EVALUATING RESEARCH PERFORMANCE OF TURKISH UNIVERSITIES

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

PELİN DENİZ TEKNECİ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE DOCTOR OF PHILOSOPHY
IN
THE PROGRAMME OF SCIENCE AND TECHNOLOGY POLICY STUDIES

SEPTEMBER 2014

Approval of the Graduate School of Social Sciences

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ABSTRACT

EVALUATING RESEARCH PERFORMANCE OF TURKISH UNIVERSITIES

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Ph.D., The Programme of Science and Technology Policy Studies
Supervisor: Prof. Dr. Erol Taymaz

September 2014, 275 pages

This dissertation employs different methodologies to evaluate research performance of 94 Turkish universities over the period between 2008 and 2010, compares their results, and identifies factors that enhance their performance. It consists of three papers revolving around the research performance of Turkish universities. First, we apply different Data Envelopment Analysis models and identify the best-fitting model. Second, we investigate the impact of selected factors on different research outputs using panel data analyses. Third, we use Stochastic Frontier Analysis to measure the research efficiency of Turkish universities in terms of their publication and citation performance and investigate factors affecting their efficiency.

Our study will contribute to the literature in three aspects. First, we use both DEA and SFA to measure solely the research performance of both public and private Turkish universities. Secondly, we use normalized research outputs to take field-based performance differences into account. Third, while analyzing the impact of factors on the research performance, we include different research outputs instead of focusing on a single research output.

Our results show that measuring research performance of universities is a complicated issue such that DEA and SFA provide different rankings. On the other hand, both models indicate that private universities (compared to public universities), and associate professors (compared to professors and assistant professors) have better performance; PhD students, external research funds and academic support personnel per faculty member significantly enhance the research performance. Moreover, it is seen that research efficiency most probably depends on the inherent abilities, culture and management practices of universities.

Keywords: Universities, Research Performance, Data Envelopment Analyses, Stochastic Frontier Analyses.

ÖZ

TÜRKİYE'DEKİ ÜNİVERSİTELERİN ARAŞTIRMA PERFORMANSLARININ DEĞERLENDİRİLMESİ

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Tez Yöneticisi: Prof. Dr. Erol Taymaz

Eylül 2014, 275 sayfa

Bu tez, 94 adet Türk üniversitesinin 2008-2010 yılları arasındaki araştırma performanslarını farklı yöntemler kullanarak ölçmeyi, sonuçlarını karşılaştırmayı ve araştırma performansını artıran faktörleri tespit etmeyi amaçlamaktadır. Bu kapsamda üç farklı analiz yapılmıştır. İlkinde farklı Veri Zarflama Analizi (VZA) modelleri uygulanmış, en uygun model belirlenmiştir. İkinci çalışmada panel veri analizi yöntemiyle bazı faktörlerin farklı araştırma çıktıları üzerindeki etkileri incelenmiştir. Üçüncü çalışmada Stokastik Sınır Analizi (SSA) yöntemi kullanılarak Türk üniversitelerinin yayın ve atıf performanslarına ilişkin etkinlikleri ölçülmüş, buna etki eden faktörler araştırılmıştır.

Bu çalışmanın literatüre üç temel katkısı bulunmaktadır. İlk olarak VZA ve SFA yöntemleri kullanılarak hem devlet hem de vakıf üniversitelerinin sadece araştırma alanındaki performansı incelenmiştir. İkinci olarak her iki yöntemde disiplinler arası görülen performans farklılıklarını değerlendirmeye yansıtabilmek için normalize edilmiş çıktılar kullanılmıştır. Üçüncü olarak faktörlerin tek bir çıktıya değil, farklı çıktılara olan etkileri bir arada değerlendirilmiştir.

Analiz sonuçları SSA ve DEA yöntemlerinin farklı etkinlik değerleri hesapladığını göstermektedir. Diğer yandan her iki yöntemde de vakıf üniversitelerinin devlet üniversitelerine kıyasla daha etkin olduğunu, araştırma çıktılarına en yüksek katkıyı doçentlerin verdiğini, öğretim üyesi başına düşen doktora öğrencisi, araştırma fonu ve destek personel sayısının araştırma performansını yükselttiği bulunmuştur. Ayrıca, araştırma etkinliğinin üniversitelerin kurum içi becerilerine, kültürüne ve yönetim süreçlerine oldukça bağlı olduğu tespit edilmiştir.

Anahtar Kelimeler: Üniversiteler, Araştırma Performansı, Veri Zarflama Analizi, Stokastik Sınır Analizi.

To My Parents, Aslan and Nezahat Eren

ACKNOWLEDGMENTS

I am deeply grateful to Prof. Dr. Erol Taymaz, Prof. Dr. Erkan Erdil, Assoc. Prof. Dr. M. Teoman Pamukçu, Assoc. Prof. Dr. Emre Özçelik and Prof. Dr. Burak Günalp for their guidance, advice, criticism, encouragements and insights throughout the research.

I thank my colleagues Hamide Karahan Turan and Eser Pirgan Matur for their encouragements and psychological support.

All kinds of technical and motivational support and limitless understanding provided by Serkan Tekneci during all phases of this study is extremely precious.

My family has given me marvelous support during the preparation of this thesis. In this respect, I thank my son Aslan Levin Tekneci, and my parents Aslan Eren and Nezahat Eren for all they have done for me during this long journey.

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AARD	Academic and Applied Research and Development
AFVS	Agricultural, Forestry and Veterinary Sciences
AHCI	Arts and Humanities Citation Index
AHES	Annual Higher Education Statistics
AİBÜ	Abant İzzet Baysal Üniversitesi
AR	Assurance Region
ARDEB	Academic Research Funding Program Directorate
ARWU	Academic Ranking of World Universities
Asc.Prf.	Associate Professor
Ast.Prf.	Assistant Professor
BCC	Banker, Charnes and Cooper
BTY	Bilim, Teknoloji ve Yenilik
ÇAYDAG	Environment, Atmosphere, Earth and Marine Sciences Research Group
CCR	Charnes, Cooper and Rhodes
CF	Citations per Faculty
CHERPA	Consortium for Higher Education&Research Performance Assessment
CIVR	Committee for the Evaluation of Research
CPCI-SSH	Conference Proceedings Citation Index –Social Science & Humanities
CPP	Citations per Publication
CRS	Constant Returns To Scale
CWTS	Centre for Science and Technology Studies
DEA	Data Envelopment Analyses
DEÜ	Dokuz Eylül Üniversitesi
DRS	Decreased Return to Scale
EC	European Commission
EEAG	Electrical, Electronics and Informatics Research Group
ERI	External Research Income
ES	Efficiency Scores
ESOGÜ	Eskişehir Osmangazi Üniversitesi
EU	European Union
FE	Fixed Effects
FP	Fractional Program
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditures on R&D
GYTE	Gebze Yüksek Teknoloji Enstitüsü
HEFCE	Higher Education Funding Council for England
IRS	Increased Return to Scale

ISSN	International Standard Serial Number
İTÜ	İstanbul Teknik Üniversitesi
İYTE	İzmir Yüksek Teknoloji Enstitüsü
KSÜ	Kahramanmaraş Sütçü İmam Üniversitesi
KTÜ	Karadeniz Teknik Üniversitesi
LP	Linear Program
LR	Likelihood Ratio
MAG	Engineering Research Group
MBA	Master of Business Administration
METU	Middle East Technical University
MoD	Ministry of Development
MSGSÜ	Mimar Sinan Güzel Sanatlar Üniversitesi
MSTI	Ministry of Science Technology and Industry
NAS	Natural and Applied Sciences
NCF	Normalized Citations per Faculty
NGO	Non-Governmental Organization
NI	Normalization Index
NPF	Normalized Publications per Faculty
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
ÖSYM	Öğrenci Seçme ve Yerleştirme Merkezi
PBRF	Performance Based Research Funding
PF	Publications per Faculty
PhD	Doctor of Philosophy
POLS	Pooled Ordinary Least Square
Prf.	Professor
QS	Quacquarelli Sysmonds
R&D	Research and Development
RAE	Research Assessment Exercise
RDC	Research Degree Completions
RE	Random Effects
REF	Research Excellence Framework
REGPOT	Regional Potential
SBAG	Health Sciences Research Group
SCI	Science Citation Index
Sci.	Sciences
SDÜ	Süleyman Demirel Üniversitesi
SFA	Stochastic Frontier Analyses
SME	Small and Medium Sized Enterprises
SOBAG	Social Sciences Research Group
SPO	State Planning Organization
SSA	Stokastik Sınır Analizi

SSCI	Social Science Citation Index
Std.Dev.	Standard Deviation
STI	Science, Technology and Innovation
TARAL	Turkey Research Area
TBAG	Basic Sciences Research Group
TEC	Tertiary Education Commission
THES	Times Higher Education Supplement
TOVAG	Agriculture, Forestry and Veterinary Research Group
TÜBİTAK	Scientific and Technological Research Council of Turkey
TURKSTAT	Turkish Statistics Institute
UK	United Kingdom
ULAKBIM	Turkish Academic Network and Information Center
UNESCO	United Nations Organization for Education, Science and Culture
URAP	University Ranking by Academic Performance
US	United States
VRS	Variable Returns to Scale
VTR	Valutazione Triennale della Ricerca
VZA	Veri Zarflama Analizi
WoS	Web Of Science
YTÜ	Yıldız Teknik Üniversitiesi

CHAPTER 1

INTRODUCTION

This dissertation deals with employing different methods to evaluate research performance of Turkish universities, comparing their results, and identifying factors that enhance their research performance. To this end, we use both data envelopment analysis (DEA) and stochastic frontier analysis (SFA) methods to calculate the research efficiency of 94 public and private Turkish universities over a three-year period; compare the results of the two methods; and determine factors that enhance research performance. Distinctive from previous studies in the literature, we make field-based normalizations with the research outputs in both DEA and SFA models in order to reflect per-faculty productivity differences that are observed across different scientific fields.

During the last decades, the demand for the services provided by universities has increased considerably. Because these institutions produce and disseminate knowledge, host modern research infrastructures, employ researchers and scientists, and raise qualified human resources. For this reason, they are placed among the most important actors of global techno-economic competition.

In several countries, we observe significant growth in mass higher education system during the last decades. Consequently, both total number of universities and university students have increased considerably. Total number of students in the world which was 20 million in 1984, has raised to approximately 150 million in 2007 (UNESCO, 2009; İlyas, 2012). This global enlargement in the tertiary education is supported by the demand from a continually growing segment of the population who believes having a graduate-level diploma will lead to greater lifetime earnings and opportunities, and by the needs of knowledge-based global economy (Altbach, 2011).

With increased number of universities and growing enrollment of students, several governments started to devote more funds for higher education, whereas the competition among universities to get more funds became fiercer. In this context, evaluating performance of universities has become critical for effective allocation and utilization of educational resources. Consequently, policies for increased selectivity and concentration aroused and performance evaluation systems for universities were introduced. In the end, performance-based funding of universities has become a notable feature of higher education systems in several countries due to the increased emphasis given on governance, accountability and quality assurance.

Gaining an academic reputation necessitates being a pioneer in knowledge production, fostering innovation, and having reputable researchers. As a result, research performance becomes one of the most important factors for assessing the overall performance of a university.

Research activity in universities is a process in which several inputs such as human capital, scientific infrastructure, financial resources and intangible resources such as knowledge and networks are used to produce both tangible and intangible outputs such as publications, patents, consulting activities, knowledge accumulation and human resources development (Abramo et al, 2011b). Thus, evaluating research performance of universities is not a straightforward process.

Performance of universities in the society and national economy should be investigated carefully in Turkey, since these institutions are among the major actors in terms of the research and development activities performed throughout the country. As of 2012, 43.9 % of R&D expenditures was realized in universities and 38.2% of full-time equivalent research personnel were employed by them (TURKSTAT, 2013).

Despite of this critical importance of universities in the Turkish R&D system, there isn’t a national-level evaluation system that focus on measuring their research and/or teaching performance. In addition, there are very few academic studies that focus on this issue.

This dissertation aims to fill this gap through employing both data envelopment analysis and stochastic frontier analysis methods to measure research performance of 94 public and private Turkish universities for the period between 2008 and 2010. In addition, we try to identify the impact of selected factors on the research performance through panel data analyses and come up with policy proposals regarding fostering research performance across Turkish universities.

The basic research questions that we try to find answers in this study are as follows:

1. Does productivity per faculty member in terms of the publications, citations, R&D projects, and PhD graduates vary across scientific fields?
2. If so, how can we reflect field-based productivity differences of research outputs into the DEA and SFA models?
3. Is DEA an appropriate methodology to measure research efficiency of Turkish universities?
4. Which DEA model is the most appropriate one to measure the research efficiency of Turkish universities?
5. What are the factors that positively and negatively affect research productivity and research efficiency of Turkish universities?
6. Do factors that have significant impact on one research performance measure have insignificant or opposite-directional impact on another one?
7. Do DEA models and SFA models that utilize similar inputs and outputs come up with similar efficiency rankings?
8. Between DEA and SFA, which methodology is more preferable to measure the research efficiency of Turkish universities?

While searching for the answers to these research questions, this dissertation generates some significant contributions to the existing literature on the assessment of research performance of universities. First of all, we implement DEA and SFA models that take field-based differences into account while measuring research efficiency of Turkish universities. In this context, we propose using field-based normalized outputs, rather than simply taking the sum of outputs from different scientific fields.

Secondly, we calculate per faculty productivity of Turkish universities in terms of different research outputs, for different scientific fields, and over a three-year period.

Thirdly, we evaluate research performance of both public and private Turkish universities for three consecutive years, using both DEA and SFA methods. We have not come up with this much comprehensive study for Turkish universities in the existing literature.

Fourth, different than previous studies that have employed stochastic frontier models with cost-function structures and evaluate the overall teaching and research efficiency of universities together, we develop stochastic frontier models with production-function structures and measure solely the research efficiency of universities.

In accordance with our research questions, this study is composed of seven chapters. First, different types of studies that aim to measure research performance of universities. In this respect, national research evaluation systems, classification exercises, rankings, and academic studies from the literature will be put forward. The literature survey performed in the second chapter has shown that several parametric and nonparametric methods are employed to evaluate teaching and research performance of universities, whereas Data Envelopment Analysis and Stochastic Frontier Analysis are among the most frequently used ones.

In the third chapter, we briefly provide information on key science, technology and innovation (STI) indicators of Turkey and trends observed in the Turkish higher education system. All of these figures depict the importance of higher education institutions in terms of national R&D studies. We also investigate performance of 94 Turkish universities in terms of the selected research outputs.

In the fourth chapter, we make a detailed bibliometric analysis with the output variables that are selected for the Data Envelopment Analysis and Stochastic Frontier Analysis. Additionally, bibliometric analyses for faculty members who are assumed to be the main human resources of the research activities are provided. These analyses enable us to capture the trends and differences in terms of research outputs and scientific fields over a three-year period. This chapter will contribute to the literature such that it provides per faculty productivity of different research outputs by separate scientific disciplines, and this type of data has not been presented in any other studies as far as we were able to reach.

The fifth chapter aims to specify and implement different DEA models to measure research efficiency of Turkish universities for the period between 2008 and 2010and identify the best fitting model. This chapter will contribute to the literature in three main aspects. First, we assess whether using DEA is an appropriate tool to measure research efficiency of universities. We have not come up with any other studies that assess suitability of using the DEA to measure research efficiency of universities.

Secondly, we implement DEA models that take field-based productivity differences into account. In this respect, we propose to use field-based normalized outputs, rather than simply taking the sum of outputs from different scientific fields. Normalizations made with the outputs alleviate biases that occur due to productivity-per-faculty differences across different scientific fields. A distinctive point of this study is that we make field-based normalizations in terms of PhD graduates and academic projects, apart from the previous studies that have made normalizations only with citations and publications but not with any other outputs.

Third, we evaluate research efficiency of both public and private Turkish universities for three consecutive years, which to our knowledge has not been done in other academic studies. In fact, all studies that we were able to reach have evaluated the overall teaching and research performance of universities, and none of them have focused solely on the research efficiency. In addition, the majority of them have either concentrated on only public or only private universities, and most of them have covered only one-year period.

In the sixth chapter, we investigate the impact of the selected factors on the research performance of Turkish universities. To this end, we use three years panel data from 2008 to 2010 and employ five different performance measures as dependent variables which are as follows:

(i) research efficiency scores
(ii) publications per faculty member (with field-based normalized values),
(iii) citations per faculty member (with field-based normalized values),
(iv) publications per faculty member (with absolute values),
(v) citations per faculty member (with absolute values).

We establish pooled OLS, fixed effects, and random effects models with each dependent variable so we establish a total of 15 panel data models. All models have the same independent variables. We run panel data models that have the same independent, but different dependent variables because we suspect that a factor that have significant impact on one performance measure might have insignificant or opposite directional impact on another one. This chapter will contribute to the literature in two main aspects. First of all, we were not able to find any other studies that simultaneously analyze the impact of factors on different research performance measures. Rather, they selected one research measure (such as publications per faculty) and made their analyses solely for this measure. Secondly, there are studies that have calculated research efficiency or research productivity of Turkish universities, but none of them have both calculated the research performance and also scrutinized the impact of factors on the research performance at the university level.

The seventh chapter has three objectives: First we develop two SFA models to measure research efficiency of 94 Turkish universities in terms of their publication and citation productivity. Secondly, impact of selected factors on research efficiency will be discussed. Third, the results of these two SFA models and DEA Model 6 that is developed in the sixth chapter will be compared. This chapter will contribute to the literature in two main aspects. First, none of the previous studies that we were able to reach have used SFA to measure solely the research efficiency of universities. Rather, they have evaluated the overall teaching and research efficiency together. Moreover, all of these studies have used a cost - function form of SFA and used total expenditures as the dependent variable, whereas we run a production function and include total publications and citations as the dependent variables. Secondly, we will implement SFA models that take field-based differences into account. In this respect, we propose to use the sum of field-based normalized outputs, rather than simply taking the sum of outputs from different fields, similar to what we have done in the previous chapters.

Finally, in the eighth chapter we present policy proposals towards enhancing research performance of Turkish universities based on our econometric analyses and literature survey.

CHAPTER 2

RESEARCH EVALUATION STUDIES FOR UNIVERSITIES

The importance of having qualified human resources, modern research infrastructures and innovation capacity has been increasing mainly due to the increased global techno-economic competition among countries. Consequently, the demand for services provided by universities, where knowledge is produced and disseminated, research infrastructures are established, researchers and scientists are working and qualified human resources are raised has increased considerably.

In several countries such as United States (UNESCO, 2009), United Kingdom (Geuna and Martin, 2003), Spain (Gomez-Sancho and Mancebon-Torrubia, 2010), and Australia (Abbott and Doucouliagos, 2003) an elitist system of higher education has been overtaken by a system of mass higher education, in which total number of universities and university students have increased considerably. The aim of mass education is to add maximum value to as many students as possible, whereas the elitist system favors an elite group of universities to maintain the market share by sustaining reputation (Ramsden, 1999). Due to this paradigm shift in higher education, total number of students in the world which was 20 million in 1984, has raised to approximately 150 million in 2007 (UNESCO, 2009; İlyas, 2012).

With increased number of universities, growing enrollment of students and limited funding resources, universities found themselves in competition for resources, students and reputation. Several governments faced with the problem of providing higher education in a more effective manner.

Evaluating the efficiency of universities becomes critical for effective allocation and utilization of educational resources. As a result, policies for increased selectivity and concentration were initiated and evaluations of university performance were introduced. The assumption behind these efforts is that if funds are allocated through performance evaluation systems, then there will be greater returns to the society (Geuna and Martin, 2003). Consequently, performance-based funding of universities becomes a notable feature of trends in higher education systems in several countries due to the increased emphasis given on governance, accountability and quality assurance.

Research performance is perhaps among the most important factors for assessing the performance of a university. Accelerating changes in the higher education sector and technology have obliged universities to increase their research capabilities and productivity. Universities are realizing that gaining an academic reputation necessitates being a pioneer in knowledge production, fostering innovation, and having reputable researchers.

Governments comprehend the importance of promoting universities that can successfully offer different types of services such as education, training, providing information on contemporary issues, consulting and research and development (R&D) activities, since all of these services eventually provide positive externalities to society. Among these services, R&D activities have a key role to ensure other services to be delivered at desired level and quality since they ensure keeping up with the social and technological changes realized in local and global environments.

We observe that public funding is the predominant source of funding for R&D activities realized in universities for most of the countries. In 2009 the mean for industry funding of university research is 6.3 % in OECD countries (OECD, 2012a). Nevertheless, to enhance R&D capacities in universities, several governments started to distribute funds based on productivity measures instead of funding research through block grants. The UK was the first to introduce performance based research funding based on the results obtained from the Research Assessment Exercise (RAE) in the mid 1980's. Australia and Finland started to use tools for competitive funding of research from the mid-1990s (Auranen and Nieminen, 2010).

Despite of providing transparent criteria to allocate funds, research assessment exercises are also criticized for discriminating against institutions which do not have strong scientific departments and a historical tradition of research (Dehon et al., 2010). Furthermore, performance-based funding might have adverse effects on the status of teaching and might lead to the separation of undergraduate curricula from research (Ramsden, 1999).

The aim of this chapter is to compile different studies aiming to measure research performance of universities. First of all, frequently used systems used in these studies will be explained. Then different performance evaluation studies related to research performance of universities will be discussed. In this respect, national research evaluation systems, classification exercises, rankings and academic studies from the literature will be put forward.

2.1. Frequently Used Systems for Measuring Research Performance

Performance measurement in research is a difficult and controversial process since it is a multidimensional process and results may change depending on the criteria selected and weights imposed on these criteria.

There are three classes of evaluation instruments to measure the research performance. They are (i) effort reporting or self-assessment, (ii) direct performance measurement and (iii) indirect performance measurement (Gibson, 1979). Each method has its liability and efficiency.

In effort reporting, individual researchers or research groups present their attainment in research using standard forms. Effort reporting is a flawed instrument to measure the quality and quantity of research. Only reputable outputs are reported in the forums, but performance in other areas such as training new scientists, time and effort spent for research are neglected (Gibson, 1979).

The best known type of direct measurement is peer review, whereas the most popular indirect measurement is bibliometric analyses. Based on the results of a survey of research methodologies in 11 European countries carried out by Geuna and Martin

(2001), bibliometric analyses and peer review are found as the most widespread methods for assessing research performance.

Research evaluation studies may employ one of these methods to evaluate research performance. But there are some studies which utilize two or more methods simultaneously. When peer review is supplemented with publication and citation data and other information, it is called ‘informed peer review’ (Geuna and Martin, 2003). In this section, brief information regarding peer review and bibliometric analyses, which are the most widespread evaluation methodologies, is provided.

2.1.1. Peer Review

Oxford Dictionaries define peer review as the assessment of scientific, academic, or professional work by others working in the same field. Evaluations done by peer-review differ considerably in structure and focus. Panels may examine the individual researchers, research groups or institutes. But the assessment unit in peer review is normally a project or an individual researcher.

Peer review can be done by one expert, but to minimize subjective decisions, usually a group of experts are included in evaluation panels. Panels are grouped by scientific fields and include experts in that scientific discipline. This methodology is frequently used by research funding authorities either to select the research projects to be funded or to assess the performance of an individual researcher or an institution.

Panel members receive various qualitative and quantitative data from a wide variety of sources and stakeholders regarding the unit under evaluation. These may include data on financial support, infrastructure opportunities, human resources, number of students, self-evaluations and lists of publications. The evaluation period can cover one year or multiple years. For example, Italian VTR investigates 3-year performance (Minelli et al., 2008), whereas national level research evaluations done by The Research Council of Norway covers a 5-year period (Aksnes and Taxt, 2004).

Some countries such as the Netherlands prefer hiring experts outside the country to avoid conflict of interest, whereas some others do not have such kind of a priority. The panels are requested to assess the strengths and weaknesses of each unit of analysis with respect to its research activities. Both quantitative and qualitative assessments are performed by panels and the results of national level peer reviews generally announced for transparency purposes. These results can be used by researchers who want to investigate the dynamics of the research performance of universities further.

Academic assessments done by peer review panels have both positive and negative aspects. Expert panels with high competence in the relevant disciplines provide a basis for advice for improving research and education as well as taking care of institutional diversity. They also have auxiliary benefits such that membership on panels provides panel members being able to keep in touch with current trends and promising young scientists (Gibson, 1979). On the other hand, employing peer review with wide coverage of scientific fields requires time and budget, thus they are generally applied by national research authorities of governments rather than individual organizations. Moreover, peer review is generally accused of including subjective assessment and not allowing country-wise comparisons since each country designs the system according to its own priorities. Thus, data covered in one set up is not covered in another and this prevents making international comparisons. Finally, this methodology is criticized for not promoting consistency and equal treatment among units of assessment (Langfeldt et al., 2010).

2.1.2. Bibliometric Analyses

Webster's Dictionary defines bibliometrics as the set of quantitative methods used to study or measure texts and information and it is often used to evaluate or compare the impact of groups of researchers within a field and to describe the development of fields. Citation analyses and content analyses are the most commonly used methods in bibliometric analyses.

Several quantitative research assessments that aim to measure academic output are using bibliometric analyses with the basic assumptions that number of papers that are published in international journals is an indicator of research productivity, whereas papers cited by scientists represent influence or quality of their work. Under these assumptions, data from citation indices can be analyzed to determine the popularity and impact of both researchers and their publications.

Several types of information can be derived from bibliometric data and studies with different evaluation purposes may employ different techniques to analyze the bibliometric data. For instance, specific research fields can explore the impact of their field on other scientific fields. Institutions or nations can identify in which scientific fields they are strong and which fields should be enhanced compared to others. Furthermore, trends in different scientific fields, collaboration patterns of scientists or interactions among different fields can be elaborated. Data envelopment analysis and statistical analyses, such as regression, correlation analysis and logit models are frequently used techniques to analyze bibliometric data.

The most frequently used bibliometric databases in the literature are Web of Science (WoS), Scopus, and Google Scholar. While WoS and Scopus are commercial databases, Google Scholar is an open access database.

WoS is an online academic citation index provided by Thomson Reuters. It is designed for providing access to multiple databases, cross-disciplinary research, and in-depth exploration of specialized subfields within an academic or scientific discipline. It covers full text publications, reviews, editorials, chronologies, abstracts, proceedings, technical papers, and patents. It has indexing coverage from 1900 to the present and more than 12,000 journals in approximately 256 fields are covered in WoS[1].

Scopus database of Elsevier is launched in 2004 and indices 18,500 peer-reviewed journals. It includes publications published from 1823 on, but information regarding citation analyses is available only for publications published after 1996. It covers serial publications, which include journals, trade journals, book series and conference materials that have an International Standard Serial Number (ISSN)[2]. Publications in Scopus are classified under four broad subject clusters which are: life sciences, physical sciences, health sciences and social sciences & humanities. They are further

[1] Last retrieved on May 29, 2014 from http://thomsonreuters.com/content/science/pdf/Web_of_Science_factsheet.pdf

[2] Last retrieved on May 29, 2014 from http://www.info.sciverse.com/scopus/scopus-in-detail/facts

divided into 27 major subject areas and more than 300 minor areas. Publications may belong to more than one subject area[3].

Google Scholar is a freely accessible web search engine that indices the full text of scholarly literature in the format of publications, theses, books, abstracts and court opinions from academic publishers, professional societies, online repositories, universities and other web sites. It was released in November 2004 and aims to rank documents by weighing the full text of each document, where it was published, who it was written by, as well as how often and how recently it has been cited in other scholarly literature.[4]

Bibliometric data is widely available, accessible and affordable. Furthermore, it includes the same type of data for each scientific discipline and country, and many academic studies dealing with research, evaluation nationwide or among different countries or disciplines prefer to use bibliometric data.

