universities are not efficient according to the DEA analysis.

The third group has just one University which is Palestine Polytechnic University. This University is considered inefficient according to the efficiency scores as its efficiency score in 2006 were 0.6769 as shown in table 5.1.1. The efficiency score dropped in 2008 to be 0.5878 then again improved to reach 0.8916 in 2010.

In general the traditional Universities in Palestine showed a good efficiency scores according to the chosen set of inputs and outputs. In the next two sections we will give further detailed analysis to the efficiency score to reach our final point of view according to the efficiency of those universities.

The malmiquist index (output oriented) divided the traditional universities in Palestine into three groups according to the total factor productivity change score. The first group of universities had a significance growth in productivity. In fact, we can notice from Figure 5.2.1 that Al- Aqsa University / Gaza had the most productivity growth between the other Universities with a productivity growth of (24.8%). Islamic University / Gaza comes second with a productivity growth (23.8%). The third and fourth universities according to the productivity growth were Arab American University and Al- Azhar University / Gaza with (16.3% and 12.1% respectively). Gaza strip universities clearly dominated the scores as the three traditional universities of Gaza were in the top four due to the productivity growth. We will find the reason for this enormous growth with the help of Regression analysis in the next section.

The second group of universities endured a slightly significant growth in productivity according to the analysis. Birzeit University, Palestine Technology

University and An-Najah University scored (7.3%, 4.8% and 2.5% respectively) productivity growth which is a good rate of growth in relation with the various variables that surrounds the growth of higher education in Palestine nowadays.

Hebron University, Palestine Polytechnic University, Bethlehem University and Al- Quds University endured a drop in productivity as there rates are (- 9.1%, -4.7%, 41% and 22.8% respectively) table 5.2.2. In the meantime, the efficiency of Bethlehem University and Al- Quds University shows no change as they were considered efficient. Hebron University and Palestine Polytechnic University showed a growth in efficiency from 2006 into 2010 as the efficiency change rate were (1.5% and 14.8% respectively).

Despite the ups and downs of the total factor productivity that affected universities, the total productivity for the traditional universities of Palestine between the years of 2006 and 2010 had grown by (1.9%) as we can see in table 5.2.1.

The standard regression analysis showed a statistically significant relationship between "efficiency of the traditional Universities in Palestine in the period 2006/2010" and the independent variables. The independent variables explain approximately 88% of the variance in efficiency of the traditional Universities in Palestine in the period 2006/2010. There was a positive relationship between "Total newly undergraduate enrolled students " and " efficiency of the traditional Universities in Palestine in the period 2006/2010". "Total newly undergraduate enrolled students " is the most useful predictor of dependent variable. The independent and dependent variables were suffering some problems with linearity and normality but the transformation did not have any effect on the model so the analysis were conducted using the original data without any transformations. The correlation analyses supported the presence of the set of outputs and inputs in the DEA model.

Chapter 6

Discussion

This chapter discusses the results of my analysis and compares it with some of the previous studies in the same field.

The traditional universities in Palestine graduate about 78% of the holders of bachelor's and master's degree carriers in Palestine. These Universities is the most important high education institutes in Palestine as they are considered as the educated community, leading power and the core of political decision in Palestine. Studying the efficiency and productivity of those Universities must be apriority for all the researchers that are in this field. We can determine the strength and the weakness in the high educational system in our country. We decided to do this research due to the need to improve the performance and productivity of the high education sector in Palestine.

The CCR basic model that we used in this research was used by many researches in different ways with the same objective most of the time. Réka Tóth(2009) used the basic CCR model in his paper as he compared the efficiency of higher education systems and examined whether their efficiency is influenced by the extent of the contribution of the state and the private sector or socio-economic factors like GDP per capita and education level of parents in the European Union. He used the output oriented CCR mode in addition to the standard CCR model. The two models supported each other as the results were almost the same for the two models. He found that the GDP per capita has the most considerable influence on what results the countries achieve in higher education relative to their inputs, and the degree of the state contribution is negatively correlated to the efficiency measure. He concluded

that the rise of the private contribution to the expenses of higher education is a more effective tool of the enhancement of efficiency in the poorer countries than in the richer ones. In this research we founded a positive relationship between "Total newly undergraduate enrolled students " and " efficiency of the traditional Universities in Palestine in the period 2006/2010" which is consistent with Réka Tóth(2009) conclusions as the traditional Palestinian Universities depends on the tuition fees which increases with the increase of total newly undergraduate enrolled students. The output oriented CCR model results were consistent in both research's Neglecting the deferent data set that the model were used on [34].

The output oriented CCR model was used also by A. Aristovnik and A. Obadic (2011) [5] evaluate the efficiency of higher education in Croatia and Slovenia. They used four different models depending on the CCR model and founded that without using statistical analysis the results will be limited and not processed enough in order to make a valid and accurate decision. In this research we used the traditional regression analysis to back up my results the came from the CCR model. We used the correlation analysis to echoer that my set of inputs and outputs are valuable and important to the DEA analysis. None of my inputs or outputs was found unnecessary and the excluded from the analysis. The statistical analysis used in the research is considered an advantage as they were consistent with the DEA analysis that we used.