Bibliometric analyses are criticized as they include only a limited amount of publications, and favor publications written in English. Publications that are not covered by the bibliometric databases such as domestic journals, books, and case studies are also forms of research outputs. However, these outputs are so diversified in their forms that it is difficult to judge their research value. Publications that are not covered by international journal indices can be assessed by scientific panels in national level analyses, thus combining peer review and bibliometric analyses will provide a more comprehensive coverage of the research performance.

Aksnes and Taxt (2004) investigated the relationship between bibliometric indicators and the outcomes of peer reviews. Based on a case study of research groups at the University of Bergen, Norway, they examined how various bibliometric indicators were correlated with evaluation ratings given by expert committees. The results showed positive but relatively weak correlations for all selected indicators. Similarly,

[3] Last retrieved on May 29, 2014 from
http://files.sciverse.com/documents/pdf/ContentCoverageGuide-jan-2013.pdf

[4] Last retrieved on May 29, 2014 from http://scholar.google.com/intl/en/scholar/about.html

Saisana et al. (2010) observed low degrees of correlation between expert-based indicators and citation-based indicators.

Francescheta and Costantini (2011) compared outputs of Valutazione Triennale della Ricerca (VTR), which is an Italian research assessment exercise based on peer review with bibliometric indicators and found a positive correlation between expert decisions and bibliometric indicators.

2.2. Studies on Evaluation of Research Performance of Universities

Research evaluation activities may cover a wide range of activities. In addition to typical research evaluation activities done by governments and researchers, classification of universities, and academic rankings provide evidence on the research performance of universities since classification exercises and rankings heavily depend on the research performance of universities. Accordingly, evaluation exercises regarding research performance of universities are classified under 4 different groups in this study. These are:

1- National research evaluation systems,
2- University rankings,
3- Classification of universities by research performance,
4- Academic studies on evaluating research performance of universities.

Some of these studies focus solely on the research performance, whereas some focus both on the educational and research performance of universities. But whatever the focus is, the criteria used in these schemes contain several common elements. Namely, number of publications, citations received by these publications, number of PhD graduates and amount of funds received from competitive sources are the most frequently used as outputs, whereas number of academic and non-academic staff, total expenditures, and infrastructure facilities are among the most commonly used inputs.

2.2.1. National Research Evaluation Systems

In terms of the allocation of research funds, there is a trend away from the model which is based on block grants to institutions towards resource allocation based on the performance of individual researchers or departments (Bornman et al., 2010). National research evaluation exercises provide a comparative measure of research performance of the nation's research institutions, and are used as a tool for stimulating research productivity (Abramo et al., 2011a).

National research evaluation systems serve for two main purposes of governments. The first is to enhance the return of the funds allocated to universities, and the second is to increase their accountability and transparency in terms of distributing those funds. They also serve information about the strengths and capabilities of universities, which will be quite useful for researchers, students and companies in their decisions to select universities that they want to study in or work with.

Governments can select different sets of evaluation criteria to influence and direct universities. For example, evaluating the research products of a limited number of researchers per university can support the goals of reinforcing centers of excellence, whereas evaluating all researchers of a university supports the goals of raising the overall performance level (Abramo et al., 2011a).

University administrators generally develop internal incentive systems as a response to evaluation systems, especially when there are financial incentives or penalties. In this context, they may require their faculty members to conform to the performance criteria set by the evaluation process and may link promotion or resource allocation systems to evaluation results. Consequently, performance-based research funding influences faculty members and the work they produce.

For universities, adaptation to new evaluation systems may take some time before they can give the desired results. Hence, one of the most common complaints regarding national research evaluation systems is the frequent changes in criteria. As an example, in 1992 the United Kingdom (UK)'s Research Assessment Exercise (RAE) was giving emphasis on the quantitative aspect of scientific production and the response was an increase in publication numbers. However, in 1996, the focus shifted from quantity of outputs to quality of outputs. Initially government received complaints regarding this change, but after a couple of years they observed higher propensity of faculty members to publish in journals with higher impact factors (RAE Manager's Report, 2009)[5].

When we investigate national level research performance evaluation systems, we notice that some countries such as the UK go for a qualitative system of departmental ratings using panels of experts; whereas some others such as New Zealand prefer to use a quantitative approach at institutional level. In the following section, we will briefly explain national research evaluation systems of the United Kingdom, New Zealand, Italy and Netherlands. We select these evaluation systems basically for two reasons. First, they are among the earliest evaluation systems and have been consistently conducted for more than 20 years. Secondly, detailed information about these systems can be retrieved from internet sources and academic studies.

2.2.1.1. United Kingdom (UK)

UK has developed one of the earliest research evaluation systems in Europe, which is called as the Research Assessment Exercise (RAE). The first RAE was performed in 1986, and was repeated in 1989, 1992, 1996, 2001 and 2008. It is an *ex post* evaluation based on peer review, which evaluates the quality of research in UK universities. Its primary purpose is to determine quality profiles for research activities of universities, reward quality and volume of research output and provide policy options for enhancing research outputs of universities.

RAE had been conducted jointly by the Higher Education Funding Council for England (HEFCE), the Scottish Funding Council, the Higher Education Funding Council for Wales and the Department for Employment and Learning, Northern Ireland. These higher education funding bodies intend to use the quality profiles to determine their grant for research to the institutions which they fund.[6] RAE evaluations

[5] Last retrieved on July 14, 2014 from http://www.rae.ac.uk/pubs/2009/manager/manager.pdf

[6] Last retrieved on July 13, 2014 from http://www.rae.ac.uk/,

take place not only at the level of the individual researcher and project, but also at institutional and national levels.

In the last RAE, which was performed in 2008, each academic discipline was assigned to 15 main panels and 67 sub-panels. Work submitted to the exercise was assessed by panels which were composed of experts drawn from universities and the wider research community[7]. 2,344 submissions were made by 159 universities and the results were published in 2008.[8]

Panels judged the quality of each department and assigned a rating on a scale from 1 to 5. This rating was used to determine funding for each unit, with the total block grant calculated by summing across all units.

HEFCE does not allocate funds to universities placing in the bottom quartile of RAE rankings. Further, universities with an evaluation profile in the first quartile are assigned funds that are triple of the universities in the second quartile, and three times that of the ones in the third quartile.

Research Excellence Framework (REF), which is the new system for assessing the quality of research in UK higher education system, replaced RAE in 2011. REF will cover research activities over the 5 years from 2008 to 2012. Institutions were invited to make submissions during 2013 and the assessment will take place in 2014 (Abramo et al., 2011a).

2.2.1.2. New Zealand

In 1999 the Tertiary Education Commission (TEC) of New Zealand introduced the Performance Based Research Funding (PBRF) to allocate funds for universities. New Zealand allocates 20 percent of its institutional core research funding on the basis of PBRF, with the remainder based on student numbers (Edgar and Geare, 2010).

[7] Last retrieved on July 13,2014 from http://www.rae.ac.uk/panels/

[8] Last retrieved on July 13,2014 from http://www.rae.ac.uk/aboutus/history.asp

The aim of the PBRF is to encourage and reward research excellence and it considers the quality of research of individual researchers rather than quantity of research outputs. In other words, PBRF supports universities to increase the quality and quantity of their research activities.

The PBRF has three components with different fund allocation rates[9]:

1. Quality Evaluation: 60 % of the funds are distributed to reward and encourage the quality of researchers,
2. Research Degree Completions (RDC): 25 % of the funds are distributed for post-graduate research degree completions,
3. External Research Income (ERI) 15 % of the funds are distributed based on the amount of external research income of universities.

RDC and ERI measures are calculated annually using weighted three-year averages. Each university's share of funding for each of these components is determined by its performance relative to other universities (Tertiary Education Commission, 2010).

Publication outputs such as publications, books, and conference papers are collected at individual researcher level and 'evidence portfolios' for each researcher is compiled in PBRF (Hodder and Hodder, 2010). This portfolio is externally assessed by a panel that includes experts from the same discipline. Each researcher receives individual grades from the panel and these grades are then aggregated to produce a departmental grade. According to averaged scores, departments are classified into either high performers or low performers. In PBRF, only research performance is tried to be captured, so departmental performance in terms of teaching or service activities are not considered (Edgar and Geare, 2010).

PBRF exercises were held in 2003 and 2006, and 2012 and the next round of evaluations will take place in 2018.[10] In 2009-2010, 45 universities were eligible for

[9]Last retrieved on July 13,2014 from http://www.tec.govt.nz/Funding/Fund-finder/Performance-Based-Research-Fund-PBRF-/

[10] Last retrieved on July 13,2014 from http://www.tec.govt.nz/Funding/Fund-finder/Performance-Based-Research-Fund-PBRF-/

participating in the PBRF exercise and 27 of them received funding. The total amount of PBRF Funding was approximately $250 million in 2010 (Tertiary Education Commission, 2010).

2.2.1.3. Italy

In Italy, The Committee for The Evaluation of Research (CIVR) was launched in 1998 to develop a national research evaluation exercise called “Valutazione Triennale della Ricerca (VTR)”. This evaluation system aims to evaluate research activities in the state and legally recognized Italian universities, and public research institutions. The results of this exercise are used to allocate 7% share of the Ordinary Fund for Higher Education (Franceschetta and Costantini, 2011).

VTR, is an *ex post* assessment which is entirely based on peer assessment. It evaluates research performance for 3-year periods. The first evaluation term had covered 2001-2003 period and the results were announced in 2006 (Minelli et al., 2008).

To carry out VTR, 20 scientific area committees were set up and each university was requested to select a number of publications for the 2001–2003 period equal to 25% of their research staff for each scientific field. The institutions participated in the study were ranked at the end of the study.

VTR was replaced by a new evaluation exercise in 2011 which is abbreviated as VQR. VQR evaluates two research outputs from each scientist, for the period 2004–2008. Different from VTR, which directs research institutions to concentrate their resources on top scientists, VQR rewards universities on the basis of average performance of their research staff (Abramo et al., 2011a).

Although Italy has a national research evaluation system, the share of funds assigned on the basis of results from evaluation of research activity is very limited. In 2010, this share is 4.9% of total university income (Abramo et al., 2011a).

2.2.1.4. The Netherlands

In the Netherlands, The Standard Evaluation Protocol (SEP) provides common guidelines for the evaluation and improvement of research and research policy. SEP has been jointly published by the Association of The Netherlands Universities, the Royal Netherlands Academy of Arts and Sciences and the Netherlands Organization for Scientific Research for every six years since 1994 and it is based on expert assessments.[11] This system is called as "Quality Assessment of Research".

The two basic objectives of the SEP are first to improve the research quality and second to ensure accountability of funding agencies and government. Thus, the evaluations are used both to allocate funds and to develop strategies.

The assessment is based on three criteria:

4. Research quality: The committee assesses the quality of the unit's research and the contribution and the scale of the unit's research results (scientific publications, instruments and infrastructure developed by the unit, and other contributions to science).
5. Relevance to society: The committee assesses the quality, scale and relevance of contributions of units to specific economic, social or cultural target groups.
6. Viability: The committee assesses the future strategy of the research unit and the extent to which it is capable of meeting its targets. It also considers the governance and leadership skills of the research unit's management.

Unlike RAE, in which all disciplines are evaluated simultaneously, the evaluation system in the Netherlands is segmented over four to six years. To ensure fairness, committee members are predominantly selected from abroad.

2.2.2. University Rankings

Academic rankings, which are composite indices, provide statistical information on the relative performance of universities. They are among the most common, although possibly the least scientific way to measure the performance of universities. These

[11] Last retrieved on July, 13, 2014, http://www.vsnu.nl/files/documenten/Domeinen/Onderzoek/SEP2015-2021.pdf

rankings include several different criteria related to the quality of education, quality of research, quality of faculty, employability of students and international orientation. Among these criteria, the ones related to the quality of research have significant impact on the ranking results (Docampo, 2011; Dehon et al., 2010)

The foremost reason for the increased popularity of university rankings is the vast growth in higher education across the world. In addition, the growing mobility of students and researchers, the development of new statistical tools and bibliometric databases have accelerated the widely acceptance of these rankings.

Rankings were first introduced by magazines, such as US News and World Report in 1983 and The Financial Times in 1999 as an attraction to their readers. However, these rankings were done primarily for marketing certain universities and their coverage was limited. They focused on either universities in a specific country or specific academic disciplines such as MBA programs.

The first global ranking of universities was Academic Ranking of World Universities (ARWU). It was launched by Shanghai Jiao Tong University in 2003 and extensively covered by the media and soon after many other ranking systems occurred. For example, Times Higher Education Supplement (THES) started to be published jointly by the UK's Times Higher Education and Quacquarelli Sysmonds in 2004.

Other well-known international university rankings are “Leiden Ranking” which was developed by Leiden University’s Centre for Science and Technology Studies (CWTS), “The Webometrics Ranking of World Universities”, which was developed by Cybermetrics Lab of Spain, and “The Performance Ranking of Scientific Papers for World Universities”, which was developed by the Higher Education Evaluation and Accreditation Council of Taiwan. In addition to these international university rankings, several countries are issuing their national university all around the world.

An OECD study (Hazelkorn, 2007) shows that university leaders’ concern about ranking systems has consequences on the strategic and operational decisions they take to improve their institutions’ research performance. In this context, two main types of policy response arise. The first type of response aims to improve the position of national or regional institutions with respect to the existing rankings and the second aims to devise new ways to assess quality.

German case can be an example for the first response type. Germany wants to strengthen cutting-edge research and make German research more visible on the world stage with its "Excellence Initiative". This initiative is an R&D funding program that aims to promote top-level research and improve the quality of German universities and research institutions. The program was first launched in 2006, and had covered a 6-year period between 2006 and 2011. In the first phase, 39 graduate schools received a total of €1.9 billion from this initiative. The projects which will be funded in the second phase were announced in September 2012. According to this announcement, 45 graduate schools, 43 clusters of excellence and 11 institutional strategies at 44 universities will be funded with more than €2.4 billion.[12]

An example for the second type of response is an initiative started by The European Commission (EC). In 2008, EC opened a call for tender to develop a new global ranking system for higher education and in 2009 The Consortium for Higher Education and Research Performance Assessment (CHERPA) won the call.[13] The system which is named as "U-Multirank" has received €2 million in funding from the European Union, and launched in 2014[14]. It assesses the performance of more than 850 higher education institutions worldwide, and provides a multi - dimensional rating of universities on a much wider range of factors than existing international rankings. The main objective of the system is announced as "*to avoid simplistic league tables which can result in misleading comparisons between institutions of very different types or mask significant differences in quality between courses at the same university*"[15].

[12] Last retrieved on July 13, 2014 from http://www.dfg.de/en/research_funding/programmes/excellence_initiative/

[13] Last retrieved on July 13, 2014 from http://globalhighered.wordpress.com/2009/06/14/cherpa-network-based-in-europe-wins-tender-to-develop-alternative-global-ranking-of-universities/

[14] Last retrieved on July 13, 2014 from http://europa.eu/rapid/press-release_IP-14-548_en.htm

[15] Last retrieved on July 13, 2014 from http://europa.eu/rapid/press-release_IP-14-548_en.htm

These rankings are very sensitive to both the selected set of indicators and the modeling choices made in their construction, such as weighting system or type of aggregation. They proceed from the aggregation of various criteria and combine them into one dimension. Thus, special attention should be given to ensure that rankings are not misleading due to over-simplification or combining too many correlated variables.

When analyzing the indicators used to derive university rankings, it can easily be seen that they place huge emphasis on the indicators related to research performance. Considering this reality in mind, it is thought to be helpful to investigate the indicators used in the rankings. Therefore, four of the most well-known international university ranking systems will be briefly put forward in this section.

2.2.2.1. Academic Ranking of World Universities (ARWU)

ARWU was created by a group of researchers at the University of Shanghai. It was first published in 2003 and has been published every year since then. The initial purpose was to assess the relative position of Chinese universities internationally. On the other hand, it has attracted a lot of interest around the world. In total, more than 2,000 institutions are considered, 1,000 are ranked and the ranking of the top 500 is published[16].

ARWU is based on four criteria: quality of education, quality of faculty, research output, and academic performance. Under these four criteria, it uses the below listed six indicators to rank universities based:

1. Number of alumni winning Nobel Prizes and fields medals,
2. Number of staff winning Nobel Prizes and fields medals,
3. Number of highly cited researchers, selected by Thomson Scientific,
4. Number of publications published in journals of ‘Nature and Science’,
5. Number of publications indexed in Science Citation Index - Expanded and Social Sciences Citation Index,
6. Per capita publication performance.

[16] Last retrieved on July 13, 2014 from http://www.shanghairanking.com/aboutarwu.html

Despite its popularity, ARWU receives criticism regarding its methodology and choice of variables. It uses a limited set of criteria, which measure academic performance solely in terms of research excellence and ignores other objectives of universities such as education and a social mission (Dehon et al., 2010). In terms of its criteria, the ranking is biased in favor of science and technology and favors English-speaking universities as English is the predominant language of academic publications. It also favors large universities since it does not consider the effect of size on the performance and measures overall outputs of universities.

Docampo (2011) applied Principal Component Analysis for ARWU indicators. He found that ARWU was a very reliable one-dimensional scale, with a first component that explained more than 72% of the variance of the sample under analysis. When the second principal component was taken into account, the two principal components contributed to explain more than 90% of the variance. First component was related to research quality of a university system, whereas the second component mainly focused on research quantity. Similarly, Dehon et al. (2010) tried to uncover the excellence of ARWU, and found that for the majority of the universities the ranking appeared to reflect two different and apparently uncorrelated aspects of academic research which were overall research output and top-notch researchers.

2.2.2.2. University Ranking by Times Higher Education Supplement (THES)

The THES World University Ranking had been published annually by the Times Higher Education and Quacquarelli Sysmonds (QS), jointly under the name Times Higher Education Supplement between 2004 and 2009. In 2010, these two institutions ceased their collaboration. QS has followed the 2004-2009 methodology and continues to publish this ranking as the "QS World University Rankings". Times Higher Education, on the other hand, produced a new type of ranking called as "Times Higher Education World University Rankings".

THES used to publish top 200 universities, whereas QS World University Rankings considers over 2,000 institutions, and ranks over 800 of them. The top 400 are ranked individually, whereas those placed 401 and over are ranked in groups [17]. On the other hand, Times Higher Education World University Rankings provide a ranking of the top 400 universities[18].

The original THES ranking was based on four broad criteria and it used 6 different indicators, which are:

1. Research quality: It is assessed through two indicators which are obtained from an academic reputation survey, and 5-year citations per faculty,
2. Graduate employability: It is assessed through one indicator which is obtained from employer reputation surveys,
3. International orientation: It is assessed through two indicators, which are percentage of international students, and percentage of international staff,
4. Teaching quality: It is assessed through faculty student ratio.

QS World University Rankings rearranged these broader categories and included the following four new indicators to the existing 6 indicators: papers per faculty, citations per paper, the proportion of staff with PhD degrees, and Webometrics Ranking. As a result, QS World University Rankings use 10 indicators, two of which are derived through surveys.

The World University Ranking of the Times Higher Education uses a different methodology from THES by increasing the number of indicators taken into account. It employs 13 separate performance indicators under five headline categories which are as follows:[19]

1. Teaching: the learning environment (30 % of the overall ranking score)
2. Research: volume, income and reputation (30 % of the overall ranking score)
3. Citations: research influence (30 % of the overall ranking score)

[17] Last retrieved on 13 July, 2014 from http://www.topuniversities.com/qs-world-university-rankings

[18] Last retrieved on 13 July, 2014 from http://www.timeshighereducation.co.uk/world-university-rankings/2013-14/world-ranking

[19] Last retrieved on 13 July, 2014 from http://www.timeshighereducation.co.uk/world-university-rankings/2013-14/world-ranking/methodology

4. Industry income: innovation (2.5 % of the overall ranking score)
5. International outlook: staff, students and research (7.5 % of the overall ranking score).

These three variants of THES rankings are criticized for using subjective indicators that are gathered through surveys. These surveys favor universities with a historical reputation instead of taking current research performance into account (van Raan, 2007). Another criticism is about the frequent changes in the methodology, data source and sample size. Due to frequent changes occurred in THES ranking, systematic investigation of universities from one year to another becomes complicated.

2.2.2.3. CWTS Leiden Ranking

In 2007, Leiden University's Centre for Science and Technology Studies (CWTS) developed a ranking which was based solely on bibliometric indicators for 100 European universities with the largest number of scientific publications. This ranking is based on the academic publication performance of universities and it provides a ranking of the 750 largest universities in terms of publication numbers.[20] The CWTS Leiden Ranking 2014 provides statistics both at the level of science as a whole and also at the level of seven scientific fields which are:

1. cognitive and health sciences,
2. earth and environmental sciences,
3. life sciences,
4. mathematics, computer science, and engineering sciences,
5. medical sciences,
6. natural sciences,
7. social sciences.

The CWTS Leiden Ranking differs from other university rankings by focusing exclusively on measuring citation impact and scientific collaboration. It uses more advanced bibliometric analyses tools such as publications outside the international

[20] Last retrieved on 13 July, 2014 from http://www.leidenranking.com/

scientific literature are excluded because they could distort citation statistics. It also corrects for differences between scientific fields in citation and collaboration practices.

2.2.2.4. University Ranking by Academic Performance (URAP) Ranking

University Ranking by Academic Performance (URAP) Research Laboratory was established at the Informatics Institute of Middle East Technical University in 2009. It is the first national initiative that develops a ranking system based on academic performances for 2,000 universities from all over the world. It also investigates the academic performance of all Turkish universities. It has been announcing the results since 2010. The data has been gathered for about 3,000 universities and top 2,000 of them are scored. It covers approximately 10% of all universities in the world, which makes it one of the most comprehensive university ranking systems.[21]

URAP's ranking is based on 6 academic performance indicators. Each indicator is assigned a weight which was determined by Delphi analysis conducted with a group of experts and a total score of 600 is distributed to each indicator. The data regarding universities are gathered from different databases of ISI, namely WoS, and Journal Impact Factors. The indicators, the aim of their inclusion and their assigned weights are as follows: [22]

1. Number of articles (with a weight of 21 %) aim to measure current scientific productivity, which includes articles published in 2011 and indexed by WoS.
2. Number of citations (with a weight of 21 %) aim to measure the research impact and is calculated as the total number of citations received in 2011 for the articles published in 2007-2011 and indexed by WoS.
3. Total number of documents (with a weight of 10 %) aim to measure of sustainability and continuity of scientific productivity and is determined by the total number of all scholarly publications, including conference papers, reviews, letters, discussions, scripts in addition to journal articles published in 2011 and indexed in WoS

[21] Last retrieved on 13 July, 2014 from http://www.urapcenter.org/2013/methodology.php?q=2

[22] Last retrieved on 13 July, 2014 from http://www.urapcenter.org/2013/methodology.php?q=3

4. Journal citation impact (with a weight of 15 %) aims to measure the quality of citations and it is based on the impact factors of journals where the citing articles are published.
5. International collaboration (with a weight of 15 %) is the total number of publications made in collaboration with foreign universities for the years 2007-2011 and it is used as a measure of global acceptance of a university.
6. Journal impact total (with a weight of 18 %) is used as a measure of scientific impact. It is calculated by aggregating the impact factors of journals in which a university has published articles in 2007-2011.

For national level evaluations, URAP provides 8 different rankings in addition to an overall ranking. In this context separate rankings are provided for universities that established before and after 2000, for universities with and without medical schools, for public and private universities and for 6 different scientific fields, and for universities that offer and do not offer PhD level programs.[23]

2.2.2.5. Entrepreneurial and Innovative University Index

The Entrepreneurial and Innovative University Index is a national initiative that aim to evaluate entrepreneurial and innovative capacity of Turkish universities. It has been prepared by TÜBİTAK since 2012 and identifies Turkey's most entrepreneurial and innovative 50 universities each year. 144 universities that have more than 50 faculty members are included in this study. Universities are evaluated on the basis of 23 criteria which cover scientific and technological research competence, intellectual property pool, cooperation and interaction, entrepreneurship and innovation culture, and economic contribution and commercialization fields. The indicators used for each field are as follows:

1. Scientific and Technological Research Competence (20 %)
   - Number of publications
   - Number of citations
   - Number of projects funded by national R&D support programs
   - Amount of funds received from national R&D support programs

[23]Last retrieved on 13 July, 2014 from http://tr.urapcenter.org/2013/index.php

- Number of national and international science awards
- Number of PhD graduates

2. Intellectual Property Pool (15 %)
   - Number of patent applications
   - Number of utility models and industrial designs
   - Number of international patent applications
3. Cooperation and Interaction (25 %)
   - Number of R&D and innovation projects carried out through university-industry collaboration
   - Amount of funds received through university-industry collaboration projects
   - Number of international R&D and innovation projects
   - Funds received from international R&D and innovation projects
   - Number of students and faculty members in exchange programs
4. Entrepreneurship and Innovation Culture (15 %)
   - Number of graduate and undergraduate courses on entrepreneurship, technology management and innovation
   - Number of full-time employees employed in technology transfer offices, technoparks, incubation centers and technology centers.
   - Availability of a technology transfer office
   - Number of external trainings and certification programs on entrepreneurship, technology management and innovation management organized for external participants
5. Economic Contribution and Commercialization (25 %)
   - Number of operative firms owned by or partnered with faculty members in the technoparks and incubation centers.
   - Number of operative firms owned by or partnered with students or graduates in the last five years in the technoparks and incubation centers.
   - Number of persons employed in the firms that are owned by or partnered with faculty members in the technoparks and incubation centers.
   - Number of patents, utility models and industrial designs that are licensed

From this criteria set, we can see that performance of universities in terms of their publications, citations, R&D projects and PhD graduates has an impact on 20% of the total scores. This index is used as a prestige index and there are not any direct financial initiatives associated with the scores. Meanwhile, universities that are listed in the index can apply for the technology transfer offices support program which is funded by TÜBİTAK.

2.2.3. University Classifications

Creation of competitive research universities that will help to obtain a superior position in terms of R&D has penetrated into national agendas of several developing and developed countries (Altbach, 2007). Consequently, several governments have prioritized building new research universities or enhancing the capacities of the existing ones. Several countries developed special programs to promote research productivity by providing special research funds to selected universities and in this sense, classification of research universities has become a necessity.

To develop classification schemes for universities, academic researchers and/or policymakers are using a diverse set of criteria, such as institutional size, location, focus in terms of mission or focus in terms of education. Among these, classification by mission focus is the most widely applied methods (Shin, 2009b). Mission-based classification can be based on predetermined benchmark criteria, such as number of PhD programs, the number of PhD graduates, and amount of external research funds. It can also be based on institutional performance, which is measured through national evaluation systems.

One of the most well-known mission-based university classifications is the Carnegie Classification. It was initiated in 1970 by the Carnegie Foundation and was originally published in 1973. It was updated in 1976, 1987, 1994, 2000, 2005, and 2010 to reveal changes among colleges and universities in the United States.[24] In their official website, they state that their main purpose is assisting those conducting research on higher education.

[24] Last retrieved on 13 July, 2014 from http://classifications.carnegiefoundation.org/

The Carnegie Classification has been frequently used for grouping higher education institutions and utilized in both state and federal level as a higher education policy tool. For instance, the majority of states in US apply different college admission criteria, tuition rates, governance systems, and faculty evaluation systems according to institutional mission focus. Additionally, governance systems of research universities tend to be less tight than that of teaching-focused universities because academic freedom is supposed to be critical in enhancing research productivity.

Other than the Carnegie Classification, several nations developed their own classification schemes to support research universities in a more targeted way. In this respect, China approved a special funding program to build research universities as part of its ‘‘985 project’’ (Ma, 2007) in 1998. In 1999, South Korea has initiated the “Brain Korea 21” program (Shin, 2009b) and in 2002 the Japanese government launched the “Center of Excellence” program (Yonezawa, 2007). Similarly, in 2005 Germany has adopted a special project to build competitive research universities (Jürgen, 2006).

A great deal of controversy has occurred regarding the principles of “selection and concentration” in the allocation of the research funds. Since being classified as “Research University” under such funding schemes will provide additional opportunities and reputation, several universities have claimed that they are “research universities”. For example, in South Korea, soon after the initiation of the Brain Korea 21 project, political disputes had aroused about which universities to be selected as research universities. In the end, the Korean government struck a compromise by allocating research funds to all universities that had PhD-level programs (Shin, 2009b).

Despite of the ethical disputes, countries that adopted these programs have observed rapid increases in terms of research productivity of scholars at the selected universities. For instance, research productivity of faculty members who were working in the selected universities were found to be increased in China, South Korea, Singapore, and Taiwan (Balan, 2007; King, 2004; Leydesdorff and Zhou, 2005; Shin, 2009b).

2.2.4. Academic Studies and Empirical Results

We observe that there are two types of academic studies that focus on the research performance of universities. The first group measures, classifies or compares the research performance of units (Albarran et al. 2010; Borrego et al. 2010; King 2004; Neri and Rodgers 2006; Pouris and Pouris, 2010; Shin, 2009; Téllez and Vadillo, 2010), whereas the second group is mostly concentrated on understanding the factors that leads to higher research performance (Auranen and Nieminen, 2010; Dündar and Lewis, 1998; Goodall, 2009; Gulbrandsen and Smeby, 2005; Kao and Pao, 2009; Toutkoushian et al., 2003). Some of these studies have focused solely on the research performance, while some others have jointly assessed teaching and research performance.

The analyses level of studies differs among studies. Some of them have compared research performance across countries (Abbott and Doucouliagos, 2004; Goodall, 2009; Gulbrandsen and Smeby, 2005; King, 2004; Pouris and Pouris, 2010; Shin, 2009; Téllez and Vadillo, 2010), whereas some others have compared research performance of universities within one specific country (Albarran et al., 2010; Auranen and Nieminen, 2010; Toutkoushian et al., 2003). There are also studies that have compared research performance of specific departments, programs or individuals within a country (Borrego et al., 2010; Kao and Pao, 2009; Neri and Rodgers, 2006).

Research performance is generally calculated through bibliometric data (such as publications per faculty), outputs of national research evaluation schemes or rankings. Several parametric and non-parametric methods, such as Data Envelopment Analysis, Principal Component Analysis, and Hierarchical Cluster Analysis are applied. We observe that the relationship between research performance and its correlates are mostly studied through statistical analyses such as multiple regression and covariance analysis. Summaries of selected studies are presented in Table 1.

Table 1: Summary of the selected studies

Author	Summary of the Study
Abbott and Doucouliagos (2004)	They investigated the relationship between publication performance and various other factors such as research income, labor, non-current assets and expenditures on all inputs other than labor. They used data for 35 Australian public universities for the period 1995–2000. The results indicated that research income, number of academic staff and postgraduates were positively associated with the research output. They also found significant differences across different types of universities; such that younger universities were found to have lower research performance.
Albarran et al. (2010)	They measured and compared scientific performance of EU and US in 22 different scientific fields. They used the total number of publications that were indexed by Thomson Reuters ISI Web of Science (WoS), total number of citations received by these articles and average number of citations over the 1998–2002 period as individual performance indicators. As a whole, the EU share of total publications was found to be greater than that of the US, whereas the EU share of total citations was greater than the US in only 7 fields. The mean citation rates in the US were found to be higher than EU in every field.
Auranen and Nieminen (2010)	They compared 8 countries according to their publication performance and competitive characteristics of their funding environments. They classified universities into 4 groups using two dimensions. The first dimension was the share of external research funds other than public funding (high vs. low) and the second dimension was the orientation of the public funding devoted to research (input oriented vs. output-oriented). They investigated whether more competitive funding systems led to higher numbers of scientific publications. Data was collected from national sources, OECD databases and WoS database. They calculated funding per publication ratio for 6 years-periods in the timeline between 1987 and 2006. Their findings indicated that there were significant differences in the competitiveness of funding systems. On the other hand, the results did not indicate a straightforward connection between financial incentives and the publication efficiency of the university systems.
Borrego et al. (2010)	They analyzed the scientific output and impact of male and female PhD holders who were awarded their doctorate at Spanish universities between 1990 and 2002. They used WoS database to derive the data. Total number of articles published and total number of citations received per article were used to differentiate the outputs. Results showed that there were no significant differences in the amount of scientific outputs between males and females, whereas the proportion of female PhD holders with no postdoctoral output was found to be significantly higher than that of their male counterparts, and the median number of papers published after PhD completion was found to be lower among women. The results also indicated that articles by female PhD holders were cited significantly more often.
Dündar and Lewis (1998)	They measured the impact of size (in terms of faculty members), percentage of faculty who are full professors, ratio of graduate students to faculty, percentage of graduate students who hold research assistantships, institutional control (Public/Private), concentration and percentage of faculty publishing, institutional library expenditures, the percentage of faculty with research support on departmental level research productivity. They included 1,834 departments in US and used average publications per department as a measure of research productivity. They found that all factors except the ratio of graduate students to faculty had a significant and positive impact on the research performance. Impact of ratio of graduate students to faculty was found to be positive for basic & applied sciences and negative for social sciences
Goodall (2009)	She investigated the relationship between the scholarly ability of a university president and the performance of that university. She used the outputs of UK research assessment exercise (RAE) and included 157 university presidents and 55 UK research universities. To identify a president's scholarly success, each individual's normalized lifetime citations had been counted. She found that universities that were directed by more cited vice chancellors performed better in the RAE.

Table 1 (cont'd): Summary of the selected studies

Author	Summary of the Study
Gulbrandsen and Smeby (2005)	They investigated the relationship between professors' research performance and industrial funding. They used the results of a questionnaire study performed among all tenured university professors in four Norwegian 4 universities. Collaboration with other researchers and industry, number of scientific publications, and entrepreneurial outputs such as patents, commercial products, establishment of firms and consulting contracts were individually used as outputs of research performance. They found a significant relationship between industry funding and research performance, such that professors with industrial funding described their research as applied to a greater extent, they collaborated more with other researchers both in academia and in industry, and they produced more scientific publications and reported more entrepreneurial results. Moreover, they found neither a positive nor a negative relationship between academic publishing and entrepreneurial outputs.
Kao and Pao (2009)	They evaluated research performance of 168 Taiwanese universities in the field of management for the 1995–2004 period. They utilized journal publications and citations, and total number of projects funded by the National Science Council of Taiwan as proxies for research performance. They used aposteriori weights which were determined by analyzing the data collected on indicators to calculate a research performance index. Results showed that public universities performed better than private ones. Furthermore, universities with specific missions were found to have better performance compared to general comprehensive ones.
King (2004)	He measured the quantity and quality of science across 31 countries, including the G8 group and the 15 European Union countries. He gathered total number of published research papers and reviews, and their citations from WoS database. The analyses covered 1993-2002 period. Results showed that US came the first in the list of nations in terms of the volume of publications, citations and the share of top 1% cited papers, whereas, in terms of citations, the gap between US and EU-15 was found to be shrinking significantly.
Neri and Rodgers (2006)	They ranked 29 Australian economics departments by their research productivity and variability of research productivity among their faculty members for 1998–2002 period. Research productivity was proxied by the annual pages published per person adjusted for quality of journals. They used two sets of journals. First set included the top 159 journals, whereas the second set included 600 refereed journals in economics. Results showed that there were large disparities between the most and least productive departments in terms of research productivity and many economics departments had achieved very low research productivity. It was also found that research productivity was more evenly distributed within those departments that had relatively high average research productivity.
Pouris and Pouris (2010)	They developed a discipline-oriented ranking for 23 South African universities to identify their international research performance. They investigated total citations received by articles written by faculty members of each university in 22 different scientific disciplines. They used WoS database to identify the top 1% entities that received the highest citations for each scientific field. Afterwards, they checked which South African universities were among these top 1% entities. They found that only 7 of the 23 universities could reach the thresholds to be among the top 1 % of the world universities in at least one scientific discipline. Moreover, they found that South African institutions had a presence in only 12 out of 22 scientific fields in the top 1% list.
Shin (2009)	He classified 47 Korean higher education institutions into three distinct groups as research universities, research active universities, and doctoral universities using Hierarchical Cluster Analysis method for the 2003 - 2005 period. They used number of publications, external research fund, the number of PhD degrees awarded, number of full-time faculty, per faculty publication, per faculty external fund, and per faculty PhD degrees awarded as classification indicators. To validate the classifications, results were compared with U.S. peer universities and the research performance of Korean universities was found to be similar to their U.S. peers.

Table 1 (cont'd): Summary of the selected studies

Author	Summary of the Study
Téllez and Vadillo (2010)	They investigated research performance of different countries in the field of analytical chemistry. They analyzed publications from 22 countries and 18 journals over the period between 2000 and 2007. Total number of publications and mean journal impact factors for each country were used as performance measures. The data were derived from WoS database. Results indicated that the field of analytical chemistry was led by the USA, China, and Spain, whereas the contribution of China had increased to a great extent in the last five years.
Toutkoushian et al. (2003)	They used publication numbers as a proxy of research productivity and ranked 1,300 4-year colleges in the US, according to their total publications and ratio of publications per faculty. They found that majority of the research was produced by universities that were classified as research institutions and PhD-level institutions in Carnegie Classification. Moreover, universities that were not in the National University Category were found to produce fewer publications compared to average numbers. Results indicated that research expenditures, revenues of universities and average faculty salaries were highly correlated with publication output. On the other hand, graduation rates, freshmen acceptance rates and SAT scores were not found to be significantly correlated with the research output.

2.3. Concluding Remarks

Universities are seen as key actors in national innovation systems since they play a crucial role in training highly skilled human resources necessary for enhancing countries' innovation capabilities. Additionally, they provide necessary research infrastructure both for the public institutions and the private sector, which is crucial to carry out the innovative activities.

In several countries an elitist system of higher education has been overtaken by a system of mass higher education. Consequently, total numbers of universities, amount of university students and funds allocated for higher education have increased considerably. With increased number of universities, growing enrollment of students and limited funding resources, universities found themselves in competition for resources, students and reputation.

R&D activities are important to distinguish between top-quality universities from others. These activities provide a flow of quality researchers, additional research funds, and successful students in addition to academic reputation. With increased level of competition and funding in R&D, research evaluation studies regarding universities are becoming more widespread.

Research evaluation activities cover a wide range of activities from typical research evaluation activities performed by governments to academic studies, classification of universities and university rankings. The latter two exercises are also included in this study, since they also cover indicators closely related to research performance of universities.

Research evaluation studies use different instruments and indicators depending on the aim, coverage and owner of the study. However, peer review and bibliometric analyses are the most frequently used instruments in different types of evaluation activities. Similarly, indicators related to academic publications, graduate students, projects realized by external funds, and entrepreneurial activities are among the most frequently used proxies for research performance.

The results obtained from the evaluation exercises may provide insights for a wide-range of policy issues for government. The outcomes might put light on issues such as whether there exist important differences between universities, whether such differences have been increasing or decreasing, whether research should be further concentrated in certain universities. Universities can be classified using these studies and instead of coming up with unilateral policies, different regulations and incentives can be developed for different university types that have different needs. In addition, governments can develop fund-allocating mechanisms for universities via these research evaluation exercises to have more accountable and transparent allocation mechanisms. They can also investigate whether it is effective to make R&D investments in universities, and whether it is worthwhile to increase R&D investments through evaluation exercises.

Other than governments, evaluation exercises can also serve for the directors and academic staff of the universities. Since they reveal the performance of a university, university managers can use them in setting academic targets, enhancing their institutional reputation and allocating resources. Additionally the selected criteria and related weights used in evaluation processes might provide a motivational direction for universities to enhance their capacities as to get higher points from the exercises.

It is also important to understand the dynamic of research performance in addition to measuring it. As more evaluation schemes come into effect, governments and universities spend more effort on studying their processes regarding the allocation of resources, R&D infrastructure, and human resource management. They will also devote special effort to identify and foster factors that are positively correlated with higher research performance.

On the other hand, as Geuna and Martin (2003) have stated, performance-based funding in research can widen the gap between research and teaching. If rewards for research are greater than the rewards for teaching, universities will focus on the former at the expense of the latter.

CHAPTER 3

SCIENCE, TECHNOLOGY AND INNOVATION INDICATORS FOR TURKEY

This chapter will briefly provide information on key science, technology and innovation (STI) indicators and developments in the Turkish higher education sector, R&D funding of universities via public resources, and performance of Turkish universities in terms of selected research outputs. All of these figures will depict the importance of higher education sector in terms of R&D activities.

Data regarding key STI indicators for Turkey were acquired from the Turkish Statistics Agency (TÜRKSTAT), international data on STI indicators were attained from the OECD, and data regarding Turkish universities were obtained from "Annual Higher Education Statistics (AHES)", prepared by Assessment, Selection and Placement Center (ÖSYM). Information regarding TÜBİTAK projects was obtained through TÜBİTAK.

3.1 Key Science and Technology Indicators for Turkey

Performance of universities in the economy should be investigated carefully in Turkey, since these institutions are among the major actors in terms of research and development (R&D) activities in the country. As of 2012, 43.9 % of R&D expenditures was realized in universities and 38.2% of full-time equivalent research personnel are employed by them (TURKSTAT, 2013).

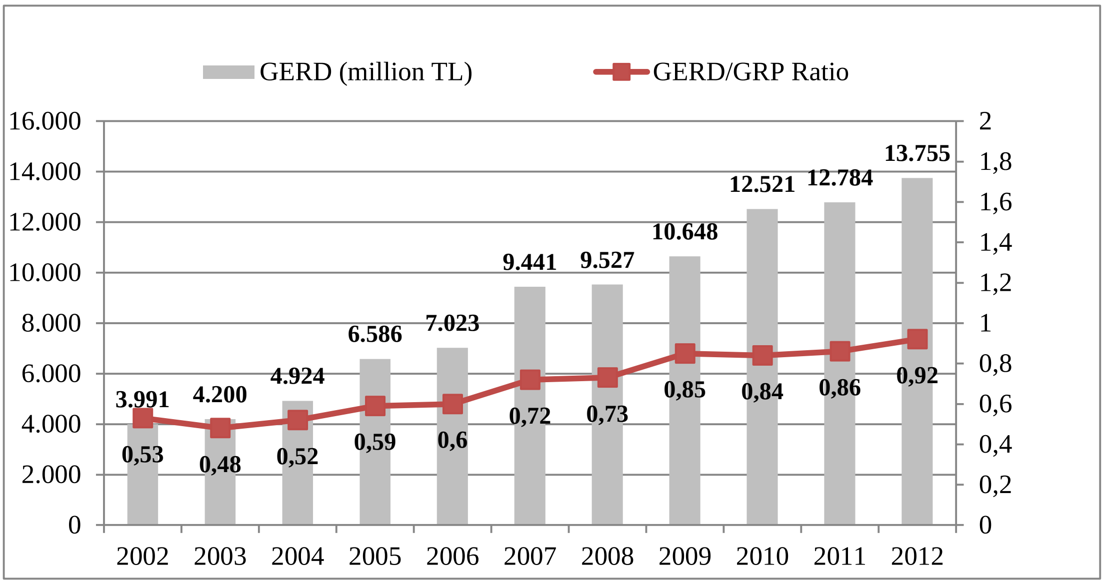


Figure 1: GERD and its ratio to GDP

Source: TURKSTAT (2013)

Figure 1 provides gross domestic expenditures on R&D (GERD) and GERD's ratio to Gross Domestic Product (GDP), with 2013 fixed prices.

We see that GERD in Turkey has increased by 196 % between 2002 and 2012, from 759 million TL to 1.49 billion TL. Additionally, GERD as a percentage of GDP has increased from 0.53 % in 2002 to 0.92 % in 2012. GERD as a percentage of GDP is 1.9% in EU-27 in 2010, and 2.4% in OECD total in 2009 (OECD, 2012a). Based on these ratios, we observe that Turkey is still far away from EU-27 and OECD averages despite of the increases in both absolute terms of R&D expenditures and its ratio to GDP.

Figure 2 depicts total number of full time equivalent (FTE) researchers and FTE researchers per 10,000 employees in Turkey. The figures show that the total number of FTE researchers has more than tripled between 2002 and 2012, from 24 thousand to 82 thousand. As a result, FTE researchers per 10,000 employees have risen by 200% from 11 to 33 during this period. FTE researcher per 10,000 employees is 70 for EU-27 in 2010 and 76 for OECD total in 2007 (OECD, 2012a). Consequently, FTE researchers per 10,000 employees in Turkey have remained less than one third of EU-27 and OECD total.

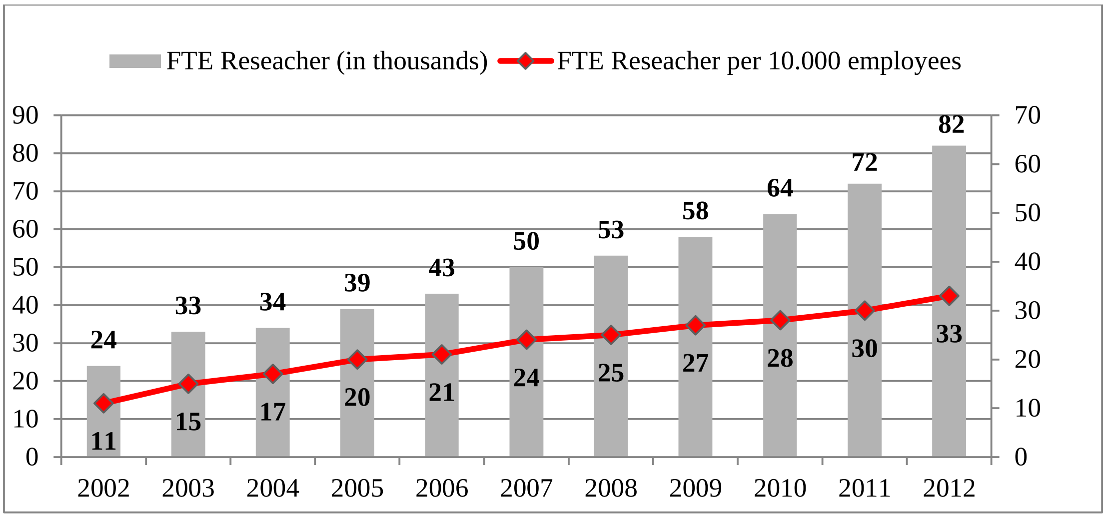


Figure 2: FTE researchers and FTE researchers per 10,000 employees in Turkey

Source: TURKSTAT (2013)

Table 2 provides total amount and share of R&D expenditures realized by three different sectors in Turkey during the period between 2002 and 2012, with 2013 fixed prices. Two conclusions can be drawn from this table. First, higher education sector has consistently realized more R&D expenditures than other sectors in the overall period. Second, the dominance of the higher education sector is being threatened by the private sector as the highest increase in both percentage and absolute terms is realized in the private sector.

Table 2: R&D expenditures and (shares) by sectors *

Sector	2002	2004	2006	2008	2010	2012
Higher Education	2,566	3,342	3,738	4,213	5,761	6,203
	(64%)	(68%)	(53%)	(44%)	(46%)	(45%)
Private Sector	1,145	1,191	2,497	4,175	5,327	6,038
	(29%)	(24%)	(36%)	(44%)	(43%)	(44%)
Public Sector	280	392	788	1,138	1,433	1,513
	(7%)	(8%)	(11%)	(12%)	(11%)	(11%)

Source: TÜBİTAK, 2013.

*: with 2013 fixed prices, in million TL

In terms of the share of R&D expenditures by sectors, higher education has followed mostly a decreasing trend between 2002 and 2012. Namely, the share of higher education sector in terms of R&D expenditures was 64 % in 2002, whereas this ratio has decreased to 45 % in 2012 (see Table 2).

3.2 Developments in Turkish Higher Education System

The Turkish higher education system has been witnessing a significant transformation towards a mass higher education system, especially in the last decade. Figure 3 depicts how fast the total numbers of both public and private universities have increased in Turkey after 2005.

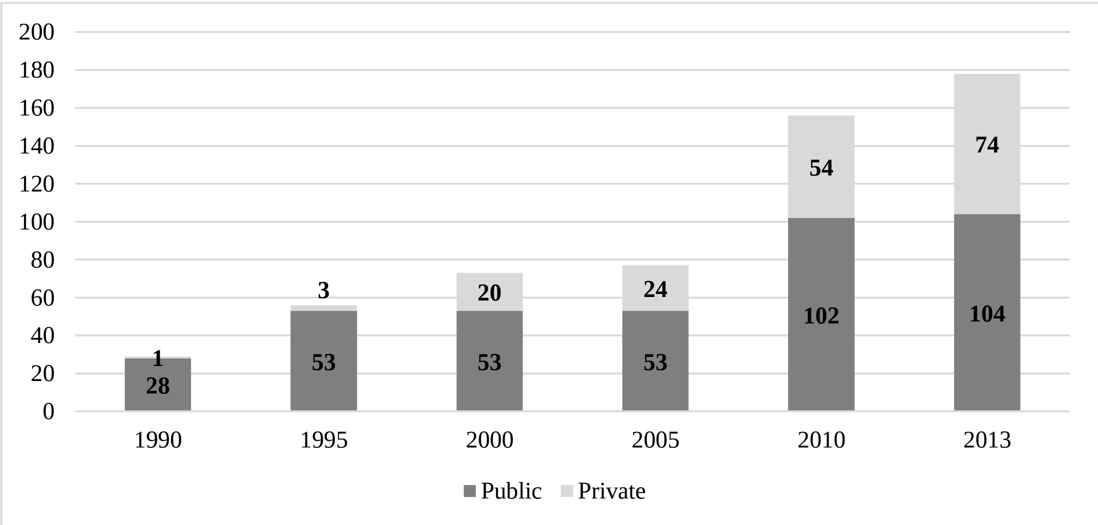


Figure 3: Number of public and private universities in Turkey

Source: Compiled by the author from the Assessment, Selection and Placement Center (ÖSYM) data.

The total number of universities has increased from 29 in 1990 to 178 in 2013. The total number of public universities which was 28 in 1990 has increased gradually to 104 in 2013. Parallel enlargements have also been witnessed in the total number of private universities. In 1990 there was only one private university, and this number has increased to 74 in 2013 (Figure 3).

In accordance with the increase in the number of universities, total number of university students (including open education) has increased by 161 % between 2002 and 2012 (Table 3). The major contribution to this increase is coming from students who are enrolled in open education. In addition, the most dramatic increase is observed in the total number of vocational training students with a 167 % increase.

Table 3: Number of university students and academic personnel

	2002-2003	2005-2006	2008-2009	2012-2013	% Incr.
Total # of University Students	**1,894,109**	**2,309,918**	**2,889,070**	**4,936,591**	**161%**
Vocational Training	**564,610**	**666,808**	**855,465**	**1,505,754**	**167%**
Normal	323,971	441,074	548,695	755,789	**133%**
Open Education	240,639	225,734	306,770	749,965	**212%**
Undergraduate Programs	**1,215,121**	**1,488,362**	**1,876,363**	**3,140,835**	**158%**
Normal	793,906	915,043	1,040,597	1,633,948	**106%**
Open Education	421,215	573,319	835,766	1,506,887	**258%**
Graduate Schools	**105,453**	**144,317**	**144,950**	**277,351**	**163%**
Masters	82,277	111,814	109,281	217,588	**164%**
PhD	23,176	32,503	35,669	59,763	**158%**
Medical Interns	**8,925**	**10,431**	**12,292**	**12,651**	**42%**
Total # of Academic Staff	**74,134**	**82,250**	**97,923**	**127,441**	**72%**
Vocational Training	5,997	6,792	8,285	13,197	**120%**
Undergraduate Programs	64,075	70,482	83,644	107,358	**68%**
Graduate Sch.& Institutes	3,762	4,727	5,681	6,402	**70%**
Research Centers	300	249	313	484	**61%**
Student per Academic Staff	**25.5**	**28.1**	**29.5**	**38.7**	**52%**

Source: Compiled by the author from the Assessment, Selection and Placement Center (ÖSYM) data.

The total number of academic personnel which was 74,131 in 2002 has reached to 127,441 in 2012, which accounts for a 72 % increase. The highest percentage increase is realized in the number of academic staff employed in the vocational training schools with 120 %. There might be three factors behind this increase. First, both new and established universities have significantly expanded their vocational schools because of the trends associated with the massification of the higher education in Turkey. With the inducement of political will, vocational schools have been opened in the districts with moderate to high population. Secondly, new public universities prefer to open vocational schools, foremost, because the cost of building vocational schools is less than the cost of building faculties, and it is easier to procure teaching staff compared to faculty members with academic titles.

We see that percentage increases in terms of students significantly exceeds percentage increases in terms of academic personnel. The last row in Table 3 provides the ratio of students per academic personnel. We see that this ratio has increased from 25.5 in 2002 to 38.7 in 2012 which accounts for a 52 % increase.

These figures altogether show that there is a clear trend towards a mass higher education system in Turkey, which arises questions regarding educational quality.

Table 4 presents R&D spending of higher education sector by 6 different scientific fields, and in terms of current and capital expenditures for 2012. On average, 86 % of the expenditures are current expenditures, whereas only 14 % of the R&D funds are allocated for investment expenditures.

Table 4: Turkish HEIs' R&D spending by disciplines for 2012 (in million TL)

		Current Expenditures			Capital Expenditures		
Scientific Discipline	**Total**	**Currents Total**	**Personnel Expenses**	**Other Expenses**	**Capital Total**	**Machinery Equipment**	**Fixed Facilities**
Natural	525	443	307	135	83	59	24
Engineering	1,050	845	593	252	205	148	57
Health	1,859	1,648	995	653	211	155	56
Agriculture	263	234	152	82	29	21	8
Social	1,256	1,086	750	336	171	111	59
Humanities	781	666	457	209	114	76	38
Total	**5,734**	**4,922**	**3,254**	**1,668**	**812**	**571**	**242**

Source: TURKSTAT, 2013

Personnel salaries, which account for the 66% of current expenditures are the largest share of the current expenditures. On the other hand, 70 % of capital expenditures are allocated for purchasing machinery and equipment, and 30 % for building R&D facilities.

In 2012, universities have spent 32% of their R&D funds for health sciences, 22 % for social sciences, 18 % in engineering sciences, 14 % of humanities, 9 % for natural sciences, and 5% for agricultural sciences.

Analyses of capital expenditures also provide striking results. We identify that the largest share of capital expenditures is used in health sciences. This is quite expectable since health sciences require expensive research infrastructure and experiment setups. On the other hand, it is interesting to see that capital expenditures are higher for social sciences than they are in engineering sciences, natural sciences and agricultural sciences. The latter disciplines normally require more expensive research infrastructure to carry out experimental studies compared to social sciences. These figures indicate that either engineering, natural, and agricultural sciences have been underfunded in terms of capital expenditures or social sciences and humanities have been overfunded in the Turkish higher education sector. Detailed analyses should be made to identify the factors leading to this outcome. In this context, performing interviews with directors of universities will be helpful.

3.3. Performance of Turkish Universities in Selected Research Outputs

As discussed in the Chapter 2, research outputs of universities can be measured by several methods such as peer reviews and bibliometric analyses. Correspondingly, several different indicators can be used as research output proxies. Number of graduates from graduate programs, academic publications, patents, academic entrepreneurships, collaboration activities with industry, and research projects supported by national and international competitive funds are the most frequently used indicators to measure research performance.