M. M. Rayeni and F.H. Saljooghi(2010) used the same set of inputs and outputs that I used in my research with some differences. They used the output number of researches (projects) in addition to the number of bachelor and masters graduates that I used in my research. The set of inputs and outputs affects the efficiency score especially when we use the DEA models in education. It is more difficult to choose the inputs and outputs because of the diversity in variables that

exist in this field compared to the variables that we can see in other fields. The results of the CCR model were consistent with the results that we found in the research despite the deference of the nature of the data as we used the CCR model to find the efficiency of the traditional Universities in Palestine. They used interval efficiency of educational departments in order to have an accurate ranking for the departments in the University. Interval efficiency was used also to determine optimistic efficiency from CCR model and pessimistic efficiency through cross-efficiency [27].

In this thesis we used the malmiquist index (output oriented) model in order to determine a more accurate ranking for the traditional Universities in Palestine in the period 2006/2010. Malmiquist index model determine the efficiency and productivity change which is more accurate in the case of a time period because of the nature of the malmiquist index that is defined to be used for a time period.

E.Martin(2003) used a big set of inputs and outputs by dividing them in to four different combinations of inputs and outputs . He used the basic data envelopment analysis in the performance assessment of the Zaragoza University departments on these four models. The results were affected by the number of inputs and outputs used in the model. The relationship between the number of variables and the efficiency were positive so the more variables are introduced, the more units computed efficient. He used these four models to compare the efficiency results between the departments. In this research we used Malmiquist index analysis to do the comparison instead of the big number of variables due to the Lack of variables and the difficulties that faced me to collect them [22].

Z. Daghbashyan(2011) investigates the economic efficiency of higher education institutions (HEI) in Sweden to determine the factors that cause efficiency

differences using both pooled and panel data approaches. He used statistical analysis to decide the set of inputs and outputs as in my research with some difference as we used the correlation analysis instead of the basic descriptive statistical analysis. Pooled and panel data approaches were utilized to check for the robustness of results. The results suggest that Swedish HEI differ in their cost efficiency. The results for his study suggest that the age and quality of students do not affect the cost efficiency. These two variables were not used in my set of variables [15].

The use of malmiquist index analysis were used also in D. Angelidis and K. Lyroudi(2006). They used malmiquist index model to calculate the Efficiency in the Italian Banking Industry. They also used the traditional regression analysis as they used neural networks regression in order to support the results of the DEA model. They had inconclusive results as the regression analysis didn't support the malmiquist index analysis. In the research we choose to use standard regression analysis which supported the DEA model results. Our results were inconsistent because of the two different regression approaches used in the two researches. In the other hand, D. Angelidis and K. Lyroudi used correlation analysis to confirm the effect of the variables in their paper which is the same way I used in order to confirm the same aspect [4].

The thesis results were consistent with the previous studies most of the time except for some different methods that has been used in some studies but leads to the same result. The slandered regression analyses were useful parametric method to support my DEA models analysis. The set of inputs and outputs were consistent with some of the groups of variables that been used in other previous studies. I discussed my results with these previous studies because of the lack of previous studies in this field of research in Palestine. This thesis is considered as the first that is using DEA

models in order to find the efficiency of the Traditional Universities in Palestine. More studies in this area are considered indispensable if we want to understand the whole picture and try developing this important part of our educational system. The efficiency and productivity of the traditional high educational institutions in Palestine needs more consideration, funding and human resources.

Chapter 7

Conclusions and Recommendations

7.1 Conclusions

In this thesis, we used the basic CCR model and the malmiquist index (output oriented) which is a data envelopment analysis models to examine the efficiency and the performance of the efficiency of the traditional Universities in Palestine in the period 2006/2010. We used the traditional standard regression analysis to find the relationship between "efficiency of the traditional Universities in Palestine in the period 2006/2010" and "total number of applications applied to the university for bachelor degree, total number of applications applied to the university for master's degree, total newly undergraduate enrolled students, total newly graduate enrolled students, number of professors(Phd holders),number of teaching assistance, and number of Phd researchers". We used these three methods in order to provide a more comprehensive and complete picture of the traditional Universities in Palestine.

The thesis aims to find the efficiency, the most growth in productivity, and the effect of the inputs and outputs on the efficiency of the traditional Universities in Palestine. The CCR basic model of data envelopment analysis was used to found the efficiency along the period 2006/2010. Most of The traditional Universities in Palestine were efficient according to this model. Two of these Universities were considered to be less efficient than the rest. Al Azhar University / Gaza and Palestine Polytechnic University had an efficiency score of (0.9887 and 0.8916 respectively in 2010) table5.1.1.