This section will provide brief data on publication outputs, the number of graduates from graduate programs, projects funded by national competitive R&D support programs and collaborative activities among industry and academia. We provide detailed analyses for input and output variables that are selected for Data Envelopment Analyses in Chapter 5.

3.3.1. Publications

Turkey-originated scientific publications that are written in 2002-2012 period and indexed by Web of Science (WoS) are given in Table 5. We see that both total publications and publications per million populations are increasing in the last 10 years. Total number of WoS indexed publications was 8,975 in 2002, and this number has increased by 179 % and reached to 25,018 in 2012.

Similarly, publication per million populations was 136 in 2002 and it has increased continuously to 331 in 2012. This accounts for a 144 % increase in terms of publications per million populations.

Table 5: Turkey-originated scientific publications indexed by WoS Database

Year	Total Publications	Publications Per Million Population	Turkey's Country Ranking*
2002	8,975	136	22
2003	10,648	159	22
2004	13,310	197	20
2005	14,275	208	19
2006	15,222	219	20
2007	18,120	257	19
2008	19,572	274	18
2009	21,876	301	17
2010	23,077	313	17
2011	23,851	319	18
2012	25,018	331	18

Source: TÜBİTAK

*: in terms of total number of articles

We also see that Turkey is taking place within the top 20 countries in terms of total publication since 2004. On the other hand, although we do not have data regarding the last 4 years, reports provided by ULAKBIM has stated that Turkey's rank in terms of publications per million population had also changed in between 44^{th} and 45^{th} rank between 2005 and 2010. In other words, researchers in Turkey are not as productive as their peers in several other countries.

3.3.2. Graduates from graduate programs

Between 2002 and 2012, number of graduate students both from the master and PhD programs has increased significantly. Figure 4 provides information regarding the total number of master students and graduates from master programs. The total number of master students has increased from 82,277 in 2002 to 217,588 in 2012. This accounts for a 167 % increase within 10-year period. Nevertheless, the total number of graduates from master programs has increased from 13,713 in 2002 to 25,704 in 2012, which is equal to an 87 % increase within the same period.

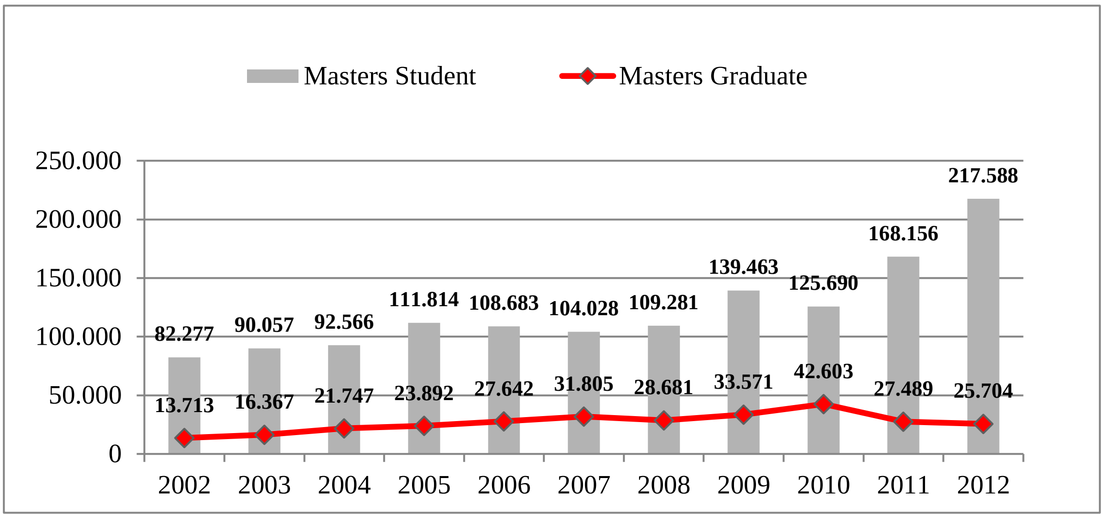


Figure 4: Number of master students and graduates

Source: Compiled by the author from the Assessment, Selection and Placement Center (ÖSYM) data.

Figure 5 provides information regarding the total number of PhD students and graduates from PhD programs. We can see that the total number of PhD students has increased from 23,176 in 2002 to 59,763 in 2012 which accounts for a 158 % increase within 10-year period. In the meantime, total number of graduates from master programs has increased from 2,458 in 2002 to 4,462 in 2012, which accounts for an 82 % increase during the same period.

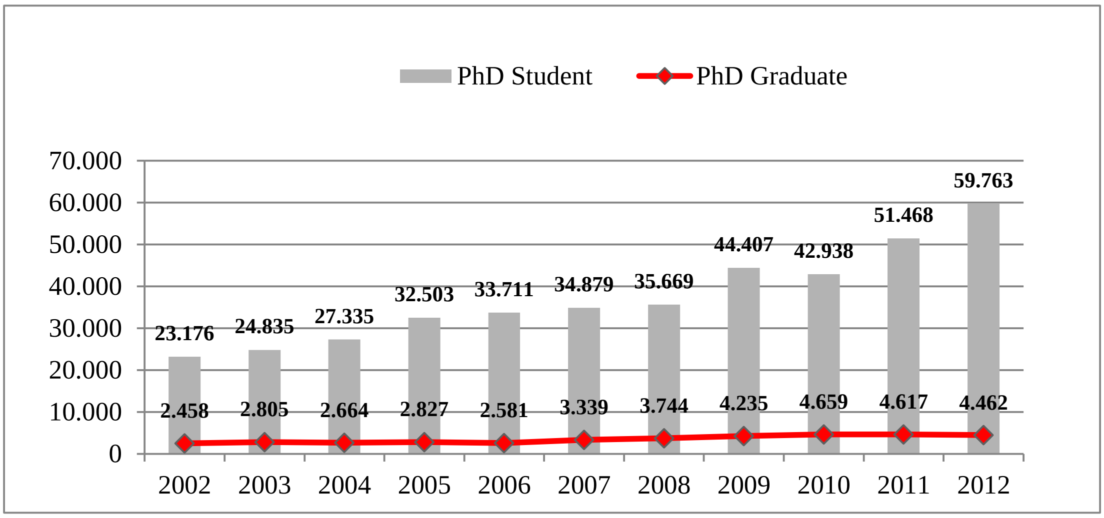


Figure 5: Number of PhD students and graduates

Source: Compiled by the author from the Assessment, Selection and Placement Center (ÖSYM) data.

We observe that the total number of students enrolled in graduate programs has increased over 150 %, whereas this increase has not been accompanied with the same level of increase in the total number of graduates. Namely, the ratio of master graduates to master students has fluctuated between 12 % and 34 %, and the ratio of PhD graduates to PhD students has fluctuated between 7 % and 11 %. We can see that drop off rates are very high in graduate level programs in Turkey.

The total number of graduate level students has also increased significantly. There might be two factors leading to this increase. First, increased number of universities and students might cause an increase in the demand for academic personnel. Consequently, more students are enrolled in the graduate programs to become academic personnel. Secondly, an increase in the number of universities has pushed universities into a competition for attracting students and they need to disclose that they are providing certain quality education. As number of graduate programs and ratio of graduate students to undergraduate students have been perceived as indicators of high quality, universities that aim to gain academic reputation might prefer to enlarge their graduate programs.

3.3.3. Academic R&D Projects funded by TÜBİTAK

As we have mentioned earlier, TÜBİTAK has initiated TARAL programme (which is a very comprehensive R&D support program) in 2005. Table 6 provides annual information about R&D projects supported in universities and funded by TÜBİTAK.

We see that number of university projects applied to TÜBİTAK funds has varied between 4,737 and 6,107 and we observe a fluctuating pattern in the total number of applications. Other statistics, such as acceptance ratio, the total amount of project budgets, annual expenditures, and number of ongoing projects have also followed a fluctuating pattern between 2007 and 2012.

Table 6: R&D projects implemented by universities and supported by TÜBİTAK

	2007	2008	2009	2010	2011	2012
Number of project applications	4,764	4,737	4,812	5,036	4,900	6,107
Number of projects accepted	1,267	1,154	894	1,210	1,218	1,115
Acceptance Ratio (%)	27	24	19	24	25	18
Total Budget (million TL)**	160	142	111	160	182	188
Number of Continuing Projects	3,363	3,165	2,708	2,533	2,604	2,650
Number of Researchers Working in the Projects	2,845	1,807	1,292	1,813	1,802	1,707
Annual Expenditure (million TL)**	198	204	179	188	193	176
Expenditure Per Ongoing Project	58,876	64,454	66,100	74,220	74,116	66,415

Source: TÜBİTAK

**: in 2013 fixed prices

3.3.4. Performance in 7th Framework Program

7th Framework Program for Research and Technological Development had been in effect for seven years from 2007 until 2013. The Framework Programs had two main strategic objectives. The first was strengthening the scientific and technological base of the European industry and the second was encouraging its international competitiveness, while promoting research that supports EU policies. The program had a total budget of around €53 billion (TÜBİTAK, 2012).

Turkey has been participated in Framework programs since 2003.The 6th Framework Program was in effect in that year. Turkey did not perform well in this program. 2,947 project participants applied to program and only 453 of them were accepted (TÜBİTAK, 2006). Turkey paid 185 million Euros as country contribution and Turkish project participants received approximately 60 million Euros. The reasons of this underperformance are explained by the lack of experience in writing and submitting project proposals and inappropriate level of international scientific networks (TÜBİTAK, 2012).

During 2007-2012, Turkey paid for 165 million Euros as country contribution and Turkish project participants had received 145 million Euros in the same period. As of

July 2012, a total of 879 project participants from Turkey were accepted by different sub-programs of the 7th Framework Program (TÜBİTAK, 2012).

Although the framework programs targeted increasing competitiveness of European firms, Turkish universities received the highest amount of funds compared to public research institutes, industry, and NGOs in the country. Namely 47 % of funds that were received by Turkish entities went to universities, 23 % to industry, 10 % to public research institutions and 20 % to other type of entities. 27 out of top 50 Turkish entities that received the highest amount of funds from 7th Framework Program were the universities. Among 879 successful Turkish applicants, 434 were from universities, 145 were from research centers, 159 were from Small and Medium Enterprises (SMEs), 44 were from public institutions, 55 were from industry and 42 were from NGOs (TÜBİTAK, 2012).

In Turkey 11 research centers had been funded under Regional Potential (REGPOT) Program, where a total of 133 projects were supported between 2007 and 2012. Among these 11 centers, 7 were owned by universities and the remaining 5 were owned by public research institutes (TÜBİTAK, 2012).

3.3.5. Collaborative activities with private sector

Up to our knowledge, there has been no data available about how many collaborative activities have been performed between private sector and academia in Turkey. On the other hand, in an innovation survey performed by TURKSTAT for the period between 2010 and 2012, firms were asked whether they performed collaborations with universities and whether they perceived universities as a source of knowledge.

The results of this survey illustrate that only 4.3 % of the firms have considered universities as a very important source of knowledge while performing innovative activities. 12.3 % have considered them as having medium-level importance and 14.6% have considered them as having low level importance in terms of sources of knowledge for innovative activities. Consequently, we see that almost 69 % of the firms have not considered universities as sources of knowledge for innovative activities (TURKSTAT, 2013).

Despite of the fact that universities in Turkey are in a good position in terms of research infrastructure and researchers, national innovation survey that covers 2010-2012 period reveals that enterprises that perform technological innovations do not effectively invoke universities as sources of knowledge to perform these activities.

On the average, 39.3% of firms that perform technological innovations state that they have participated in collaborative activities with universities. In this context, 34.8 % of firms that employ 10-49 employees have collaborated with universities, while this ratio is 44.4% for firms that employ 50-249 employees and 57.9 % for the firms that employ 250 or more employees (TURKSTAT, 2013). These figures show that collaborative activities among private sector and universities positively correlate with the size of innovative activities.

From the above figures we understand that 39.3% of innovative firms have made collaborations with universities, while only 31 % of them have considered universities as a source of knowledge. This situation deserves further investigation since these ratios indicate that some of the firms that have worked with academia have not benefited from these collaborations.

3.4. Concluding Remarks

This chapter provides information on key STI indicators and related developments in the Turkish higher education sector. Universities are seen as key actors in national innovation systems since they are the main source of highly skilled human resources and research infrastructure. The role of universities in the society and economy should be investigated carefully in Turkey, since these institutions are among the major actors in terms of research and development (R&D) activities in the country. Although the share of R&D expenditures of the higher education sector has followed a decreasing trend between 2002 and 2012, still 43.9 % of R&D expenditures are realized in universities and 38.2% of full-time equivalent research personnel are employed by them (TURKSTAT, 2013).

We see that between 2002 and 2012 GERD in Turkey has increased by 196 %, GERD as a percentage of GDP has increased from 0.53 % to 0.92 %, and the total number of

FTE researchers has more than tripled. We have also witnessed significant increases in the coverage of the Turkish higher education sector during this period. The total number of universities has increased from 74 in 2002 to 178 in 2013. In accordance with this increase, the total number of university students has increased by 161 %, and total number of academic personnel has increased by 72 %.

The total number of WoS indexed publications has increased by 179 % and publication per million populations has increased by 144 % between 2002 and 2012. In addition, the total number of master students has increased by 167 %, and the total number of PhD students has increased by 158 % during the same period.

In Turkey, TÜBİTAK launched a very comprehensive R&D support program in 2005. The total number of university projects that were supported from TÜBİTAK funds has changed between 894 and 1,267 annually, during the 2007 -2012 period.

Turkey has also participated in the Framework Programs which are supported by the European Commission. As of July 2012, a total of 879 project participants from Turkey were accepted by different sub-programs of the 7th Framework Program (TÜBİTAK, 2012) and Turkish universities have received the highest amount of funds compared to public research institutes, industry, and NGOs in the country.

Despite of the enlargement of higher education and R&D sectors in Turkey, results of Innovation Survey, which was implemented by TURKSTAT for 2010- 2012 period illustrate that almost 69 % of the firms have not considered universities as sources of knowledge for innovative activities, and 39.3% of firms that perform technological innovations state that they have participated in collaborative activities with universities (TURKSTAT, 2013).

These figures altogether point out that there is especially a need for enhancing cooperative research activities between universities and private sector in Turkey. We suggest that policies should be developed and implemented towards promoting universities so that they can offer different types of services such as consulting and R&D activities in addition to educational services.

CHAPTER 4

PRELIMINARY ANALYSES WITH INPUT AND OUTPUT VARIABLES

This section provides detailed bibliometric analyses with output variables that are selected for the DEA, SFA and panel data analyses that will be performed in the following chapters. Additionally, bibliometric analyses for faculty members, who are assumed to be the main human resources of the research activities performed in universities, are provided. These analyses enable us to capture circumstances and trends for different outputs, by scientific fields, time and universities.

In this section we analyze 94 Turkish universities that were established in or before 2006. While making bibliometric analyses, we classify universities under three broad groups which are as follows:

1. Established public universities (public universities established in and before 1992),
2. New public universities (public universities established in 2006),
3. Private universities (established in and before 2006)

In total, there are 53 established public universities, 15 new public universities and 26 private universities. We will start our analyses from faculty members and then four research outputs which are publication, citations, TÜBİTAK projects, and PhD graduates will be analyzed.

4.1. Analyses of Faculty Members

Faculty members are assumed to be the main human resources that performed research activities in this study. The total numbers of professors (Prf), associate professors (Asc.Prf), and assistant professors (Ast.Prf) in each university are given in Table 7.

Table 7: Number of faculty members by years and academic degree

	2008			2009			2010		
University	**Prf**	**Asc. Prf**	**Ast. Prf**	**Prf**	**Asc. Prf**	**Ast. Prf**	**Prf**	**Asc. Prf**	**Ast. Prf**
AİBÜ	54	46	246	55	51	269	68	48	310
Adıyaman	5	3	19	5	2	23	23	10	152
A.Menderes	99	112	244	118	120	263	151	112	250
Afyon	34	63	286	47	95	231	59	126	246
Ahi Evran	9	9	101	10	10	110	16	14	118
Akdeniz	234	142	309	261	162	342	294	166	370
Aksaray	5	4	32	4	4	32	5	6	35
Amasya	3	4	37	4	4	38	4	1	47
Anadolu	158	111	389	164	123	387	170	140	377
Ankara	1061	297	260	1131	307	274	1141	297	291
Ataturk	285	271	541	323	257	563	328	264	578
Atılım	37	11	75	41	11	76	44	17	82
Bahçeşehir	45	18	65	49	22	77	52	20	88
Balıkesir	39	45	220	44	61	221	74	78	262
Başkent	138	117	243	150	138	251	167	138	247
Beykent	51	8	75	55	9	88	46	8	96
Bilkent	99	60	177	97	58	165	93	59	160
Boğaziçi	180	75	168	179	79	172	173	81	173
Bozok	4	6	68	8	6	72	10	8	92
Celal Bayar	104	94	234	111	84	228	112	83	231
Cumhuriyet	102	143	200	152	108	260	150	116	254
Çağ	15	2	20	16	4	23	10	4	28
Çanakkale	73	68	281	80	79	312	81	75	309
Çankaya	28	8	31	31	10	36	31	10	53
Çukurova	373	128	256	368	129	256	350	130	245
Dicle	156	84	307	177	92	355	195	124	417
Doğuş	41	13	36	36	12	50	35	10	50
Dokuz Eylül	449	236	425	512	257	462	574	265	533
Dumlupınar	28	24	222	30	23	206	32	66	194
Düzce	31	14	105	30	15	101	28	14	95
Ege	751	288	431	777	293	462	762	273	458
Erciyes	226	115	190	225	112	196	225	115	197
Erzincan	7	7	79	6	15	95	6	22	111
ESOGÜ	207	91	266	206	107	275	225	121	275
Fatih	45	33	131	61	45	157	55	44	155
Fırat	183	132	352	205	169	323	207	158	315
Galatasaray	39	28	58	43	28	54	40	33	50
Gazi	782	327	701	789	358	785	809	396	724
Gaziantep	82	58	153	83	59	156	95	76	192
Gaziosmanpasa	35	59	198	40	59	204	44	53	201
GYTE	32	36	88	37	51	71	46	56	60
Giresun	1	2	30	4	1	32	10	1	39
Hacettepe	730	361	243	809	317	268	812	314	253
Halic	34	8	54	38	8	66	36	6	60
Harran	52	79	223	62	67	235	71	78	246
Hitit	6	12	47	6	10	49	17	20	81
Işık	27	5	23	28	5	24	29	9	40
İnönü	94	103	205	115	127	239	120	135	246
İstanbul Aydın	22	5	12	26	6	11	58	10	72
İstanbul Bilgi	47	28	61	55	28	82	48	33	96
İstanbul Bilim	33	8	11	32	8	11	59	12	26
İstanbul Kültür	66	18	64	70	18	71	71	21	93
İTÜ	391	185	340	416	201	371	418	214	349

Table 7 (cont'd): Number of faculty members by years and academic degree

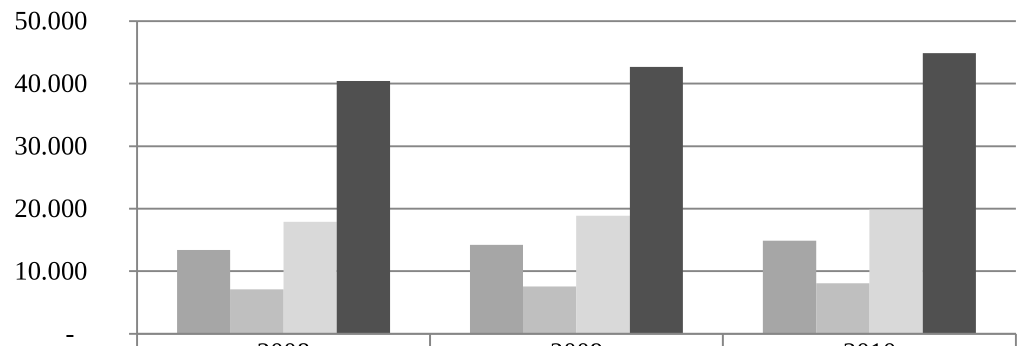
	2008			2009			2010		
University	**Prf**	**Asc. Prf**	**Ast. Prf**	**Prf**	**Asc. Prf**	**Ast. Prf**	**Prf**	**Asc. Prf**	**Ast. Prf**
İstanbul Ticaret	41	8	22	39	11	32	49	13	35
İstanbul	1483	431	622	1494	400	712	1500	419	731
İzmir Ekonomi	16	20	58	16	20	58	26	19	85
İYTE	30	33	75	35	37	75	38	41	80
Kadir Has	28	9	37	29	9	43	28	16	47
Kafkas	25	38	89	25	38	89	46	38	108
KSÜ	36	52	161	38	55	169	59	67	159
KTÜ	235	139	328	250	151	353	278	159	357
Kastamonu	5	4	49	8	3	51	9	3	48
Kırıkkale	56	75	213	62	83	226	90	95	223
Kocaeli	153	95	426	163	119	389	162	111	389
Koç	46	38	82	47	56	73	59	62	74
Maltepe	59	9	91	66	14	120	65	14	140
Marmara	533	221	537	488	215	527	479	212	520
Mehmet Akif	9	6	69	12	21	116	18	24	114
Mersin	83	147	265	124	128	276	120	130	272
MSGSÜ	78	36	160	78	40	169	73	40	172
Muğla	50	35	184	50	47	191	67	59	186
M.Kemal	45	48	248	55	56	299	57	50	305
N.Kemal	42	14	86	42	16	92	51	35	163
Nigde	22	22	161	20	21	157	18	20	167
Okan	20	2	25	20	2	25	51	9	97
OMÜ	224	128	380	229	134	382	227	135	393
Ordu	9	4	47	9	8	63	10	11	73
ODTÜ	377	123	223	379	131	244	375	145	233
Pamukkale	103	76	319	102	76	316	100	75	308
Rize	4	8	48	14	9	50	17	11	58
Sabancı	43	34	90	43	33	90	41	30	103
Sakarya	110	87	399	122	114	440	137	112	472
Selçuk	386	203	646	416	238	639	483	261	683
SDÜ	143	152	420	151	183	425	175	193	452
TOBB-ETÜ	22	14	51	24	16	53	31	15	82
Trakya	104	72	279	104	85	298	111	94	316
Ufuk	66	15	22	63	9	28	71	12	31
Uludağ	368	210	202	399	205	230	387	250	216
Uşak	7	2	56	7	2	57	9	9	85
Yasar	32	2	35	41	8	47	44	8	69
Yeditepe	166	76	290	180	87	303	173	73	309
YTÜ	180	81	312	191	90	324	199	130	341
Yuzuncuyıl	86	87	290	118	92	277	109	82	292
Z. Karaelmas	32	57	187	36	68	205	50	80	202

Source: Data is compiled by the author, using ÖSYM (2009, 2010, and 2011)

Before going further in the analyses, we would like to remind that analyzes performed in this study have covered only inputs and outputs of 94 Turkish universities, that were established in and before 2006. Thus, data provided in this chapter is not an analysis of the whole Turkish Higher Education sector.

For 94 universities, the total number of faculty members is 40,430 in 2008, 42,666 in 2009, and 44,845 in 2010. It corresponds to an 11% increase during the 3 years. Ratios of professors, associate professors and assistant professors have not changed within this period. They are 33 %, 18 %, and 44 %, respectively.

The sum of professors, associate professors, and assistant professors will be called as "faculty members" in this study. The total numbers of faculty members by their academic degree are given in Figure 6.



	2008	2009	2010
Prof	13.389	14.210	14.871
Asc. Prof.	7.117	7.554	8.052
Ast. Prof.	17.916	18.893	19.912
Total	40.430	42.666	44.845

Figure 6: Number of faculty members by academic degrees and years

Source: Data is compiled by the author, using ÖSYM (2009, 2010, and 2011)

When the total number of faculty members by university types is investigated, it is seen that 85 % are employed by established public universities, 10 to 11 % are employed by private universities and 3 to 4 % are employed by new public universities during the period between 2008 and 2010. We have observed a slight decrease in the percentage of faculty members employed by the established public universities, which has been accompanied by slight increases in the ratios of private and new public universities (Table 8).

Table 8: Number of faculty members by university types

	The Total Faculty Members			Percentage of The Total		
Type of University	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Established public	33,586	35,321	36,540	87	87	85
New public	1,119	1,276	1,733	3	3	4
Private	3,717	4,060	4,562	10	10	11
TOTAL	**38,422**	**40,657**	**42,835**	**100**	**100**	**100**

Source: Data is compiled by the author, using ÖSYM (2009, 2010, and 2011)

One of our major motivations, while preparing this chapter is to identify discipline-based differences in terms of productivity of research outputs. Thus, we decide to differentiate faculty members in terms of the scientific fields that they are working in. We use Annual Higher Education Statistics (AHES) which is being published by ÖSYM.

In AHES faculty members are classified under eight major scientific fields, whereas approximately 5% of the faculty members are unclassified. The eight fields are as follows:

1. Language and Literature
2. Mathematics and Natural Sciences
3. Health Sciences
4. Social Sciences
5. Applied Social Sciences
6. Technical Sciences
7. Agricultural Sciences
8. Art

On the other hand, in the following chapters we will utilize publications, citations, TÜBİTAK projects and PhD graduates in our models and since the data regarding these outputs are obtained from different data sources they have different classification schemes. As a result, we need to obtain a common classification scheme. We rearrange AHES's distribution of faculty members and obtain the following 5 scientific fields:

1. Agricultural, Forestry and Veterinary Sciences (AFVS)
2. Basic Sciences
3. Engineering Sciences
4. Health Sciences
5. Social Sciences

Calculation of faculty members in AFVS: It is obtained by adding faculty members listed under “Agricultural Sciences” which is a major field in AHES and faculty members listed under “Veterinary Sciences” which is a sub-field under health sciences in AHES.

Calculation of faculty members in basic sciences: Numbers of faculty members who are listed under “Mathematics and Natural Sciences” in AHES are directly used.

Calculation of faculty members in engineering sciences: Numbers of faculty members who are listed under “Technical Sciences” in AHES are directly used.

Calculation of faculty members in health sciences: In the classification schemes of AHES “Health Sciences” includes “Veterinary Sciences” as a sub-field. On the other hand, we combine veterinary sciences with agricultural sciences in our study design. Thus, we subtract the total number of faculty members who are classified under “Veterinary Sciences” of AHES from the total number of faculty members listed under “Health Sciences”.

Calculation of faculty members in social sciences: It is obtained by adding the number of faculty members which are listed under “Language and Literature”, “Social Sciences”, “Applied Social Sciences”, and “Arts” major fields of AHES.

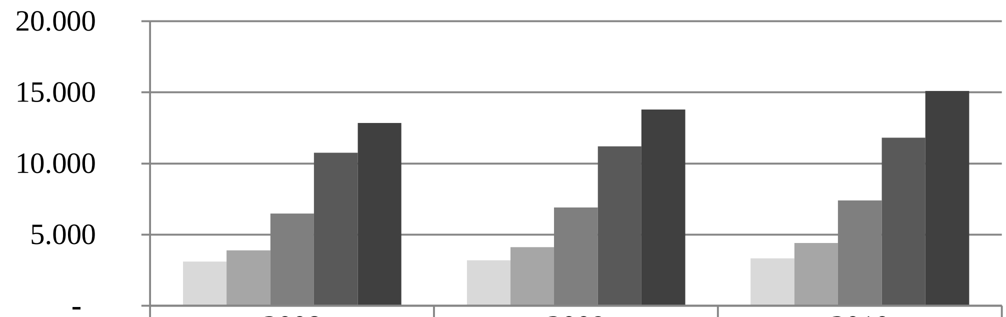
Rearranged numbers of faculty members by 5 scientific fields are given in Table 9. We notice that the highest numbers of professors are employed in health sciences, and highest numbers of assistant professors are employed in social sciences for all years.

Table 9: Number of faculty members by scientific fields

	2008			2009			2010		
Scientific Field	Prf	Asc. Prf	Ast. Prf	Prf	Asc. Prf	Ast. Prf	Prf	Asc. Prf	Ast Prf
AFVS	1,188	669	1,249	1,249	697	1,247	1,368	717	1,254
Basic Sci.	1,340	700	1,851	1,395	798	1,919	1,479	922	2,005
Eng. Sci.	2,205	956	3,330	2,312	1,055	3,539	2,442	1,229	3,740
Health Sci.	5,111	2,477	3,175	5,540	2,434	3,240	5,854	2,494	3,467
Social Sci.	3,322	2,076	7,446	3,489	2,295	8,006	3,692	2,500	8,912
Unclassified	276	242	867	352	316	1,164	392	332	1.412

Source: Data is compiled by the author, using ÖSYM (2009, 2010, and 2011)

Figure 7 provides the total number of faculty members by scientific fields. Percentage increases in the total number of faculty members from 2008 to 2010 are 8 % in AFVS, 13 % in basic sciences, 14 % in engineering sciences, 10 % in health sciences, and 18 % in social sciences. Consequently, the highest percentage increase in terms of faculty members has been realized in social sciences, and the lowest increase has realized in AFVS during the 2008-2010 period.



	2008	2009	2010
AFVS	3.106	3.193	3.339
Basic Sci.	3.891	4.112	4.406
Eng. Sci.	6.491	6.906	7.411
Health Sci	10.763	11.214	11.815
Social Sci.	12.844	13.790	15.104

Figure 7: Number of faculty members by 5 scientific fields.

Source: Data is compiled by the author, using ÖSYM (2009, 2010, and 2011)

For the analyses of PhD graduates, we need to rearrange the total number of faculty members under 3 scientific fields because statistics regarding PhD graduates are given for graduate level institutes and they are available only for 3 scientific fields. To decrease fields from 5 to 3, we combine faculty members working in basic sciences, engineering sciences and AFVS (which are provided in Table 8) and obtain a new scientific field, which is called as "Natural and Applied Sciences (NAS)". Numbers for health and social sciences remain the same. Numbers of faculty members by 3 disciplines are given in Table 10:

Table 10: Number of faculty members by 3 scientific fields.

Scientific Field	2008	2009	2010
NAS	11,930	12,606	13,677
Health Sciences	11,462	11,960	12,503
Social Sciences	12,408	13,334	14,599

Source: Data is compiled by the author, using ÖSYM (2009, 2010, 2011)

4.2. Analyses of Publications

Bibliometric analyses of publications are performed through data that is retrieved from the WoS database for 94 Turkish universities. A detailed search is performed during 12 and 15 January 2013. Some of the researchers have made mistakes while coding their institutions in the database. Thus, we perform our search first by writing the names of universities in the search field, and then writing the names of provinces that these universities are located. For example, for Adnan Menderes University following alternative codifications are made during the 2008-2010 (Table 11).

Publications that are written by 94 Turkish universities and indexed by SCI-expanded, SSCI, AHCI, Conference Proceedings Citation Index- Science (CPCI-S), and Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) databases of Web of Science are included in our data set. Articles, proceedings papers, reviews, corrections, meeting abstracts, letters, editorial materials and news items are documents that are covered in this study. We call all academic documents as "**publications**" in this study.

Table 11: Examples of codifications in WoS

Codified Name	Amount
ADNAN MENDERES UNIV	695
UNIV ADNAN MENDERES	56
ADNAN MENDERES UNIV HOSP	8
ADNAN MENDERES UNIV SCH MED	4
ADNAN MENDERS UNIV	4
ADRIAN MENDERES UNIV	4
ADNAN MENDERES UNIV AYDIN	3
ADNAN MEDERES UNIV	2
ADNAN MENDERES UNIV TIP FAK	2
ADNAN MENDARES UNIV	1
ADNAN MENDCRES UNIV	1
ADNAN MENDERES U AYDIN SAGLIK YUKSEKOKULU	1
ADNAN MENDERES U TIP FAK	1
ADNAN MENDERES UNIV HASTANESI	1
ADNAN MENDERES UNIV IIBF	1
ADNAN MENDERES UNIV MED FAC	1
ADNAN MENDERES UNIV MED SCH HOSP	1
UNIV ADRIAN MENDERES	1
UNIV ADNAM MENDERES	1
TOTAL	**788**

Source: Data is compiled by the author, using WoS database

The total numbers of publications written by faculty members of 94 Turkish universities in 2008, 2009 and 2010 are 23,988, 26,748, and 27,193, respectively and there is an increasing trend for all years. The percentage increase is higher for the 2008-2009 period, compared to 2009-2010 period. The total number of publications and publications per faculty member for different university types are given in Table 12. Since some publications are written in collaboration with faculty members from different universities, some publications are counted twice or three times in this table.

Table 12: Total and per faculty numbers of publications by university type

University Type	Total Number of Publications			Publications Per Faculty		
	2008	2009	2010	2008	2009	2010
Established Public	24,083	27,067	27,597	0.72	0.77	0.76
New Public	572	975	1,257	0.51	0.76	0.73
Private	2,907	3,302	3,409	0.78	0.81	0.75

Source: Data is compiled by the author, using WoS database

The total number of publications by each university type is given in Table 13. When we look at the total numbers, the most productive group is found to be the established public universities, followed by private universities and new public universities. On the other hand, publications per faculty member does not significant differs in terms of university types.

Table 13: Total publications written by 94 universities

University	Total Publications (2008)	Total Publications (2009)	Total Publications (2010)	Total Publications (3years)
AİBÜ	205	247	220	672
Adıyaman	25	68	113	206
A.Menderes	205	271	312	788
Afyon	335	333	285	953
Ahi Evran	41	85	94	220
Akdeniz	425	600	606	1,631
Aksaray	56	86	122	264
Amasya	5	25	32	62
Anadolu	299	391	396	1,086
Ankara	1,323	1,404	1,436	4,163
Atatürk	664	855	877	2,396
Atılım	77	115	119	311
Bahçeşehir	52	59	95	206
Balıkesir	114	151	175	440
Başkent	671	695	604	1,970
Beykent	32	41	33	106
Bilkent	462	499	493	1,454
Boğaziçi	425	497	467	1,389
Bozok	44	54	75	173
Celal Bayar	227	326	321	874
Cumhuriyet	222	270	274	766
Çağ	2	9	17	28
Çanakkale	262	316	296	874
Çankaya	86	72	122	280
Çukurova	603	619	643	1,865

Table 13 (cont'd): Total publications written by 94 universities

University	Total Publications (2008)	Total Publications (2009)	Total Publications (2010)	Total Publications (3years)
Dicle	348	369	377	1,094
Doğuş	51	63	86	200
Dokuz Eylül	799	807	804	2,410
Dumlupınar	150	185	167	502
Düzce	121	149	198	468
Ege	1,161	1,287	1,344	3,792
Erciyes	610	703	798	2,111
Erzincan	19	29	53	101
ESOGÜ	376	426	474	1,276
Fatih	210	232	258	700
Fırat	479	523	533	1,535
Galatasaray	42	42	46	130
Gazi	1,321	1,370	1,395	4,086
Gaziantep	355	347	348	1,050
G.osmanpaşa	236	254	241	731
GYTE	180	225	225	630
Giresun	35	44	69	148
Hacettepe	1,579	1,626	1,679	4,884
Haliç	18	21	24	63
Harran	235	253	262	750
Işık	51	45	42	138
İnönü	271	274	340	885
İst. Aydın	2	6	6	14
İst. Bilgi	33	33	27	93
İst. Bilim	48	64	85	197
İst. Kültür	49	61	67	177
İTÜ	845	931	845	2,621
İst. Ticaret	25	25	25	75
İstanbul	1,585	1,738	1,872	5,195
İzmir Ekon.	52	85	97	234
İYTE	145	189	220	554
Kadir Has	38	39	47	124
Kafkas	146	168	179	493
KSİU	165	242	238	645
KTÜ	522	553	632	1,707
Kastamonu	27	45	34	106
Kırıkkale	279	302	266	847
Kocaeli	417	437	460	1,314
Koç	212	241	253	706
Maltepe	44	55	57	156
Marmara	657	759	725	2,141
Mehmet Akif	47	94	95	236
Mersin	274	277	306	857
M.Sinan	5	11	12	28
Muğla	132	162	187	481
M. Kemal	236	347	340	923
N. Kemal	50	101	131	282
Niğde	157	181	165	503

Table 13 (cont'd): Total publications written by 94 universities

University	Total Publications (2008)	Total Publications (2009)	Total Publications (2010)	Total Publications (3years)
Okan	20	26	42	88
OMÜ	551	741	695	1,987
Ordu	24	57	43	124
ODTÜ	1,063	1,173	1,137	3,373
Pamukkale	373	387	346	1,106
Rize	47	81	122	250
Sabancı	211	248	237	696
Sakarya	189	248	227	664
Selçuk	668	840	926	2.434
SDÜ	450	520	534	1,504
TOBB-ETÜ	149	147	156	452
Trakya	305	317	289	911
Ufuk	49	53	65	167
Uludağ	555	590	634	1,779
Uşak	16	31	32	79
Yaşar	16	22	38	76
Yeditepe	246	347	313	906
YTÜ	355	417	410	1,182
Yüzüncüyıl	294	346	383	1,023
Z.Karaelmas	262	218	230	710

Source: Data is compiled by the author, using WoS database

Figure 8 provides the distribution of publications by their language. Out of 71,902 publications that are written in 2008-2010 period, 67,802 are written in English, 3,957 in Turkish, and 143 in other languages. There are some journals that are indexed in WoS and publish articles in Turkish; their ratio does not exceed 6 % of the total.

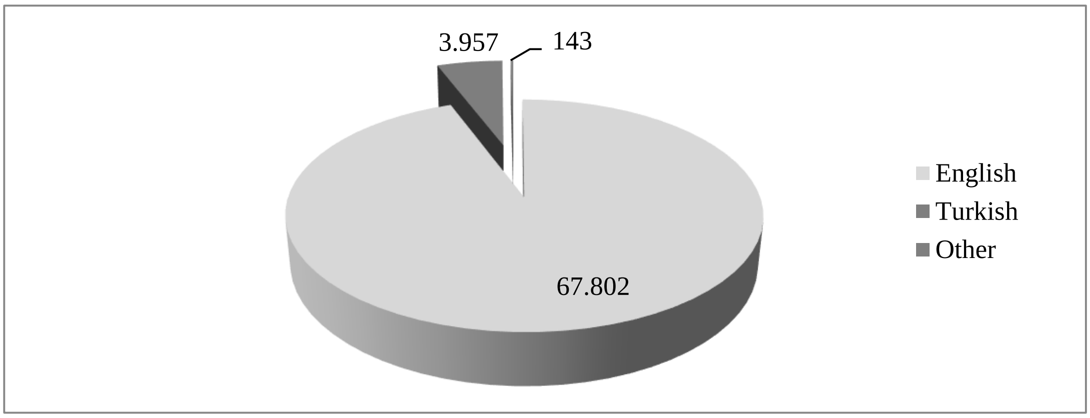
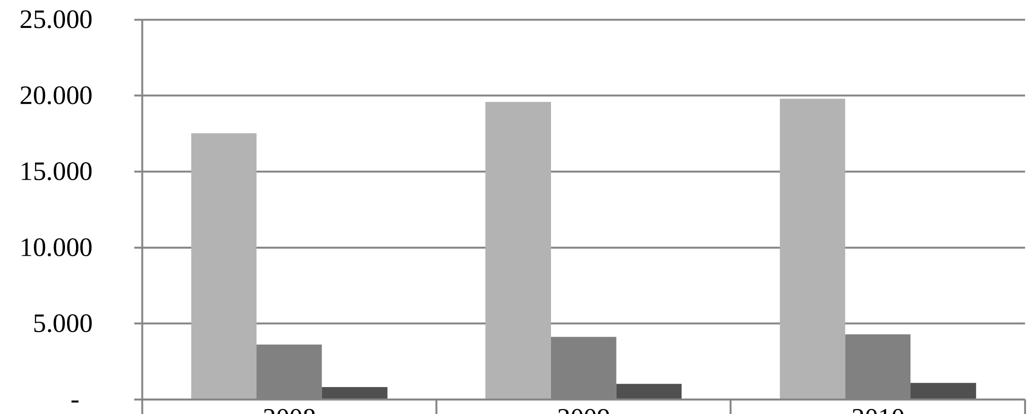


Figure 8: Publications by language (2008-2010 period total)

Source: Data is compiled by the author, using WoS database

Researchers from different universities frequently collaborate for writing publications. Figure 9 shows the distribution of publications in terms of the total number of Turkish universities that have collaborated in writing them.



	2008	2009	2010
1	17.536	19.589	19.798
2	3.613	4.124	4.289
3&more	831	1.026	1.096

Figure 9: Number of Turkish universities contributing to publications

Source: Data is compiled by the author, using WoS database

For the 3-year period, 79 % of the publications have authors from a single Turkish university, 16-17 % of publications are written in collaboration of researchers from two different Turkish universities, and 3-4 % of publications are written by researchers from three and more Turkish universities.[25]

Table 14 presents the distribution of publications by the total number of authors. Between 2008 and 2010, the most prevailing form of the authorship is the two-author case, which is followed by three-author, four-author, and single-author cases.

[25] These numbers were calculated without considering researchers from other countries and domestic researchers that were affiliated with institutions other than universities.

Table 14: Distribution of publications by the total number of authors

Number of authors	2008	2009	2010	3-year
1 author	2,561	3,069	3,123	8,753
2 authors	4,725	5,359	5,482	15,566
3 authors	4,157	4,695	4,668	13,520
4 authors	3,522	3,904	3,819	11,245
5 authors	2,483	2,936	2,943	8,362
6 authors	1,800	1,969	1,995	5,764
7 & more authors	2,732	2,807	3,153	8,692

Source: Data is compiled by the author, using WoS database

Table 15 includes information about the average number of authors per publication in different types of universities. This ratio is very close between new public and private universities. Meanwhile, we observe that it is higher in public universities.

Table 15: Average number of authors per publication by university type

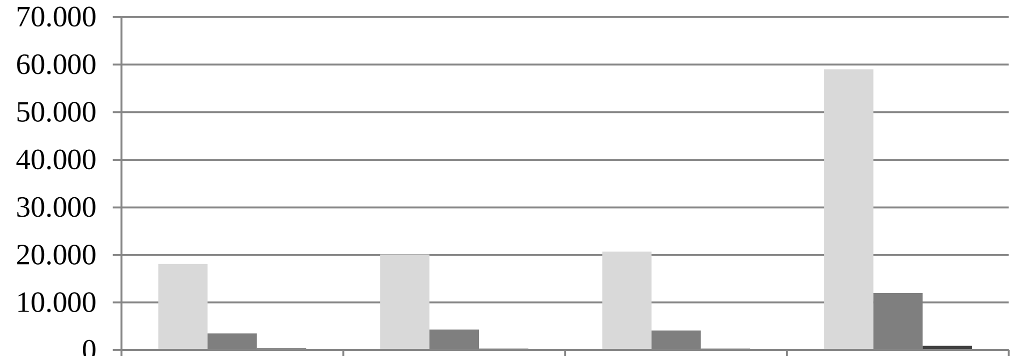
Type of University	2008	2009	2010	3-year
Established public	4.43	4.34	5.40	4.74
New public	3.73	3.67	4.01	3.83
Private	3.73	3.73	4.29	3.93

Source: Data is compiled by the author, using WoS database

Studies show that scientific productivity (in terms of the total number of publications) and scientific impact (in terms of the total citations received by these publications) has differed significantly across different scientific fields (Abramo et al., 2011b; Dündar and Lewis, 1998). To be able to capture whether there also occur differences for Turkish universities, publications are classified under five different scientific fields similar to the classification of faculty members that we had done earlier in this chapter.

A publication may cover one or more scientific fields. From Figure 10 we can see that 82% of the publications written by 94 universities during the period between 2008 and 2010have covered one scientific discipline, whereas 18 % have covered multiple disciplines.

To avoid multiple counts in the field-based calculations, publications that cover multiple scientific fields are equally allocated into those disciplines. Namely, if a publication covers n scientific disciplines, then each discipline receives (1/n) publications. The same procedure is applied for citations as well.



	2008	2009	2010	Total
1 field	18.100	20.139	20.743	58.982
2 fields	3.542	4.309	4.152	12.003
3 fields	338	291	288	917

Figure 10: Publications by number of scientific fields that they covered

Source: Data is compiled by the author, using WoS database

The total numbers of publications by five scientific fields are calculated via applying this procedure and results are demonstrated in Table 16. It can be seen that the most productive scientific discipline, in terms of the total publications, is health sciences, whereas the least productive ones are AFVS and social sciences. When we investigate the percentage increase in terms of publication productivity from 2008 to 2010, we can see that the highest increases are observed in the least productive fields, whereas the lowest increase is realized in the most productive field. Namely, a 76 % increase is realized in social sciences, 34 % in AFVS, 22 % in basic sciences, 4 % in engineering sciences, and 3 % in health sciences.

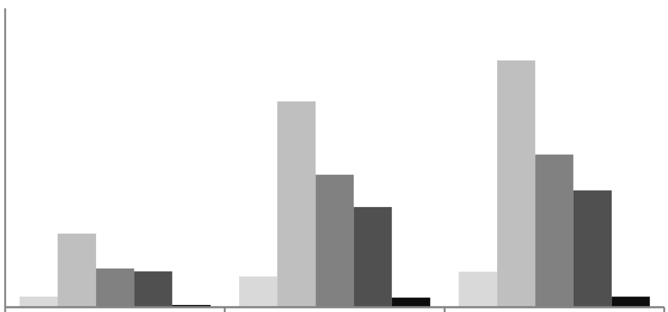
Table 16: Total number of publications by scientific fields

Scientific Field	2008	2009	2010	3-Year Total	% Increase
AFVS	1,066	1,464	1,427	3,957	34%
Basic Sciences	5,240	6,223	6,378	17,841	22%
Engineering Sci.	4,798	5,447	4,999	15,243	4%
Health Sciences	9,315	9,482	9,635	28,432	3%
Social Sciences	1,561	2,123	2,744	6,428	76%
Total	21,980	24,739	25,183	71,902	15%

Source: Data is compiled by the author, using WoS database

Some publications are written in the context of scientific projects which are funded by national and international organizations. TÜBİTAK, Scientific Research Project Funds of universities, and Ministry of Science, Industry and Technology are the most prevailing national fund providers, whereas EU Framework programs can be given as an example for international fund providers.

14,082 out of 71,902 publications that are written in the period between 2008 and 2010have utilized results of the funded projects. These publications will be called as "**funded publications**" and their distribution by scientific fields is given in Figure 11.



	2008	2009	2010
AFVS	125	361	415
Basic Sciences	861	2.411	2.888
Engineering Sciences	454	1.552	1.789
Health Sciences	420	1.175	1.369
Social Sciences	26	112	124

Figure 11: Distribution of "funded publications" by scientific fields

Source: Data is compiled by the author, using WoS database

From Figure 11, we observe that the total number of "funded publications" has increased steadily from 2008 to 2010. The highest amount of "funded publications" is realized in the basic sciences, whereas the social sciences comes the last.

For each of the five scientific fields, we calculate publications per faculty member. To do this, data provided in Table 16 are divided by data provided in Figure 7 and results are presented in Table 17.

Table 17: Publications per faculty member by scientific fields

Scientific Field	2008	2009	2010
AFVS	0.34	0.46	0.43
Basic Sciences	1.35	1.51	1.45
Engineering Sciences	0.74	0.79	0.67
Health Sciences	0.87	0.85	0.82
Social Sciences	0.12	0.15	0.18

Source: Data is compiled by the author, using WoS database

It is observed that publication per faculty member has differed by both scientific field and year. Basic sciences is the most productive field and it is followed by health sciences, and engineering sciences. The least productive field is social sciences, such that publication per faculty member is almost one tenth of the basic sciences. One of the factors affecting the observed lower publication productivity in the social sciences is that we don't include books, or publications written in Turkish journals that are not indexed in WoS. Probably, social scientists in Turkey prefer to make publications in these journals. When we investigate productivity over years, we see that the most productive year is 2009 for most of the disciplines.

Table 18 presents information about the authorship patterns in different scientific fields. The most prevailing forms have changed from one discipline to another, such that the most dominant form is 2-authors' case for AFVS, basic sciences, and engineering sciences, whereas it is 7 and more authors' case for the health sciences, and single author's case for the social sciences.

Table 18: Authorship patterns in different scientific fields (Overall period)

# of Authors	AFVS	Basic Sciences	Engineering Sciences	Health Sciences	Social Sciences
1 author	303	2,500	2,092	1,307	2,551
2 authors	936	4,702	5,206	2,692	2,031
3 authors	899	3,999	3,886	3,753	984
4 authors	831	2,783	2,251	4,959	421
5 authors	494	1,702	994	4,979	193
6 authors	270	876	457	4,037	125
7 & more	224	1,280	358	6,706	124

Source: Data is compiled by the author, using WoS database

The ratio of single-author's cases to all publications is 8% for AFVS, 14 % for basic and engineering sciences, 5 % for health sciences, and 40 % for social sciences. Additionally, percentage of publications written by 7 and more authors is significantly higher for health sciences compared to other disciplines.

4.3. Analyses of Citations

Total amount of citations received by publications that are written in 2008, 2009, and 2010 are given in Table 19. The total amount of citations is found significantly correlated with the total amount of publications at 5 % significance level. They are calculated as 0.98 in 2008, 0.97 in 2009, and 0.95 in 2010.

As it can be seen from Table 19, the total citations follow a decreasing pattern for most of the universities by years. This trend is quite expected, since it takes time for a publication to get citations from others, and citations are calculated cumulatively. On the other hand, universities that have noticeable increases in terms of their total number of faculty members (such as new public universities), have also recorded increases in terms of the total citations during the analysis period.

Table 19: Total citations received by publications written in different years

University	Total Citations (publications of 2008)	Total Citations (publications of 2009)	Total Citations (publications of 2010)	Total Citations (3years)
AİBÜ	839	734	499	2,072
Adıyaman	172	247	364	783
A.Menderes	796	810	642	2,248
Afyon	1,221	1,145	733	3,099
Ahi Evran	375	550	352	1,277
Akdeniz	2,404	2,708	1,444	6,556
Aksaray	332	304	305	941
Amasya	22	108	113	243
Anadolu	2,638	1,772	1,058	5,468
Ankara	5,863	4,509	3,464	13,836
Atatürk	3,441	3,521	2,409	9,371
Atılım	432	388	341	1,161
Bahçeşehir	219	270	345	834
Balıkesir	602	834	366	1,802
Başkent	2,486	1,924	997	5,407
Beykent	141	71	65	277
Bilkent	3,457	3,240	2,058	8,755
Boğaziçi	2,482	1,867	2,648	6,997
Bozok	288	272	232	792
Celal Bayar	1,825	979	681	3,485
Cumhuriyet	1,059	1,042	588	2,689
Çağ	2	40	170	212
Çanakkale	1,221	1,190	801	3,212
Çankaya	788	487	473	1,748
Çukurova	2,971	2,331	2,293	7,595
Dicle	1,839	1,207	835	3,881
Doğuş	260	259	681	1,200
DEÜ	4,178	2,983	1,976	9,137
Dumlupınar	815	758	832	2,405
Düzce	579	342	349	1,270
Ege	6,989	5,625	4,444	17,058
Erciyes	4,465	3,613	2,184	10,262
Erzincan	116	131	169	416
ESOGÜ	2,402	1,885	1,028	5,315
Fatih	1,193	1,231	813	3,237
Fırat	3,309	2,805	1,459	7,573
Galatasaray	167	123	85	375
Gazi	5,905	4,863	3,544	14,312
Gaziantep	2,005	1,282	1,275	4,562
G.osmanpaşa	1,933	1,639	736	4,308
GYTE	1,530	1,452	858	3,840
Giresun	186	206	151	543
Hacettepe	9,162	7,271	4,812	21,245
Haliç	33	37	34	104
Harran	1,077	985	565	2,627
Hitit	22	126	99	247
Işık	186	149	98	433
İnönü	1,436	979	791	3,206

Table 19 (cont'd): Total citations received by publication written in different years

University	Total Citations (by publications of 2008)	Total Citations (by publications of 2009)	Total Citations (by publications of 2010)	Total Citations (3years)
İst. Aydın	17	6	20	43
İst. Bilgi	104	46	20	170
İst. Bilim	147	216	181	544
İst. Kültür	282	187	101	570
İTÜ	5,52	4,485	3,716	13,253
İst. Ticaret	100	34	38	172
İstanbul	8,072	8,019	5,621	21,712
İzmir Ekon.	161	294	159	614
İYTE	927	1.083	1,211	3,221
Kadir Has	124	155	63	342
Kafkas	630	495	780	1,905
KSİU	660	733	464	1,857
KTÜ	2,921	2,493	1,557	6,971
Kastamonu	104	188	32	324
Kırıkkale	1,267	864	639	2,770
Kocaeli	1,958	1,914	1,184	5,056
Koç	1,479	1,446	1,240	4,165
Maltepe	180	162	115	457
Marmara	3,509	3,064	1,800	8,373
Mehmet Akif	76	151	119	346
Mersin	1,887	1,082	1,123	4,092
M.Sinan	14	16	11	41
Muğla	1,107	782	393	2,282
M. Kemal	992	1,006	724	2,722
N. Kemal	149	431	215	795
Niğde	1,071	721	359	2,151
Okan	53	89	45	187
OMÜ	2,447	2,276	1,675	6,398
Ordu	51	104	50	205
ODTÜ	6,975	5,985	5,036	17,996
Pamukkale	1,847	1,516	753	4,116
Rize	260	397	277	934
Sabancı	1,503	1,600	1,358	4,461
Sakarya	1,293	1,104	592	2,989
Selçuk	3,431	3,384	2,221	9,036
SDÜ	2,702	1,950	1,714	6,366
TOBB-ETÜ	992	678	798	2,468
Trakya	1,049	935	409	2,393
Ufuk	196	196	137	529
Uludağ	2,442	2,408	1,366	6,216
Uşak	47	125	61	233
Yaşar	70	98	163	331
Yeditepe	1,432	1,384	894	3,710
YTÜ	1,784	1,858	1,210	4,852
Yüzüncüyıl	1,027	1,056	911	2,994
Z.Karaelmas	1,175	801	679	2,655

Source: Data is compiled by the author, using WoS database

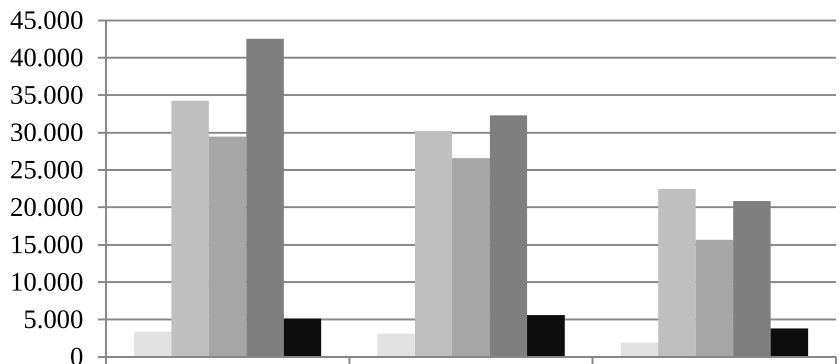
Citations per publication (CPP) received by each type of university are given in Table is It can be seen that CPP of each university type are very close to each other. Meanwhile, the highest CPP is received by established public universities in 2008, by established and new public universities in 2009 and by private universities in 2010.