The malmiquist index (output oriented) model supported the results of the CCR model in terms of the efficiency and showed a 2.1 % growth in the efficiency between the years 2006 and 2010. The total factor productivity shows a (1.9%) growth as shown in table 5.2.1. this growth is relatively significance taking into account the political changes in Palestine in that period. the most developed universities in Palestine in the period 2006/2010 according to the productivity growth were Gaza's traditional Universities as Al- Aqsa University / Gaza come first with productivity growth of (24.8%), Islamic University / Gaza comes second with a productivity growth of (23.8%) and Al- Azhar University / Gaza were in fourth place with a productivity growth of (12.1%). The West bank traditional Universities had just one University in the top four which was the Arab American University as it comes third with productivity growth of (16.3%) table 5.2.2. the remaining universities had either a more modest growth in productivity or had a drop in productivity. The worst drop in productivity were (- 41%) productivity change for Bethlehem University.

The traditional regression analysis showed that there is a statistically significant relationship between "efficiency of the traditional Universities in Palestine in the period 2006/2010" and "the number of bachelor and master gradates". Regression analysis supported the data envelopment models as it shows that the set of inputs and outputs explains approximately 88% of the variance in efficiency of the traditional Universities in Palestine in the period 2006/2010. The regression analysis considers "Total newly undergraduate enrolled students " as the most variable that effects the efficiency score. Correlation analysis shows that neither one of inputs nor outputs needs to be excluded from the DEA model.

The traditional universities in Palestine in general showed a growth in many aspects as the data shows promising evolution in the next few years. Tending to higher education is also growing in Palestine and has a promising future.

7.2 Recommendations

The field of higher education is very important to every nation as it can be considered the strength, success, and evolution for any community. In this research we used some of the data envelopment models to evaluate the position that our nations higher education institutes in order to develop this section in the coming years. Still this sector needs much more research. Some of the most important recommendations that we can suggest to the next period is as follow:

1- In this thesis the sets of inputs and outputs were gathered after lots of difficulties that faced me so expanding the set of inputs and outputs for more useful and accurate results for the traditional Universities in Palestine are recommended when possible.

2- A similar research including Al Quds Open University is recommended to get an idea of the efficiency and productivity growth of open higher education in Palestine.

3- Using data envelopment analysis to determine the efficiency of departments within the same University is crucial to the development of the traditional Universities in Palestine when the data is available and accessible.

4- A comparison study between the traditional Universities in Palestine and the traditional Universities in the surrounding countries may be very important when data and resources are available.

5- The mathematics behind the DEA is very important and it’s a very good field to investigate. It’s crucial to work in this field in the near future especially that no more positivity restrictions are recommended as A. Emrouznejad and A. Anouze had modified some of the DEA models. More and more work can be done in this field in the near future.

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Appendix:

Data set for the years 2006, 2008, and 2010

Table App.1

(Data set for Universities in 2006)

U name	App. Und	App. grd	En. und	En. grd	Phd	Res.	T.ass.	Bach grd	Mast grad
Al Azhar/	2179	96	1176	15	179	0	123	638	0
Islamic/	6146	666	4945	345	250	0	164	1944	70
Al Aqsa/	3495	0	2793	0	154	1	142	1249	37
Hebron	1492	44	1015	28	95	0	116	676	0
Palestine Polytechnic	1032	0	877	0	45	1	61	280	0
Bethlehem	1637	25	784	41	54	0	83	372	51
Al Quds	3000	606	1056	492	172	0	175	843	296
Birzeit	2946	1217	1330	316	211	8	197	932	281
An Najah	4598	497	3691	374	259	1	199	1739	145
Arab American	882	0	604	0	58	0	84	468	0
Palestine Technology	692	0	444	0	8	0	30	208	0

Table App.2

Data set for Universities in 2008

U name	App. Und	App. grd	En. und	En. grd	Phd	Res.	T.ass.	Bach grd	Mast grad
Al Azhar/	3608	0	2572	0	183	0	91	1309	41
Islamic/	5950	903	4889	547	259	0	222	3186	143
Al Aqsa/	5050	0	4544	0	174	1	179	1967	0
Hebron	1975	78	1368	51	91	0	134	890	16
Palestine Polytechnic	1557	34	1473	34	48	0	79	399	0
Bethlehem	2156	25	835	24	61	0	107	598	19
Al Quds	4631	740	2771	411	214	0	203	1258	309
Birzeit	4124	723	1745	319	175	7	157	1256	306
An Najah	6422	558	4601	254	307	0	340	2476	200
Arab American	1324	0	971	0	69	0	82	750	0
Palestine Technology	743	0	554	0	15	0	37	272	0

Table App.3

Data set for Universities in 2010

U name	App. Und	App. grd	En. und	En. grd	Phd	Res.	T.ass.	Bach grd	Mast grad
Al Azhar/	5122	351	2901	8	188	1	78	1398	0
Islamic/	5800	1896	4321	804	267	0	240	3991	305
Al Aqsa/	3796	0	3084	0	176	1	140	2538	0
Hebron	2158	120	1558	52	90	0	111	867	17
Palestine Polytechnic	1218	77	880	42	51	0	67	445	6
Bethlehem	2048	116	865	57	81	0	109	667	17
Al Quds	4253	1225	3219	643	309	0	285	1462	316
Birzeit	4026	1272	1806	433	242	12	253	1088	449
An Najah	7348	770	4465	315	358	0	421	2677	233
Arab American	1768	88	1522	25	90	0	97	612	0
Palestine Technology	389	0	182	0	27	3	54	346	0