Table 20: Citations per publications received by university type

University Type	2008	2009	2010
Established public	5.4	4.0	2.8
New public	4.6	4.0	2.3
Private	4.8	3.8	3.2

Source: Data is compiled by the author, using WoS database

The total numbers of citations received in each discipline are given in Figure 12. We observe that the total number of citations by scientific fields and the total number of publications by scientific fields (Table 16) follow similar trends for each year. This result is not surprising since it is expected that if higher amounts of publications are written in a specific field, then that field has also higher number of citations. On the other hand, we need to calculate citations per publication for each specific field, to understand the citation trends in that field.



	2008	2009	2010
AFVS	3.356	3.103	1.902
Basic Sciences	34.281	30.246	22.494
Engineering Sciences	29.457	26.574	15.683
Health Sciences	42.525	32.298	20.797
Social Sciences	5.130	5.620	3.786

Figure 12: Total number of citations by scientific disciplines

Source: Data is compiled by the author, using WoS database

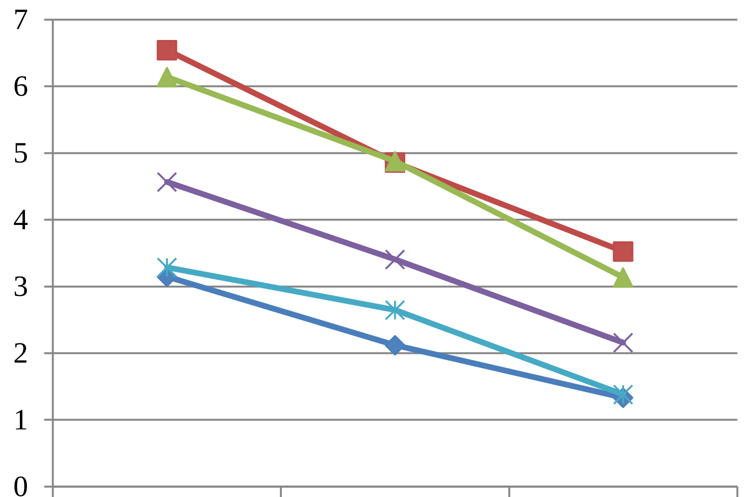
In Table 21, the relationship between citation per publication (CPP) and number of authors are investigated. The lowest CPP is received by single-authored articles, and the highest CPP is received by articles written by seven and more authors. The other cases lie in between these two groups.

Table 21: Citations per publication with respect to number of authors

# of authors	2008	2009	2010
1 author	3.50	2.89	1.54
2 authors	4.62	3.55	2.17
3 authors	5.21	3.90	2.60
4 authors	5.07	3.81	2.39
5 authors	4.90	3.58	2.37
6 authors	5.30	3.96	2.47
7 authors	8.32	6.58	4.70

Source: Data is compiled by the author, using WoS database

Using data provided in Figure 12 and Table 16, citations per publications are calculated for each discipline (Figure 13).



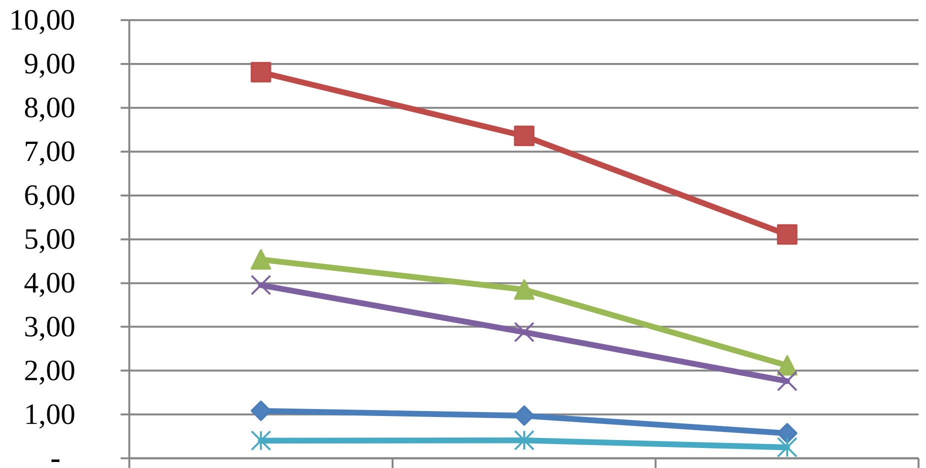
	2008	2009	2010
AFVS	3,15	2,12	1,33
Basic Sciences	6,54	4,86	3,53
Engineering Sciences	6,14	4,88	3,14
Health Sciences	4,57	3,41	2,16
Social Sciences	3,29	2,65	1,38

Figure 13: Citations per publication by scientific disciplines

Source: Data is compiled by the author, using WoS database

Figure 13 clearly depicts the differences in terms of CPP for different scientific disciplines. There are also differences in the total number of citations by years. As the publication year gets closer, total number of citations has decreased for each scientific field. Publications written in basic sciences and engineering sciences have received approximately twice more citations compared to that of AFVS and social sciences for every year, and CPP for health sciences have been located in the middle of 5 disciplines.

We also calculate citations per faculty (CF) for each discipline and for each year (Figure 14). These figures show that CF has differed by scientific fields. The highest ratio is received in basic sciences and it is almost twice higher than the following scientific fields, which are health and engineering sciences. The lowest ratio is observed in social sciences.



	2008	2009	2010
AFV	1,08	0,97	0,57
Basic	8,81	7,36	5,11
Engineering	4,54	3,85	2,12
Health	3,95	2,88	1,76
Social	0,40	0,41	0,25

Figure 14: Citations per faculty by scientific disciplines

Source: Data is compiled by the author, using WoS database

4.4. Analyses of TÜBİTAK Projects

Between 2008 and 2010, 1,844 academic research projects in Turkish universities have been supported through Academic and Applied R&D Support (AARD) Program of TÜBİTAK. AARD Program has been implemented by Academic Research Funding Program Directorate (ARDEB) and there are seven research groups separated by academic fields in this directorate. These groups are:

1. Environment, Atmosphere, Earth and Marine Sciences (ÇAYDAG)
2. Electrical, Electronics and Informatics (EEEAG)
3. Engineering (MAG)
4. Health Sciences (SBAG)
5. Social Sciences and Humanity (SOBAG)
6. Basic Sciences (TBAG)
7. Agriculture, Forestry and Veterinary (TOVAG)

Numbers of projects supported under different research groups are given in Table 22. As of three-year total, the highest number of projects are supported in basic sciences (441 projects), followed by engineering (357 projects), social sciences and humanity (271 projects), agriculture, forestry and veterinary (254 projects), environment, atmosphere, earth and marine sciences (184 projects), health sciences (174 projects), and electrical, electronics and informatics (163 projects).

Table 22: Number of projects supported by TÜBİTAK research groups

Research Group	2008	2009	2010	Total
ÇAYDAG	65	54	65	184
EEEAG	52	51	60	163
MAG	125	104	128	357
SBAG	60	61	53	174
SOBAG	95	83	93	271
TBAG	140	137	164	441
TOVAG	78	70	106	254
Total	615	560	669	1844

Source: TÜBİTAK, ARDEB

Table 23: TÜBİTAK projects implemented by Turkish universities

University	2008-2010 Total Basic Sci.	Eng. Sci.	Health Sci.	Soc. Sci.	AFVS	TOTAL	2008 Total	2009 Total	2010 Total
AİBÜ	6	1	1	3	1	12	5	3	4
Adıyaman	0	0	0	1	0	1	0	0	1
A.Menderes	5	0	2	4	9	20	5	8	7
Afyon	1	7	0	1	1	10	1	5	4
Ahi Evran	5	0	0	0	0	5	0	0	5
Akdeniz	4	2	10	7	8	31	6	8	17
Aksaray	5	0	1	0	0	6	1	1	4
Amasya	0	0	0	0	0	0	0	0	0
Anadolu	10	8	1	12	0	31	13	8	10
Ankara	22	6	20	24	24	96	39	26	31
Atatürk	20	7	3	4	5	39	21	11	7
Atılım	1	5	0	2	0	8	0	4	4
Bahçeşehir	2	4	0	2	0	8	1	2	5
Balıkesir	7	1	0	1	2	11	5	0	6
Başkent	0	2	0	5	0	7	1	2	4
Beykent	0	0	0	0	0	0	0	0	0
Bilkent	17	31	8	14	1	71	15	29	27
Boğaziçi	19	26	3	7	0	55	18	18	19
Bozok	3	1	0	0	0	4	2	1	1
Celal Bayar	0	2	2	1	0	5	4	0	1
Cumhuriyet	5	3	0	1	0	9	1	3	5
Çağ	0	0	0	0	0	0	0	0	0
Çanakkale	12	0	0	3	7	22	6	8	8
Çankaya	0	1	0	1	0	2	1	0	1
Çukurova	11	5	3	3	13	35	11	10	14
Dicle	9	0	0	0	3	12	3	5	4
Doğuş	1	1	0	1	0	3	2	1	0
Dokuz Eylül	19	16	9	5	1	50	11	19	20
Dumlupınar	0	4	1	0	0	5	1	3	1
Düzce	2	0	0	0	1	3	0	1	2
Ege	19	17	19	8	28	91	33	25	33
Erciyes	9	6	5	1	6	27	6	8	13
Erzincan	0	0	0	0	0	0	0	0	0
ESOGÜ	6	3	2	0	0	11	4	6	1
Fatih	9	2	2	4	0	17	6	3	8
Fırat	5	4	2	3	4	18	3	7	8
Galatasaray	2	3	0	2	0	7	1	5	1
Gazi	9	12	6	8	0	35	13	12	10
Gaziantep	1	5	0	1	0	7	5	0	2
G.osmanpaşa	5	1	0	0	8	14	8	2	4
GYTE	21	12	1	1	0	35	12	8	15
Giresun	1	0	0	0	0	1	0	0	1
Hacettepe	26	16	18	15	1	76	31	22	23
Haliç	0	0	0	0	0	0	0	0	0
Harran	8	2	0	3	5	18	5	4	9
Hitit	0	0	0	1	1	2	2	0	0
Işık	1	2	0	1	0	4	1	1	2
İnönü	7	1	2	0	0	10	4	3	3
İst. Aydın	0	0	0	0	0	0	0	0	0
İstanbul Bilgi	0	0	0	3	0	3	1	2	0

Table 23 (cont'd): TÜBİTAK projects implemented by Turkish universities

University	2008-2010 Total								
	Basic Sci.	Eng. Sci.	Health Sci.	Soc. Sci.	AFVS	TOTAL	2008 Total	2009 Total	2010 Total
İst.Bilim	0	0	0	0	0	0	0	0	0
İst. Kültür	0	0	0	0	0	0	0	0	0
İTÜ	53	52	1	3	3	112	41	37	34
İst. Ticaret	0	0	0	0	0	0	0	0	0
İstanbul	12	9	12	8	1	42	10	16	16
İzmir Ekon.	0	2	0	1	0	3	1	1	1
İYTE	25	13	0	1	3	42	12	12	18
Kadir Has	1	3	0	0	0	4	1	2	1
Kafkas	0	0	0	0	3	3	0	1	2
KSİU	2	0	0	2	15	19	4	5	10
KTÜ	12	4	3	6	5	30	10	9	11
Kastamonu	1	0	0	0	0	1	1	0	0
Kırıkkale	4	1	2	0	2	9	5	1	3
Kocaeli	7	11	5	2	0	25	11	8	6
Koç	24	13	0	13	0	50	11	20	19
Maltepe	0	0	0	1	0	1	1	0	0
Marmara	8	8	3	5	0	24	11	3	10
Mehmet Akif	0	1	0	0	2	3	1	2	0
Mersin	2	2	5	3	3	15	4	5	6
M.Sinan	0	0	0	5	0	5	0	0	5
Muğla	9	1	0	5	1	16	4	5	7
M. Kemal	1	5	0	0	6	12	5	4	3
N. Kemal	3	1	0	0	5	9	2	4	3
Niğde	4	5	0	0	0	9	5	1	3
Okan	0	0	0	0	0	0	0	0	0
OMÜ	2	2	0	0	13	17	7	4	6
Ordu	0	0	0	0	0	0	0	0	0
ODTÜ	51	54	7	17	8	137	50	49	38
Pamukkale	7	7	3	4	2	23	10	3	10
Rize	5	0	0	0	0	5	2	1	2
Sabancı	12	28	2	11	0	53	18	16	19
Sakarya	8	9	0	1	1	19	11	5	3
Selçuk	13	8	2	8	17	48	13	17	18
SDÜ	9	6	0	8	16	39	10	12	17
TOBB-ETÜ	6	21	0	2	0	29	8	10	11
Trakya	1	2	1	4	0	8	4	2	2
Ufuk	0	0	0	0	0	0	0	0	0
Uludağ	8	5	2	3	12	30	7	10	13
Uşak	0	2	0	1	0	3	1	0	2
Yaşar	0	1	0	0	0	1	0	0	1
Yeditepe	3	11	4	0	0	18	8	2	8
YTÜ	14	13	1	4	0	32	12	7	13
Yüzüncüyıl	1	0	0	0	6	7	3	2	2
Z.Karaelmas	2	1	0	0	1	4	3	0	1
Total	**625**	**520**	**174**	**271**	**254**	**1844**	**615**	**560**	**669**

Source: TÜBİTAK, ARDEB

To be consistent with the analyses which are performed in the previous sections, research groups are rearranged under 5 scientific fields. In this respect, electrical, electronics and informatics research group is combined with the engineering research group, whilst environment, atmosphere, earth and marine sciences research group is combined with the basic sciences. The performances of universities in terms of the supported TÜBİTAK projects under five scientific fields are provided in Table 23.

In all three years of analyses and as of total, ODTU has received the highest number of TÜBİTAK projects, with 137 projects. It is followed by İTÜ with 112 projects, and Ankara University with 96 projects. Meanwhile, 12 universities have not received any TÜBİTAK projects (Table 23).

Figure 15 illustrates the distribution of TÜBİTAK projects funded by 5 academic disciplines during the period between 2008 and 2010. Basic sciences come first in terms of the total number of projects, and it is followed by engineering, social sciences, and AFVS. Health sciences have the least number of TÜBİTAK projects.

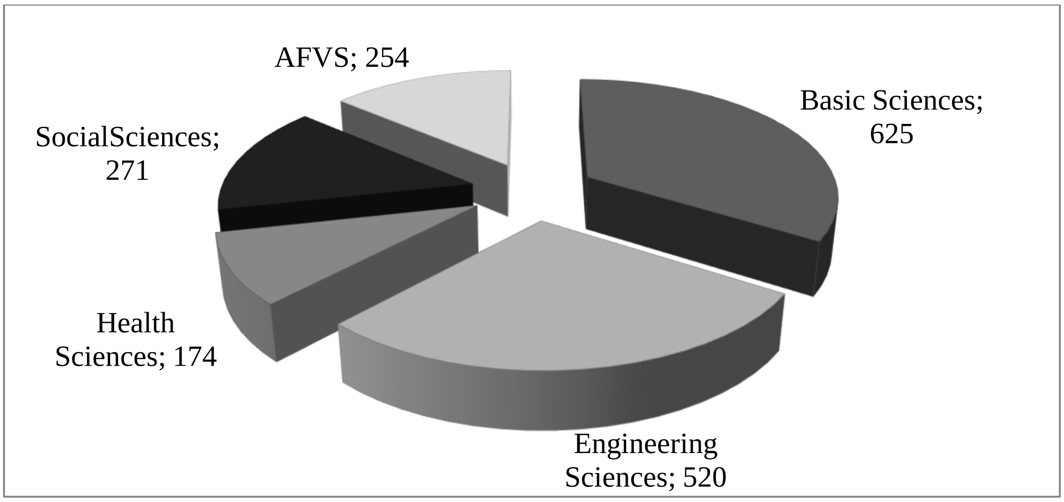


Figure 15: Distribution of TÜBİTAK projects by 5-scientific fields

Source: TÜBİTAK, ARDEB

Table 24 is prepared to identify whether performances of different types of universities have varied in terms of the total and average number of TÜBİTAK projects.

Table 24: TÜBİTAK projects by university types

University Type	Basic Sci.	Eng. Sci.	Health Sci.	Social Sci.	AFVS	TOTAL	Project Per Univ.	% of universities that received projects
Est. Public	523	388	157	207	244	1,519	28.66	100
New Public	25	5	1	3	9	43	2.87	80
Private	77	127	16	61	1	282	10.85	58
Total	**625**	**520**	**174**	**271**	**254**	**1,844**	**19.62**	**87**

Source: Compiled by the author using TÜBİTAK, ARDEB statistics

During the 2008-2010 period, 82 % of the TÜBİTAK projects have been implemented by established public universities and all established universities have at least one TÜBİTAK project. Average number of projects per university is 29 for the established public universities, and one way ANOVA tests show that it is significantly higher than the new public and private universities.

When we investigate the ratios of projects that are implemented by public universities by scientific disciplines, we observe that they are relatively better in AFVS (96.1%) and health sciences (90.2 %), and relatively worse in engineering sciences (74.6%). But even in the engineering sciences, established universities have implemented the majority of the TÜBİTAK projects.

Only 2 % of the TÜBİTAK projects that are funded between 2008 and 2010 are implemented by new public universities, and consequently, project average is very low among them, with approximately 3 projects. 80% of the new public universities have received at least one TÜBİTAK project. When we calculate ratios of projects received by new public universities for each scientific discipline separately, we identify that new public universities are relatively more successful in basic sciences (4%) and AFVS (3.5 %), and less successful in health sciences (0.6 %).

15 % of the TÜBİTAK projects are implemented by private universities, and the average number of projects per them is approximately 11 for private universities. Meanwhile, 42% of the private universities do not have any TÜBİTAK projects. In other words, ratio of universities that has not received any TÜBİTAK projects is the highest for private universities, compared to the established and new public universities. When we calculate ratios of projects received by private universities for each scientific discipline separately, we find that private universities are relatively better in engineering sciences (24.4 %) and social sciences (22.5 %), and worse in AFVS (0.4 %).

For five scientific fields, number of TÜBİTAK projects per faculty member is calculated separately for each year. To do this, data provided in Figure 14 are divided by data provided in Figure 7 and results are presented in Table 25. It is observed that TÜBİTAK projects per faculty member have differed both by scientific field, and time (Table 25). The most productive field in terms of per faculty productivity is found as basic sciences. The productivity level in basic sciences is almost twice of AFVS and engineering sciences, and is 9 times higher than health sciences and social sciences.

Table 25: TÜBİTAK Projects per faculty member by scientific fields

Scientific Field	2008	2009	2010
AFVS	0.025	0.022	0.032
Basic Sciences	0.053	0.046	0.052
Engineering Sciences	0.027	0.022	0.025
Health Sciences	0.006	0.005	0.004
Social Sciences	0.007	0.006	0.006

Source: Compiled by the author using TÜBİTAK, ARDEB statistics

4.5. Analyses of Graduates from PhD Programs

The total numbers of PhD graduates in terms of scientific disciplines are calculated using “Number of Graduate Students in The Various Graduate Schools” tables of AHES. For the previous three outputs, we are able to make bibliometric analyses in 5 scientific fields. But data that is compiled by AHES for graduate level students does not allow discriminating data regarding AFVS, basic sciences, and engineering sciences such that they are all classified under one graduate institute (which is Institute for Natural and Applied Sciences). Consequently, bibliometric analyses of graduates from PhD programs are performed for three scientific fields, which are: natural and applied sciences, health sciences, and social sciences. The total numbers of graduates from PhD Programs of universities by scientific fields are given in Table 26.

Table 26: Number of PhD graduates by universities, disciplines and years

University	2008			2009			2010		
	NAS	Health Sci.	Social Sci.	NAS	Health Sci.	Social Sci.	NAS	Health Sci.	Social Sci.
AİBÜ	6	0	2	5	1	7	10	0	8
Adıyaman	0	0	0	0	0	0	0	0	0
A.Menderes	6	4	3	11	4	6	9	7	11
Afyon	1	2	7	8	3	4	8	11	18
Ahi Evran	0	0	0	0	0	0	0	0	0
Akdeniz	4	7	7	34	8	4	9	11	19
Aksaray	0	0	0	0	0	0	0	0	0
Amasya	0	0	0	0	0	0	0	0	0
Anadolu	22	1	52	14	7	44	40	2	64
Ankara	90	85	269	83	124	312	108	79	207
Ataturk	84	20	42	126	30	51	62	28	63
Atılım	0	0	0	0	0	0	0	0	0
Bahcesehir	0	0	0	0	0	0	0	0	0
Balıkesir	6	0	2	19	0	0	24	0	6
Başkent	0	5	3	0	11	4	2	10	8
Beykent	0	0	0	0	0	0	0	0	0
Bilkent	19	0	19	26	0	24	25	0	34
Boğaziçi	46	5	19	34	1	19	38	6	28
Bozok	0	0	0	0	0	0	0	0	0
Celal Bayar	1	1	6	6	0	13	2	2	10
Cumhuriyet	4	10	1	6	7	8	9	13	5
Çağ	0	0	0	0	0	0	0	0	0
Çanakkale	9	0	0	11	0	0	18	0	1
Çankaya	0	0	0	0	0	0	0	0	0
Çukurova	68	17	18	89	11	23	77	22	27
Dicle	11	3	2	13	15	1	18	7	3
Doğuş	0	0	0	0	0	0	0	0	0
Dokuz Eylül	51	11	114	53	20	103	76	14	125
Dumlupınar	3	0	7	4	0	7	5	0	10
Düzce	0	0	0	0	0	0	0	0	0
Ege	80	49	34	99	49	46	118	49	66
Erciyes	18	3	12	19	6	31	28	17	34
Erzincan	0	0	0	0	0	0	0	0	0
ESOGÜ	50	7	0	34	8	0	24	4	0
Fatih	0	0	0	0	0	0	0	0	0
Fırat	58	13	18	37	13	13	67	17	19
Galatasaray	0	0	2	0	0	5	2	0	5
Gazi	71	62	140	92	51	198	103	45	182
Gaziantep	11	1	1	11	1	1	9	3	0
G.osmanpasa	4	0	0	2	0	0	14	0	1
GYTE	9	0	7	13	0	4	19	0	9
Giresun	0	0	0	0	0	0	0	0	0
Hacettepe	57	58	100	62	50	86	64	81	91
Haliç	0	0	0	0	0	0	0	0	1

Table 26 (cont'd): Number of PhD graduates by universities, disciplines and years

University	2008			2009			2010		
	NAS	**Health Sci.**	**Social Sci.**	**NAS**	**Health Sci.**	**Social Sci.**	**NAS**	**Health Sci.**	**Social Sci.**
Harran	4	0	0	6	0	1	5	0	10
Hitit	0	0	0	0	0	0	0	0	0
Işık	0	0	12	0	0	8	2	0	0
İnönü	14	4	17	11	3	5	3	2	5
İst.Aydın	0	0	0	0	0	0	0	0	0
İst. Bilgi	0	0	0	0	0	3	0	0	2
İst. Bilim	0	0	0	0	0	0	0	0	0
İst.Kültür	1	0	3	3	0	1	3	0	4
İTÜ	77	0	12	122	0	17	134	0	7
İst. Ticaret	0	0	0	0	0	0	0	0	0
İstanbul	45	97	160	57	79	110	71	111	143
İzmir Ekon.	0	0	0	0	0	1	0	0	5
İYTE	8	0	0	14	0	0	19	0	0
Kadir Has	0	0	7	0	0	9	0	0	24
Kafkas	1	5	0	1	7	0	3	9	0
KSÜ	0	0	0	9	0	0	8	0	0
KTÜ	59	0	5	74	3	8	66	1	6
Kastamonu	0	0	0	0	0	0	0	0	0
Kırıkkale	6	1	0	7	0	2	13	2	4
Kocaeli	20	2	5	23	5	13	30	5	14
Koç	1	0	0	5	0	0	5	0	0
Maltepe	0	0	0	0	0	0	0	0	0
Marmara	37	65	260	35	70	274	28	89	335
Mehmet Akif	0	0	0	0	0	0	0	0	0
Mersin	1	3	2	12	3	0	13	7	6
MSGSÜ	29	0	8	21	0	25	8	0	19
Muğla	0	0	1	0	0	2	0	0	5
M.Kemal	2	0	0	4	1	0	7	2	0
N. Kemal	0	8	0	9	0	0	15	0	0
Nigde	0	0	2	0	0	5	1	0	5
Okan	0	0	0	0	0	0	0	0	0
OMÜ	32	18	4	24	15	6	30	24	14
Ordu	0	0	0	0	0	0	0	0	0
ODTÜ	145	0	47	158	0	28	181	0	45
Pamukkale	3	0	0	7	0	1	7	11	2
Rize	0	0	0	0	0	0	0	0	0
Sabancı	10	0	4	12	0	5	13	0	4
Sakarya	29	0	17	27	0	25	48	0	39
Selçuk	39	35	62	38	45	74	56	36	77
SDÜ	32	15	17	33	13	40	38	13	53
TOBB-ETÜ	0	0	0	0	0	0	0	0	0
Trakya	16	3	3	15	4	5	18	4	1
Ufuk	0	0	0	0	0	0	0	0	0
Uludağ	28	17	40	27	11	30	36	10	25
Uşak	0	0	0	0	0	0	0	0	0
Yasar	0	0	0	0	0	0	0	0	0
Yeditepe	0	15	8	0	15	14	2	11	14
YTÜ	55	0	3	104	0	10	59	0	7
Yuzuncuyıl	15	4	5	16	8	1	13	12	8
Z.Karaelmas	3	0	0	5	0	0	16	0	0

Source: Data is compiled by the author, using WoS database

Out of 94 universities, 29 do not have any PhD graduates during the 2008-2010 period. 14 of them are new public universities and 15 of them are private universities. All of the established public universities have PhD graduates during the 2008-2010 period.

The total numbers of graduates from PhD programs by scientific fields are given in Figure 16. As it can be seen clearly from this figure, there is an increasing pattern in all fields during the period between 2008 and 2010. The total numbers of PhD graduates are very close to each other in NAS and social sciences, whereas, the total number of PhD graduates in the health sciences is less than half of the PhD graduates in the other two fields.

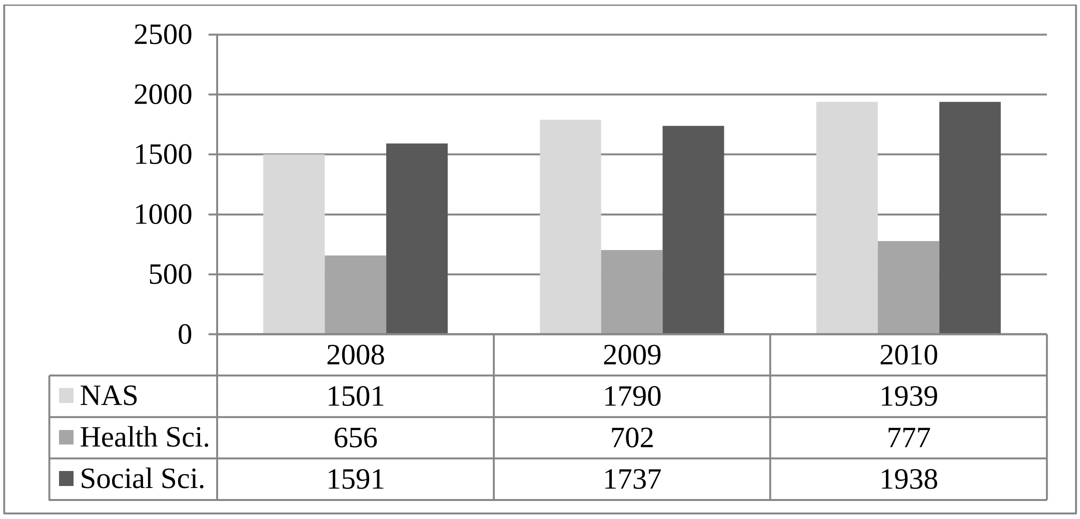


Figure 16: Number of PhD graduates by scientific disciplines

Source: Data is compiled by the author, using ÖSYM (2009, 2010, 2011)

For three scientific fields, the number of PhD graduates per faculty member is calculated annually. To do this, data provided in Figure 4.16 are divided by data provided in Table 10 and the results are presented in Table 27.

Table 27: PhD graduates per faculty per year by scientific fields.

	PhD Graduates per Faculty Member		
Scientific Field	**2008**	**2009**	**2010**
Natural &Applied Sciences	0.13	0.14	0.14
Health Sciences	0.06	0.06	0.06
Social Sciences	0.13	0.13	0.13

Source: ÖSYM (2009, 2010, 2011)

It is observed that the ratio of PhD graduates per faculty member differs significantly by scientific field, but remains stable for each discipline by years (Table 27). The most productive fields in terms of PhD graduates are found as natural and applied sciences, and social sciences. In health sciences PhD graduates per faculty member is less than the half of these two fields.

When we investigate statistics regarding PhD graduates by university types, we detect that majority of the PhD graduates are trained in established public universities (Table 28). Less than half of the private universities and only one of the new public universities have outputs in terms of PhD graduates. Based on these results, we interpret that public universities are the major source of PhD graduates in the Turkish higher education system.

Table 28: PhD Graduates by university types:

	Total PhD Graduates			**PhD Graduates per University**			
University Type	ANS	Health Sci.	Social Sci.	ANS	Health Sci.	Social Sci.	% of universities with PhD Graduates
Est. Public	5,077	2,060	5,045	95.79	38.87	95.19	100
New Public	24	8	0	1.60	0.53	0.00	7
Private	129	67	221	4.96	2.58	8.50	42

Source: Data is compiled by the author, using ÖSYM (2009, 2010, and 2011)

4.6. Concluding Remarks for Chapter 4

This section provides detailed analyses of faculty members and selected research outputs for 94 Turkish universities that were established in and before 2006. While making bibliometric analyses, we classify universities under three broad groups which are: established public universities, new public universities, and private universities. We also classify the data under five different scientific fields which are; (i) agricultural, forestry and veterinary sciences (AFVS), (ii) basic sciences, (iii) engineering sciences, (iv) health sciences, and (v) social sciences (Due to lack of data on PhD graduates, we combine first three groups under one category and obtain three scientific fields).

We investigate whether the structure of faculty members, performance of universities in terms of publication, citations, TÜBİTAK projects, and PhD graduates differ by scientific fields and university types.

The total number of faculty members in 94 universities has increased from 40,430 in 2008 to 44,845 in 2010 which corresponds to an 11% increase. Ratios of professors, associate professors and assistant professors in the whole faculty members set have not changed within this period. They are 33 %, 18 %, and 44 %, respectively. 85 % faculty members are employed by established public universities, 10.5 % are employed by private universities and 3.5 % are employed by new public universities. The total number of faculty members is the highest in social sciences (35 % faculty members), and it is followed by health sciences (29 % faculty members), engineering sciences (18 % faculty members), basic sciences (10 % faculty members) and AFVS (8 % faculty members), for the overall analysis period.

We observe that the most productive scientific discipline during the period between 2008 and 2010in terms of the total publications, is the health sciences (with 28,432 publications), and it is followed by basic sciences (17,841 publications), engineering sciences (15,243 publications), AFVS (6,428 publications) and social sciences (3,957 publications). Publications per faculty member are the highest for private universities with a ratio of 0.78. It is followed by established public universities (0.75), and new public universities (0.68).

Number of citations is significantly correlated with number of publications at 5 % significance level. Citations per publication (CPP) are very close to each other across different university types. Meanwhile, we detect differences in terms of CPP's of different scientific disciplines. Publications written in basic sciences and engineering sciences have received approximately twice more citations compared to that of AFVS and social sciences for every year, and CPP for health sciences have been located in the middle of 5 disciplines. We also calculate citations per faculty (CF) for each discipline and observe that CF ratios also differ by scientific fields. The highest CF ratio is received in basic sciences and it is almost twice higher than the health and engineering sciences. The lowest ratio is observed in social sciences.

In terms of the total number TÜBİTAK projects funded in universities, basic sciences come first (with 625 projects), and it is followed by engineering sciences (520 projects), social sciences (271 projects), AFVS (254 projects), and health sciences (174 projects) the analysis period. For this timeline, 82 % of the TÜBİTAK projects have been implemented by established public universities. Average number of projects per university is 29 for established universities, and one way ANOVA tests show that it is significantly higher than the new public (3 projects) and private universities (11 projects). Between 2008 and 2010 all established universities have at least one TÜBİTAK project, whereas 20% of the new public universities and 42% of the private universities do not have any TÜBİTAK projects.

When we investigate PhD graduates by university type, we detect that majority of the PhD graduates are trained in established public universities (around 96 %). Less than half of the private universities and only one of the new public universities have outputs in terms of PhD graduates. Based on these results, we interpret that established public universities are the major source of PhD graduates in the Turkish Higher Education system. The total numbers of PhD graduates are very close to each other in natural and applied sciences (around 41 % of the total graduates) and social sciences (around 42 % of the total graduates), whereas, the total number of PhD graduates in the health sciences is around 17 % of the total graduates. It is observed that PhD graduates per faculty member also differ significantly by scientific field. The most productive fields in terms of PhD graduates are found as natural and applied sciences (0.14), and followed by social sciences (0.13), and health sciences (0.06).

In summary, we observe significant differences in terms of the structure of faculty members, and performance of universities in terms of publication, citations, TÜBİTAK projects, and graduates from PhD programs both across scientific fields and university types.

As a result of these figures, we argue that it is not fair to compare absolute values of outputs to be fair in evaluation studies.

CHAPTER 5

MEASURING RESEARCH PERFORMANCE OF TURKISH UNIVERSITIES VIA DATA ENVELOPMENT ANALYSES

5.1. Introduction

Research activity in universities is a process in which several inputs such as human capital, scientific infrastructure, financial resources and intangible resources such as knowledge and networks are used to produce both tangible and intangible outputs such as publications, patents, consulting activities, knowledge accumulation and human resources development (Abramo et al, 2011b).

Several parametric and nonparametric methods have been used to measure the performance of universities. Data Envelopment Analysis (DEA) which is a nonparametric method, is among the most frequently used methods in measuring the efficiency of universities (Abbott and Doucouliagos, 2003; Abramo et al, 2011b; Athanassopoulos and Shale, 1997; Avkıran, 2001; Colbert et al, 2000; Johnes, 2006; Johnes and Yu, 2008; Kao and Pao, 2009; Kuah and Wong, 2011; Kounetas et al, 2011; Tyagi et al, 2009; Wolszczak-Derlacz and Parteka, 2011).

This study aims to specify and implement different DEA models, which will take field-based productivity differences into account, to measure research efficiency of Turkish universities for the period between 2008 and 2010and identify the best fitting model or models. We will also appraise the suitability of using the DEA to measure research efficiency.

Our study will contribute to the literature in three main aspects. First, we will assess whether using DEA is an appropriate tool to measure research efficiency of Turkish universities. We have not come up with a study that makes this kind of assessment. To understand this we implement 10 different DEA models that have different assumptions regarding returns to scale, and constraints but similar inputs and outputs. Following the methodology developed by Bauer et al. (1998), we hypothesize that if these models generate similar efficiency distributions, rank orders, top and low performers and efficiency scores show stability over time, then it indicates that DEA is an appropriate tool to measure research efficiency of universities and policy makers may be able to draw some important policy conclusions from the analysis of the efficiency scores. Up to our knowledge this kind of assessment study has never performed for evaluating research performance of universities, in both international national studies.

Secondly, we will implement DEA models that take field-based differences into account while measuring research efficiency of Turkish universities. A frequently applied solution to the problem of different productivity levels in different scientific fields is investigating efficiencies for separate scientific fields (Abramo et al, 2011b; Dündar and Lewis, 1998). If this option is selected, then the number of units included in the analyses decreases due to the fact that some universities did not have any inputs or outputs in all scientific disciplines. On the other hand, decreasing the number of units in the analyses in a DEA model brings the possibility of decreasing the robustness of the model, since it increases the possibility of finding suboptimal frontiers (Avkıran, 2001). To alleviate this problem, we propose to use the sum of field-based normalized outputs, rather than simply summing outputs from different scientific fields. In this way we will be able to relieve field-based productivity differences on one side and obtain a single ranking on the other. The originality of our study is that we make field-based normalizations in terms of PhD graduates and academic projects, apart from previous studies that made normalizations on citations and publications but not on any other outputs.

Third, and finally we will evaluate research efficiency of both public and private Turkish universities for three consecutive years, which to our knowledge, has not been done in any other academic study. All of the related studies that we were able to reach had evaluated the overall teaching and research performance of universities, and none of them had focused solely on research efficiency. In addition, some studies either concentrated on only public or private universities, and majority of them made analyses only for one year.

This chapter is structured from four sections. In the first section, we will provide brief information about empirical studies that used DEA to measure efficiency of universities. In the second section, we will discuss our methodology. In this context, we will briefly explain DEA methods to be used, define our input and output variables, discuss the rationale of making normalizations with the outputs, and describe the models. Third, results of DEA models are put forward, and comparisons of different models are provided. Finally, we will provide recommendations for both policy implications and applying DEA for measuring research performance of universities.

5.2. Review of Literature

Productivity of universities covers several functions from knowledge production and dissemination to teaching and outreach activities. Among these, research productivity has received a great amount of attention in the literature. In this section, we will provide a summary of the empirical studies that focus on measuring performance of universities using DEA. These studies are summarized in Table 29.

While there is a large literature on performance indicators to measure research productivity, there is little consensus about which methodology or which set of indicators is the best. Since the goals of evaluation are defined according to the needs and aims of the evaluating agency, different agencies may come up with quite different criteria (Geuna and Martin, 2003).

From the literature survey, we identify that number of publications, citations or impact factor of the journals, number of graduates, number of presentations, and conferences, results of rankings other evaluation exercises or prestige indices, research projects or funds from third parties, number of patents and awards are the most frequently used outputs in research efficiency studies performed via DEA.

Similarly, human resources, such as number of academic staff, non-academic staff, and research assistants, financial resources such as research expenditures or salaries of academic staff, the total number of students, available infrastructure such as equipment, non-current assets, area of buildings, and library resources, and ratios related with academic staff or students, such as ratio of full-professors; ratio of post-graduate students; staff to student ratio are the most frequently used inputs in research efficiency studies performed via DEA.

Table 29: Summary of the selected studies

Author	**Summary of the Study**
Abramo et al. (2008)	They developed a bibliometric non-parametric methodology for measuring the performance of the public research activity. They included all the Italian universities with at least 4 employed resources between 2001 and 2003. They applied output-oriented DEA model. Eight scientific disciplines (SD) were identified and efficiencies of universities were calculated in terms of each SD. Technical Efficiency, Pure Technical Efficiency and Scale Efficiency were identified for every university. General ranking of universities was calculated by averaging the scores obtained for each SD. To assess the sensitivity of the model, additional funds variable was excluded from the model. There were significant differences found in average efficiency and score variability among different SDs. Percentage of efficient universities varied by different scientific disciplines and number of efficient units decreased with exclusion of the input variable.
Abramo et al. (2011b)	They proposed an application of DEA methodology for measurement of technical and allocative efficiency of university research activity. They investigated 78 Italian universities for the five-year period 2004–2008 and the analyses were applied to all scientific disciplines of the so-called hard sciences, and conducted at subfield level. They used input-oriented DEA with constant returns to scale assumption. They found high variability for cost efficiency among the various sectors within the university.
Baysal et al. (2005)	They measured overall efficiency of 50 Turkish public universities in 2004 using output-oriented VRS DEA model. Afterwards, they suggested a performance-based budget allocation according to these efficiencies. They had 5 inputs (personnel expenses, other current expenses, investment expenses, transfer expenses, faculty members), and 4 outputs (publications, undergraduate students, masters students and PhD students). They found that 25 universities were efficient and 25 were inefficient.
Johnes and Yu (2008)	They used data envelopment analysis (DEA) to examine the relative efficiency of research productivity of 109 Chinese universities in 2003 and 2004. They used full-time staff to student ratio, the percentage of the faculty with associate professor position or higher, the proportion of postgraduate students to all students who are postgraduates, research funding, an index for the library books and an index for the area of the buildings as input variables. There were 3 output indicators which were total number of research publications, research publications per member of academic staff, and prestige index. The data were obtained from the 'NETBIG Chinese University Rankings', which is an unofficial ranking. Four different models were estimated such that models 1 and 3 included all three outputs, while models 2 and 4 excluded inputs relating to students. The rankings of the universities across models and time periods were found to be highly correlated. Additionally, the results showed that research efficiency was higher in comprehensive universities compared to specialist universities, and in universities located in the coastal region compared to those in the western parts.

Table 29 (cont'd): Summary of the selected studies

Author	Summary of the Study
Kağnıcıoğlu and İcan (2011)	They measured teaching and research efficiency of 93 Turkish universities in 2007 using output-oriented CRS and VRS models. They had single input which was the total number of faculty members, and 6 outputs which were SCI publications, SSCI publications, AHCI publications, undergraduate students, masters students and PhD students. They found that 17 universities were efficient. They also found that VRS model was more reliable than the CRS model.
Köksal and Nalçacı (2006)	They measured relative efficiencies of 14 academic departments in a Turkish engineering college using Data Envelopment Analysis. They used salaries of academic staff, the potential of the department (which was calculated from the awards and prices won by faculty, professional memberships, and average publication output), and number of entering undergraduate and graduate students as inputs. Publications, educational activities and their quality (calculated by theses completed, average grades, average number of students in classes, student evaluations and new course development), other activities (administrative duties, conference and seminar organizations) and number of graduates from B.SC., M.Sc., and Ph.D. programs were used as outputs. They run different scenarios to test robustness of their model and found that results were sensitive to selected input and output criteria.
Kounetas et al. (2011)	They assessed the research performance of 18 departments within a single Greek university. They used DEA with 6 model variants to estimate efficiencies. The total expenditures, number of academic staff, number of undergraduate students and number of graduate students were used as input variables, whereas number of conference papers, number of publications and number of monographs were used as output variables. In the second stage they applied a Tobit model to examine the impact of several environmental factors on efficiency scores. They found that ownership of the buildings, the total amount of departmental facilities and age had a positive influence on research efficiency.
Kuah and Wong (2011)	They developed a joint DEA maximization model for jointly evaluating the relative teaching and research efficiency of universities. They collected a total of 16 measures and the model was tested using a hypothetical example. For calculating teaching efficiency number of academic staff, number of students, average qualification of students and university expenditures were used as inputs and graduation rates, and graduates' employment rate (%), number of graduates and average GPA of graduates were used as outputs. For calculating research efficiency, university expenditures, number of research staff, average research staffs' qualifications, number of research students and research grants were used as input indicators; and number of graduates from research, number of publications, number of awards and number of intellectual properties are used as output indicators.
Kutlar and Babacan (2008)	They calculated overall efficiency of 53 Turkish public universities for 5 separate years from 2000 to 2004 via DEA. They used input-oriented CRS model with 8 inputs (the total budget, extra budgetary expenditures, professors, associate professors, assistant professors, teaching instructors, research assistants, administrative staff) and 6 outputs (publications, revenues, undergraduate students, graduate students, graduates from undergraduate programs, graduates from graduate programs) They found that 17 universities were efficient and 36 were inefficient. They also found that most of the universities were not operating at the optimum scale.
Kutlar and Kartal (2004)	They calculated efficiency scores for 8 different faculties of Cumhuriyet University for separate years between 2000 and 2004. They used input-oriented CRS DEA model. They used 7 inputs (academic staff, administrative staff, travelling allowances, personnel expenses, service procurements, consumption materials, indoor space area), and 4 outputs (undergraduate students, graduate students, student tuitions, academic projects). They found that the most efficient faculties were engineering, economic and administrative sciences, education, whereas the least efficient faculties were medicine, dentistry, theology and fine arts. Faculty of Science and Arts reached to an efficiency level in between low performers and high-performers.

Table 29 (cont'd): Summary of the selected studies

Author	Summary of the Study
Leitner et al. (2007)	They explored the performance efficiency of natural and technical science departments at Austrian universities using DEA. The data were provided by the Austrian Rector's Conference, which contained 48 indicators that were available for all Austrian university departments. Input and output variables had been determined in a previous step using correlation analyses and OLS regression to eliminate highly-correlated variables and to be able to determine the most relevant input and output indicators. The number of staff was selected as the only input and several industry-specific, teaching-specific and research- specific outputs were selected. 10 different DEA models, 5 with variable returns to scale and 5 with constant returns to scale assumption, with different combination of outputs were estimated. They found that the size of a department had influence its overall and specialization performance, namely both small and large departments were found to perform above average. Furthermore, a high correlation was detected between research performance and industrial cooperation and between research performance and teaching performance.
Meng et al. (2008)	They explored the possibility of using DEA for efficiency evaluation of research institutes with large numbers of indicators. They developed a DEA model that utilized hierarchical structures of input–output data so that they were able to handle quite large numbers of inputs and outputs. They carried out a pilot study on 15 institutes for basic research by exploring multi-level data structures. First sub-indicators were aggregated using the weights generated by Analytical Hierarchical Processing, and then 2 DEA models (BCC and BCC with a new constraint) were applied. They standardized the indices to remove scale differences in the weighted sums. They found that ranking of research institutes varied in different scientific disciplines.
Özden (2008)	He calculated technical and allocative efficiency of 24 Turkish private universities using year 2006 data. He employed 4 DEA models (input-oriented CRS, output-oriented CRS, input-oriented VRS, output-oriented VRS). The model had 3 inputs (total expenditures, faculty members, other academic staff) and 5 outputs (undergraduate students, graduate students, publications, educational revenues, other revenues). The results showed that most of the private universities were efficient such that only 9 of them were inefficient. Among those, 5 had only allocative inefficiency, and 4 had both technical and allocative inefficiency.
Ulucan (2011)	He computed overall efficiency of 50 public universities, for the year 2008, using DEA that assumed measure specific VRS model. He used 4 inputs (professors, associate professors, assistant professors, total budget) and 8 outputs (undergraduate students, masters students, PhD students, publications, TÜBİTAK projects, TÜBİTAK funds, university entrance score (Equal weighted), university entrance score (Quantitative)). 15 universities were found efficient, and 35 were inefficient. He also analyzed differences by 7 geographic regions. On average, universities located in the Black Sea and Central Anatolia region were found to be the most efficient, whereas universities located in the Southeast Anatolia region were found to be the least efficient.
Wolszczak-Derlacz and Parteka (2011)	They measured teaching and research efficiency of 259 European public higher education institutions from 7 EU countries using two-stage DEA. Their study covered the time between 2000 and 2005. They used the total number of academic staff and students, and the total revenue as input variables, whereas the number of graduates and number of scientific publications were used as output variables. They evaluated DEA scores first and regressed the scores over potential factors with the use of bootstrapped truncated regression. They found considerable variation in the efficiency scores between and within the countries. Results showed that universities with higher number of different faculties, medical school, and greater share of the external source fund were more efficient. Additionally, age and higher share of women in the total faculty were also found to be positively and significantly correlated with high efficiency scores.

Sometimes the role of a variable may be flexible, meaning that it can be considered as either an input or an output variable. When this is the case, integration of flexible variables into the DEA model creates a problem. The main problem is not counting the influence in both places, but rather finding the most appropriate place.

R&D project funds can be a good example of this type of flexible variables. It can be used either an input variable since funds are used to make further research and generally articles are published or innovations are generated afterwards. Research funds can also be used as an output, as they are generally allocated through a competitive process and several universities target obtaining more research funds (Cook and Seiford, 2009). When the focus of analysis shifts from production of research to a financial outlook, then it is quite acceptable to consider research income as an output.

Beasley (1995) has presented a formulation for a situation where research funding has been counted as both an input and an output in evaluating UK universities. Cook and Zhu (2007) have established a model that allows each unit to select the status of flexible variable that will credit it with the highest possible score. They have suggested to take a majority rule position, giving each variable the status preferred by the majority of the units.

There are certain problems regarding both input and output variables while studying the research performance of higher education institutions. The first problem lies under the hardship of determining the exact amount of inputs. As we all know, universities provide two basic services, which are teaching and research. Some of the inputs required to deliver those services are shared (such as faculty, administrative staff), whereas some of the resources are used for only one type of the service (such as social and cultural services). In evaluating teaching and research efficiency, the proportions of the resources used for both functions need to be determined. However, it is normally hard for a university to determine it. Additionally, there can be long and variable lead times between receipt of inputs and achievement of outputs so that it is not easy to put the corresponding data together (Özpeynirci, 2004).

There are also problems in collecting data on input and output variables. Most of the time, standardized and reliable data regarding indicators for complete set of units cannot be found. Even if the data are available, indicators have their own flaws. For example, number of publications and citations suffer from the problem of different practices across disciplines or reputational rankings use a considerable amount of subjective assessments.

5.3. Methodology

In this section, we start with providing a brief theoretical background on DEA methodologies that will be used in this study. Afterwards, we will describe our input and output data and discuss the rationale of making field based normalizations on the outputs. Finally, we will define specifications of 10 different DEA models that will be implemented in this chapter.

5.3.1. Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) aims to evaluate relative productive efficiency of a set of units, where prices of inputs and outputs are not available. The concept of productive efficiency was first introduced by Farrel's (1957) pioneering research. He described productive efficiency as how effectively resources were used to generate outputs and categorized efficiency into technical efficiency and allocative efficiency.

In their seminal work on Data Envelopment Analysis, Charnes et al. (1978) used optimization techniques to generalize Farrell's single output and single input technical efficiency measures. They transformed a fractional linear measure of efficiency into a linear programming format via computing a comparative ratio of outputs to inputs for each unit.

DEA can assess the productive efficiency of homogeneous and comparable units on the basis of multiple inputs and outputs, even when the production function is unknown. DEA determines the productivities of units, which is defined as the ratio of the weighted outputs to the weighted inputs, compares them to each other and distributes all units into two sets according to whether they are efficient or inefficient.

The objective can be either minimizing weighted inputs over weighted outputs (called as input-oriented model) or maximizing weighted outputs over weighted inputs (called as output-oriented model).

In DEA, units are handled individually and a linear program is solved for each of them. Optimal weights for all inputs and outputs are obtained without attributing any prior constraints. Efficiency scores for units are generated by maximizing the objective function subject to constraints which are determined by the observed performances of other units.

Efficient units define the efficient production (Pareto) frontier for the whole set of data. Both in output-oriented, and input oriented models, any unit that lies on the efficient production frontier receives a score equal to 1 and is called as an efficient unit. Efficient units are the ones that utilize inputs in the best way to produce outputs. In input oriented models the efficiency score is a number between 0 and 1 and in output-oriented models it is equal to or greater than 1. For a unit being inefficient means that there is a possibility of increasing outputs with the same level of inputs or producing the same level of outputs by using fewer inputs.

DEA compares individual units with best practicing ones, unlike regression analysis, which compares each unit with the average performance. As a result of this, units are forced to achieve the performance level of the best units, rather than reaching an average performance (Nakanishi and Falcocchio, 2004).

Since the introduction of DEA by Charnes et al. (1978), there has been a remarkable growth both in theoretical developments and applications of models to practical situations. DEA had initially been used to investigate the relative efficiency of nonprofit organizations, but its applications spread to profit-making organizations, as well. In the literature we can see that DEA has been successfully applied in several different settings. For example, DEA was used in the service sector by Sherman and Zhu (2006), in health care applications by Chilingerian and Sherman (2004), in bank failure predictions by Barr and Siems (1997) in athletes' performance evaluation by Anderson and Sharp (1997) and in intelligent transportation systems by Nakanishi and Falcocchio (2004). DEA had also used to assess the performances of higher education institutes. Studies of Köksal and Nalçacı (2006); Johnes (2006); Johnes and Yu (2008); Tyagi et al. (2009); Kounetas et al. (2011); and Kuah and Wong (2011) can be given as the examples of application of DEA in universities.

DEA models that are implemented in this study are briefly described in the following section.

5.3.1.1. Charnes, Cooper and Rhodes (Constant Returns to Scale) Model

The original DEA model was first developed by Charnes, Cooper and Rhodes in 1978 and abbreviated with initials of the authors of the study, as "CCR model". It is also called as "Constant Scale to Return (CRS) model", since it doesn't take the possibility of returns to scale conditions into account.

Let's consider a set having n units, where each unit j, (j = 1,. . .,n) is using m inputs x_{ij} (i = 1,. . .,m) to generate s outputs y_{rj} (r = 1,. . ., s).

If we know the prices of outputs ($\bar{u}_r$) and inputs ($\bar{v}_i$), then we can express the efficiency $\bar{e}_j$ of unit j as the ratio of weighted outputs to weighted inputs as given in Equation 5.1.

$$\bar{e}j = \frac{\Sigma\, u_r\, y_{rj}}{\Sigma\, v_i x_{ij}} \qquad (5.1)$$

Charnes et al. (1978) proposed deriving appropriate prices via non-linear programming for cases where prices are unknown. The fractional programming (FP) problem is as follows:

$$e_0 = \max \quad \textstyle\sum_r u_r y_{r0} \,/\, \sum_i v_i x_{i0} \qquad (FP\ 5.1)$$

$$\text{s.t.} \quad \textstyle\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0 \quad \text{all } j \qquad r = 1, \dots, s; \;\; i = 1, \dots, m$$

$$u_r, v_i \geq \varepsilon$$

The "ε" in the model is a non-archimedian value and it is used to enforce positivity on the prices (weights).

The model provided in FP 5.1 is an input-oriented model, whereas output-oriented minimization problem can also be developed by inverting the ratios, as well. Input minimization models intend to reduce inputs as much as possible without decreasing output levels. Studies aiming at cost-reduction and downsizing make use of input-oriented models.

Alternatively, when the focus is on raising productivity using the same amount of resources, output maximization models might be preferred. Furthermore, when none of the inputs are controllable output maximization models should be used. The FP 5.1 is a fractional program. To replace it with a linear program (LP), let's consider

$\mu_r = tu_r$ and $v_i = tv_i$ where $t = (\sum_i v_i x_{i0})^{-1}$

Then we can obtain the following linear program.

$$e_0 = \max \quad \sum_r \mu_r y_{r0} \qquad \text{(LP 5.1)}$$

$$\text{s.t.} \quad \sum_i v_i x_{i0} = 1$$

$$\sum_r \mu_r y_{rj} - \sum_r v_i x_{ij} \leq 0 \quad, \forall j$$

$$\mu_r, v_i \geq \varepsilon \quad \text{for all } r,i.$$

LP 5.1 is the input-oriented model. Output-oriented models are given in the following LP 5.2.

$$e_0 = \min \quad \sum_i v_i x_{i0} \qquad \text{(LP 5.2)}$$

$$\text{s.t.} \quad \sum_r \mu_r y_{r0} = 1$$

$$\sum_r \mu_r y_{rj} - \sum_r v_i x_{ij} \leq 0 \quad, \forall j$$

$$\mu_r, v_i \geq \varepsilon \quad \text{for all } r,i.$$

By duality, the LP 5.2 will be equivalent to the LP 5.3.

$$\max \quad \phi_0 - \varepsilon \left(\sum_r s_r^+ + \sum_i s_i^-\right) \qquad \text{(LP 5.3)}$$

$$\text{s.t.} \quad \sum_j \lambda_j x_{ij} + s_i^- = x_{i0} \quad , \quad i = 1, \ldots, m$$

$$\sum_j \lambda_j y_{rj} - s_r^+ = \phi y_{r0} \quad , \quad r = 1, \ldots, s$$

$$\lambda_j,\ s_i^-, s_r^+ \geq 0 \quad , \quad \forall\, i, j, r$$

The CCR model assumes constant returns to scale, meaning that no significant relationship between the scale of operations and efficiency is considered. Thus, it is used to measure the technical efficiency of units. Under constant returns to scale, input minimization and output maximization produce the same efficiency scores.

5.3.1.2. Variable Returns to Scale (Banker, Charnes and Cooper) Model

Despite, the CCR model assumes constant returns to scale (CRS), occasionally there is a correlation between size of units and their efficiency. In such cases, using variable returns to scale (VRS) model should be preferred. Banker, Charnes and Cooper (1984) extended the CCR model to enable variable returns to scale (VRS) and this model is also called as BCC Model. The VRS model differs from the CRS model by an additional variable u_0 which provides information for the sign of the return to scale.

The output-oriented VRS model (LP 5.4) and its dual (LP 5.5) are given in the following models: LP 5.5 differs from LP 5.3 in that, it has an additional convexity constraint on the λj, which states $\sum_j \lambda_j = 1$

$$e_0^* = \quad \min \quad \sum_i v_i x_{i0} + v_0 \qquad \text{(LP 5.4)}$$

$$\text{s.t.} \quad \sum_r \mu_r y_{r0} = 1$$

$$\sum_r \mu_r y_{rj} - \sum_r v_i x_{ij} - v_0 \leq 0 \quad , for\ all\ j$$

μ_r, $v_i \geq \varepsilon$ for all r,i. v_0 unrestricted

$$\max \quad \phi_0 - \varepsilon \left(\sum_r s_r^+ + \sum_i s_i^-\right) \qquad \text{(LP 5.5)}$$

$$\text{s.t.} \quad \sum_j \lambda_j x_{ij} + s_i^- = x_{i0} \quad , \quad i = 1, \dots, m$$

$$\sum_j \lambda_j y_{rj} - s_r^+ = \phi y_{r0} \quad , \quad r = 1, \dots, s$$

$$\sum_j \lambda_j = 1$$

$$\lambda_j,\ s_i^-, s_r^+ \geq 0 \quad , \quad \forall\, i, j, r, \quad \phi_0 \text{ unrestricted}$$

Contrary to the CRS Model, where input oriented and output-oriented formulations gives the same results, the VRS model provides different results under two orientations.

When there is a need to decide on whether the CRS or the VRS model has to be selected, it may be a practical option to run both models and compare the efficiency scores. If majority of the units come up with different scores under the two models, then it is safe to assume VRS (Avkıran, 2001).

5.3.1.3. Assurance Region Models

Both CRS and VRS models obtain optimal weights without enforcing any constraints on them. Consequently, problems related with weights such as non-homogeneous weight dispersion, extreme values or zeroes in weights can be occurred. Additionally, each input/output is considered to be equally important and this sometimes results in unfitness of weights, such as giving big weights to variables with less importance or vice versa (Bal et al., 2008).

Assurance regions (AR) approach has been a frequently used weight restriction methodology. Basically, the aim of AR is imposing constraints on the relative magnitudes of weights. To avoid large variability in the weights for all DEA models, they suggested using AR. Use of AR reduces the number of efficient units and therefore increases the differentiability.

Generally, using of weight restrictions leads to a worsening of efficiency scores. Thus, it is important to design them carefully. If the constraints will be determined by subjective assessments, then it becomes very important to have expert opinions.

5.3.1.4. Super-Efficiency Ranking Techniques

Andersen and Petersen (1993) developed a technique, called as super-efficiency model for differentiating the efficient units. The methodology allows an extreme efficient unit, u_k, to achieve an efficiency score greater than 1 by removing the k^{th} constraint in the primal formulation.

There are three problems associated with this model. For example, it can give specialized units excessively high rankings, and it cannot provide a complete ranking of all units (Cook and Seiford, 2009). On the other hand, the simplicity of the method leads many researchers to use this approach despite of these drawbacks (Chen, 2005; Cook et al., 2009; Lovell and Rouse, 2003).

5.3.2. Construction of Data, Description of Input and Output Variables

All 94 public and private universities that were established in and before 2006 are included in the study. For the rest of this chapter, public universities that were established in 2006 will be called as "new public universities" and other public universities will be called as "established public universities". In total, there are 53 established public universities, 15 new public universities and 26 private universities in the study. Data used in the study has covered 3 separate years from 2008 to 2010. We do not include new public universities that were established after 2006 because data regarding them are not available or processable for the analysis period.

Number of faculty members by their academic degrees (professors, associate professors, and assistant professors), the total number of research assistants and the amount of research infrastructure funds given in the previous three years are selected as input variables, whereas the total number of publications, the total number of citations, the total number of research projects and the total number of PhD graduates are selected as output variables.

Data is collected from several different sources. The number of university staff and PhD graduates are obtained from annual statistics of Assessment, Selection and Placement Center. The total numbers of TÜBİTAK projects are obtained from

TÜBİTAK - Academic Research Funding Program Directorate. The total number of publications and the total number of citations received by these publications are derived from WoS database which is an online academic citation index provided by Thomson Reuters.[26] Detailed description of input and output variables is as follows:

5.3.2.1. Input Variables:

1. ***Number of faculty members:*** We assume that the main human resources responsible for performing research activities in universities are the faculty members with PhD degrees. Some studies use faculty members with different ranks, as separate input variables in the DEA (Abramo et al., 2008; Abramo et al., 2011b, Ulucan, 2011), whereas some other use their sum as a single input variable (Kağnıcıoğlu and İcan, 2011; Kounetas et al.; 2011, Özden, 2008). We use faculty members in two different forms. In five of the models, we have faculty members with different ranks as separate input variables and in the other five, we combine all of them into a single variable. The reason behind our combination of all faculty members is that number of professors, associate professors, and assistant professors are highly correlated with each other and the high correlation between the input or output variables is not desirable in DEA.

2. ***Number of research assistants***. Research assistants contribute to the research activities performed by the universities, and lessen the workload of faculty members. On the other hand, adding this number with the total number of faculty members will be awkward, since the responsibilities of faculty members and research assistants differ significantly. As a result, the total number of research assistants is taken as a separate input variable, which is used as the auxiliary human resources for the research activities.

3. ***3-year-sum research investment funds:*** In addition to human resources, research infrastructure is an important component of research activities. In Turkey, research infrastructure funds are allocated by the Ministry of Development (previously

[26] Web of Science is designed for providing access to multiple databases, cross-disciplinary research, and in-depth exploration of specialized subfields within an academic or scientific discipline. It covers full text publications, reviews, editorials, chronologies, abstracts, proceedings, technical papers, and patents. It has indexing coverage from the year 1900 to the present and more than 12.000 journals, 30.000 books, and 148.000 conference proceedings in approximately 256 fields are covered in WoS.

known as the State Planning Organization) via annual investment budget. On the other hand, it takes time to build laboratories, buy equipment and install them. Thus, we prefer to use the total amount of research infrastructure funds given in the previous three years. The total amount of funds is calculated in real terms using 2010 prices.

5.3.2.2. Output variables:

1. ***The total number of scientific publications indexed by Web Of Science***. Publications such as publications, books, and conference papers written by researchers are important indicators of research. They are especially important for Turkish faculty members, since writing scientific publications is among the most important academic promotion criteria. There is not a national database that kept information on publications written by Turkish researchers, so we prefer to use Web of Science (WoS) scientific database to derive the total number of publications written by or with a contribution of faculty members employed in Turkish universities.

2. ***The total number of citations received by scientific publications***. The remaining three output indicators that are selected for the DEA models are all quantitative indicators. To be able to capture the quality of research activities, we decide to add citations as one of the output variables. Namely, the amount of citations received by scientific publications is a qualitative indicator, which basically shows the quality and impact of the scientific publications. Citations were derived from WoS between 12^{nd} and 15^{th} of March 2013.

3. ***The total number of PhD graduates:*** This variable is selected to measure research output in terms of human resources. We might also use the total number of PhD students, but some PhD students leave programs before taking their degrees and we do not want to count these drop-offs in the model.

4. ***The total number of TÜBİTAK projects funded***: Another research output is research projects funded by national and international resources. These projects can be done for the private sector or they can be funded by public organizations. We do not have reliable information regarding projects done by universities for the

private sector. As a result, we do not include them in the study. TÜBİTAK and Ministry of Science, Technology and Industry (MSTI) are the two public organizations that support research projects in Turkish universities. But MSTI funds only applied research projects and funds neither basic research projects nor projects in social and agricultural sciences. Taking these facts into consideration, we only include projects funded by Academic Research Funding Program Directorate of TÜBİTAK as output variable. We prefer to use number of projects, instead of amount of project budgets, because project budgets differ significantly from one discipline to another and it is impossible to differentiate project budgets by academic fields since the TÜBİTAK issues only the total amount of funds received by each university. In general, average project budgets in social sciences are quite lower, compared to other disciplines, since they do not require buying equipment.

As mentioned in Chapter 4, R&D project funds are flexible variables, meaning that they can be used either as an input variable or as an output variable (Cook and Seiford, 2009). We apply the model suggested by Cook and Zhu (2007) to decide whether we should take R&D projects as an input or an output variable. In this context, we select VRS model. Each unit is allowed to select the flexible variable first as an input and then as an output variable. Efficiency scores are obtained separately for two scenarios. In the end, the scenario, in which majority of the units receive higher scores will be selected. We use TÜBİTAK projects first as an input variable and then as an output variable. 56 of the units receive higher scores in the model where TÜBİTAK projects are selected as an output variable. Thus, we decide to use TÜBİTAK projects as an output variable.

5.3.3. Normalization of Outputs by Scientific Fields

Normalization by scientific fields has been frequently applied in analyzing citations (Abramo et al., 2011b; Waltman et al., 2011). On the other hand, none of the studies that aimed to measure research performance using DEA, have applied normalization procedure for other output variables. There are some studies measured performance in terms of separate scientific fields (Abramo et al, 2008; Pouris and Pouris, 2010), whereas they do not provide an overall score for each university.

The assumption under the normalization of outputs is that the average number of research outputs per faculty member differs from one scientific field to another. We first check per faculty productivity in terms of four outputs, and find that there is a significant difference among different scientific fields. Thus, we conclude that instead of adding absolute numbers of outputs from different scientific fields, it will be more meaningful to add them after making normalizations.

To normalize number of publications, first we calculate an overall publication per faculty ratio using 3 years data. To do this, we divide the total number of publications written during the 2008-2010 period, by the sum of the total number of faculty members of each year. The overall publication per faculty ratio is found as 0.61 for the analysis period (see the last row of the second column in Table 30).

In the second step, we calculate field-based publications per faculty ratios separately, again using 3-years data. Publication per faculty ratios are found as 0.41 for Agriculture, Forestry and Veterinary Sciences (AFVS), 1.44 for the basic sciences, 0.73 for engineering sciences, 0.84 for the health sciences and 0.15 for the social sciences (see the second column of Table 30).

In the next step, we divide field-based publication per faculty ratios by the overall publication per faculty ratio (which is equal to 0.61) and obtain normalization indices for each field. Normalization indices are calculated as 1.48 for AFVS, 0.42 for basic sciences, 0.83 for engineering sciences, 0.72 for health sciences and 3.94 for social sciences (see third column of Table 30).

We use these indices to find the normalized amount of publications. To do this, we multiply the total number of publications in a specific field by its normalization index. For example, we multiply the total number of publications written in the social sciences by 3.94, whereas we multiply the total number of publications written in basic sciences by 0.42. This procedure helps us to handle field-based productivity differences.

We apply the same procedure to normalize citations, projects and PhD graduates. Productivity per faculty and normalization indices (NI) for publications, citations and projects are given in Table 30.

Table 30: Productivity per faculty and NI for publications, citations and projects

Scientific Discipline	Publication Per Faculty	NI of Publication	Citation Per Faculty	NI of Citations	Projects Per Faculty	NI of Projects
AFVS	0.41	1.48	0.20	2.77	0.03	0.59
Basic	1.44	0.42	1.81	0.30	0.05	0.31
Engineering	0.73	0.83	0.75	0.72	0.02	0.62
Health	0.84	0.72	0.62	0.89	0.01	3.03
Social	0.15	3.94	0.09	6.02	0.01	2.40
Overall Mean	**0.61**		**0.55**		**0.02**	

Productivity per faculty member and normalization indices for PhD graduates are given in Table 31. Since we cannot reach data regarding the detailed distribution of AFVS, basic sciences and engineering and applied sciences, we combine them under basic and applied sciences heading.

Table 31: PPF and normalization indices for PhD graduates

Scientific Discipline	PhD Graduates Per Faculty	NI of PhD Graduates
Basic and Applied Sciences	0.14	0.81
Health Sciences	0.06	1.86
Social Sciences	0.13	0.85
Overall Mean	**0.11**	

5.3.4. Model Specifications

The objective function of the DEA can be either minimizing weighted inputs over weighted outputs or maximizing weighted outputs over weighted inputs. Input minimization models intend to reduce inputs as much as possible without decreasing output levels. Studies aiming at cost-reduction and downsizing make use of input-oriented models. Alternatively, when the focus is on raising productivity with the same amount of resources, output maximization models might be preferred. Furthermore, when none of the inputs are controllable, output maximization models should be used (Avkıran, 2001). Our focus in this study is on raising productivity with the same amount of resources rather than on cost saving, thus output-oriented envelopment models are preferred for this study.

10 different DEA models whose specifications are given in Table 32 are implemented in this section. These models include 2 CRS models, 2 VRS models, 4 assurance region models and 2 superefficiency models.

Table 32: Different DEA Models used in the study

Model	Inputs	Outputs	DEA Model
Model 1 (M1)	Professors, associate professors, assistant professors, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	CRS
Model 2 (M2)	Professors, associate professors, assistant professors, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	VRS
Model 3 (M3)	Faculty members, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	CRS
Model 4 (M4)	Faculty members, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	VRS
Model 5 (M5)	Professors, associate professors, assistant professors, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	CRS Assurance Region Model
Model 6 (M6)	Professors, associate professors, assistant professors, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	VRS Assurance Region
Model 7 (M7)	Faculty members, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	CRS Assurance Region
Model 8 (M8)	Faculty members, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	VRS Assurance Region
Model 9 (M9)	Professors, associate professors, assistant professors, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	CRS Superefficiency
Model 10 (M10)	Faculty members, research assistants, research infrastructure funds	Publications, citations, PhD graduates, TÜBİTAK projects.	CRS Superefficiency

.

During the literature survey, we see that some studies include the aggregate sum of faculty members, while some other include faculty members with different academic rank as separate inputs. We decide to apply both approaches and see whether there occur significant differences in terms of these. Consequently, in 5 of the models, we use professor, associate professors, and assistant professors as separate input variables. In the other 5 models we combine all these variables and handle the total amount of faculty members as a single input variable.

We run all models under both constant scales to return (CRS) and variable returns to scale (VRS) assumptions. But for superefficiency models, we only run CRS models, since VRS models come up with infeasible efficiency scores for some of the universities

Models 5 and 6 are the assurance region models, and the following three constraints are imposed on the relative magnitudes of weights.

$$1 \leq \frac{\text{Weight of Professors}}{\text{Weight of Associate Professors}} \leq 10 \qquad \text{(Constraint 1)}$$

$$1 \leq \frac{\text{Weight of Associate Professors}}{\text{Weight of Assistant Professors}} \leq 10 \qquad \text{(Constraint 2)}$$

$$2 \leq \frac{\text{Weight of Assistant Professors}}{\text{Weight of Research Assistants}} \leq 10 \qquad \text{(Constraint 3)}$$

These constraints impose that the weight of professors should be equal to higher than the weights of associate and assistant professors, and weight of all faculty members should be at least twice higher than the research assistants. We put these constraints, since both the experience and wage of academic personnel are increasing with the academic title and consequently, faculty members with higher academic titles should not receive less weights when compared with their subordinates. We refrain to put strict upper limits on the relative magnitude of the weights, so we select 10 as an arbitrary upper limit.

In Models 7 and 8, which are also assurance region models, following constraint is imposed on the relative magnitudes of weights.

$$2 \leq \frac{\text{Weight of Faculty}}{\text{Weight of Research Assistant}} \leq 20 \qquad \text{(Constraint 4)}$$

This constraint again required that the weight of faculty members should be at least twice higher than the research assistants.

We avoid putting any lower limit on the outputs, so that each university is allowed to decide on its research output mix. In this case, some universities might prefer not to produce from one or more research outputs. But if this is the situation, then they should produce more from other research outputs to be research efficient.

Linear optimizations are performed using "DEA Frontier" software, which is an add-in application for Microsoft Excel and developed by Joe Zhu[27].

5.4. Results and Comparison of DEA Models

In this section we run 10 different DEA models, presented in the previous section. In the first step we will use the methodology that is developed by Bauer et al. (1998) and applied by Dong et al. (2014) to compare 10 different DEA models on the basis of four consistency conditions which are efficiency distributions, rank order correlations, identification of best and worst practice universities, and stability of efficiency scores.[28] In the second step, we will discuss the outputs of different models.

5.4.1. Testing Suitability of Using DEA

Following the methodology that is developed by Bauer et al. (1998) and also applied by Dong et al. (2014) we will compare 10 different DEA models on the basis of four consistency conditions. Bauer et al. suggested that if different models will generate similar efficiency distributions, rank orders, top and low performers; and efficiency

[27] DEAFrontier developed by Professor Joe Zhu is a Microsoft Excel add-in for solving Data Envelopment Analysis models.

[28] Bauer et al.(1998) and Dong et al. (2014) used five conditions. As a fifth measure, they compared efficiency scores with accounting based performance measures. Since we do not have such criteria for universities, we check only four consistency conditions.

scores show stability over time, then the policy makers may be able to draw some important policy conclusions from the analysis of the efficiency scores.

5.4.1.1. Efficiency Distributions

Efficiency scores obtained in each model are provided in Appendix A, whereas model-based average efficiency scores and standard deviations are given in Table 33.

Table 33: Summary statistics of efficiency scores (ES)

	Average ES			**Standard Deviation of ES**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**
Model 1	1.963	2.155	1.884	1.545	1.812	1.244
Model 2	1.579	1.628	1.509	0.613	1.102	1.112
Model 3	3.350	3.080	2.546	3.628	3.257	1.991
Model 4	2.440	2.471	2.088	1.860	2.559	1.957
Model 5	2.742	2.710	2.247	4.191	3.098	2.132
Model 6	2.057	2.294	1.835	1.636	2.721	2.046
Model 7	3.567	3.119	2.638	4.668	3.261	2.330
Model 8	2.630	2.713	2.166	2.138	2.985	2.194
Model 9	1.888	2.073	1.797	1.604	1.875	1.320
Model 10	3.307	3.035	2.501	3.660	3.289	2.031

We perform one-way Anova tests to see whether mean annual efficiency scores has significantly differed across different models. Each year we have a total of 45 pairs. In 2008 means of 9 pairs are found to be significantly different than each other at 5 % significance level, and this number has decreased to 3 in 2009 and 2010. Consequently, in 2008 for 80 % of the pairwise comparisons, we have not detected any differences in terms of mean efficiency scores, and this ratio is equal to 7 % in 2009 and 2010.

Average efficiency scores vary between 1.58 and 3.57 in 2008; 1.63 and 3.12 in 2009; 1.51 and 2.64 in 2010. Although we observe some differences in the distributional properties of the efficiency scores of different DEA models, such differences might occur due to the various underlying assumptions on which the models are based and might not denote any inherent problems with the efficiency scores themselves.

In all models, average efficiency score is the lowest in 2010, compared to the previous two years. In six of the models, standard deviation is the smallest in 2010. It means that in general, the gap between research performances of efficient and inefficient universities are the smallest in 2010. There might be two factors leading to this result.

First, research performance of universities might be converging. Secondly, the citation gap between high quality and low-quality articles might be getting visible after a certain time of publication and year 2010 do not provide enough time for discrimination of citations.

The lowest average ES are calculated in Model 2, and the highest are calculated in Model 7, in all years. The standard deviation of the ES is higher for models in which faculty members are combined into one input variable, compared to the models which had faculty members with different academic titles as three separate input variables. The difference is the highest in the superefficiency model.

When we investigate the CRS and the VRS models that use the same input output combinations, we detect that the standard deviation of ES is higher in the CRS models, compared to the latter.

5.4.1.2. Rank Order Correlation between Efficiency Scores

We calculate the Spearman correlation coefficients between the efficiency scores for each model and results are given in Table 34.

We observe moderate to high positive rank order correlations between the different efficiency scores that are all significant at the 5% level. The lowest Spearman correlation coefficient is 0.567 in 2008, 0.752 in 2009 and 0.704 in 2010. It means that with similar input and output variables, different DEA models has provided quite similar results, and it becomes more important to select the appropriate variables than selecting the DEA model.

If different DEA models do not come up with consistent ranks, then these models cannot be relied upon and this might lead to conflicting policy recommendations when evaluating important policy questions.

Table 34: The Spearman correlation coefficients of DEA Models

		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
2008	M1	1.000									
	M2	0.772	1.000								
	M3	0.781	0.573	1.000							
	M4	0.692	0.708	0.864	1.000						
	M5	0.862	0.614	0.853	0.719	1.000					
	M6	0.827	0.698	0.854	0.829	0.933	1.000				
	M7	0.781	0.567	0.997	0.861	0.861	0.858	1.000			
	M8	0.745	0.641	0.929	0.943	0.797	0.895	0.930	1.000		
	M9	0.997	0.767	0.785	0.693	0.868	0.828	0.785	0.747	1.000	
	M10	0.780	0.572	0.999	0.863	0.853	0.853	0.997	0.929	0.785	1.000
2009	M1	1.000									
	M2	0.871	1.000								
	M3	0.876	0.827	1.000							
	M4	0.752	0.887	0.864	1.000						
	M5	0.918	0.805	0.929	0.772	1.000					
	M6	0.820	0.832	0.918	0.843	0.929	1.000				
	M7	0.874	0.827	0.997	0.861	0.931	0.918	1.000			
	M8	0.784	0.815	0.955	0.911	0.864	0.944	0.954	1.000		
	M9	0.997	0.867	0.878	0.756	0.921	0.820	0.877	0.788	1.000	
	M10	0.875	0.825	0.999	0.863	0.929	0.918	0.996	0.954	0.879	1.000
2010	M1	1.000									
	M2	0.868	1.000								
	M3	0.812	0.811	1.000							
	M4	0.704	0.837	0.900	1.000						
	M5	0.944	0.801	0.812	0.719	1.000					
	M6	0.808	0.904	0.822	0.883	0.851	1.000				
	M7	0.808	0.804	0.997	0.896	0.812	0.826	1.000			
	M8	0.713	0.838	0.907	0.989	0.728	0.898	0.908	1.000		
	M9	0.995	0.864	0.823	0.714	0.945	0.812	0.820	0.723	1.000	
	M10	0.811	0.811	0.999	0.901	0.812	0.823	0.997	0.909	0.824	1.000

5.4.1.3. Identification of Best and Worst Practice Universities

In performance analyses, using different methods might provide useful insight in identifying the best and worst practice decision making units (Bauer et al., 1998). To do this, a coherency measure which identifies the degree to which the different methods classify the same units as being in the highest and lowest cost efficiency groups will be defined (Dong et al, 2014). We implement this coherency measure by examining the overlap of the proportion of universities that are listed in the top 25% and the lowest 25% of universities by efficiency score for each of the ten models.

Table 35: Correspondence of the best-practicing universities

		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
2008	M1	1.00									
	M2	0.88	1.00								
	M3	0.71	0.75	1.00							
	M4	0.67	0.75	0.79	1.00						
	M5	0.88	0.83	0.71	0.67	1.00					
	M6	0.83	0.88	0.79	0.83	0.83	1.00				
	M7	0.75	0.75	0.96	0.79	0.75	0.83	1.00			
	M8	0.67	0.75	0.79	1.00	0.67	0.83	0.79	1.00		
	M9	1.00	0.88	0.71	0.67	0.88	0.83	0.75	0.67	1.00	
	M10	0.71	0.75	1.00	0.79	0.71	0.79	0.96	0.79	0.71	1
2009	M1	1									
	M2	0,96	1								
	M3	0,83	0,67	1							
	M4	0,79	0,74	0,83	1						
	M5	0,83	0,59	0,79	0,71	1					
	M6	0,79	0,70	0,83	0,83	0,75	1				
	M7	0,88	0,70	0,96	0,83	0,83	0,88	1			
	M8	0,71	0,63	0,83	0,88	0,67	0,92	0,79	1		
	M9	0,83	0,67	1,00	0,83	0,79	0,83	0,96	0,83	1	
	M10	1	0,74	0,83	0,79	0,83	0,79	0,88	0,71	0,83	1
2010	M1	1									
	M2	0,96	1								
	M3	0,83	0,58	1							
	M4	0,71	0,67	0,71	1						
	M5	0,96	0,61	0,79	0,67	1					
	M6	0,75	0,69	0,71	0,92	0,71	1				
	M7	0,83	0,61	0,96	0,75	0,79	0,67	1			
	M8	0,75	0,67	0,75	0,96	0,71	0,92	0,75	1		
	M9	0,83	0,58	1,00	0,71	0,79	0,67	0,96	0,75	1	
	M10	1,00	0,64	0,83	0,71	0,96	0,71	0,83	0,75	0,83	1

The results given in Table 35 show that different DEA models are highly consistent in identifying the most efficient universities, with an average pairwise agreement statistic of 79 % in 2008, 81 % in 2009, and 78 % in 2010. For example, in 2008, 88 % of the universities that are identified in the most efficient quarter by M1, are also identified in the most efficient quarter by M2.

Similarly, 10 DEA models are found as moderately to highly consistent in terms of identifying the least efficient universities, with an average pairwise agreement statistics of 70% in 2008, 76 % in 2009, and 74 % in 2010. The results are given in Table 36.

Table 36: Correspondence of the worst-practicing universities

		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
2008	M1	1									
	M2	0,79	1								
	M3	0,63	0,63	1							
	M4	0,46	0,54	0,75	1						
	M5	0,67	0,63	0,67	0,58	1					
	M6	0,63	0,63	0,71	0,75	0,79	1				
	M7	0,63	0,63	0,96	0,79	0,71	0,75	1			
	M8	0,54	0,54	0,83	0,92	0,67	0,83	0,88	1		
	M9	0,63	0,63	1,00	0,75	0,67	0,71	0,96	0,83	1	
	M10	1,00	0,79	0,63	0,46	0,67	0,63	0,63	0,54	0,63	1
2009	M1	1									
	M2	0,79	1								
	M3	0,71	0,67	1							
	M4	0,58	0,71	0,75	1						
	M5	0,79	0,83	0,79	0,67	1					
	M6	0,67	0,75	0,75	0,75	0,83	1				
	M7	0,71	0,67	1,00	0,75	0,79	0,75	1			
	M8	0,63	0,71	0,83	0,92	0,75	0,83	0,83	1		
	M9	0,71	0,67	1,00	0,75	0,79	0,75	1,00	0,83	1	
	M10	1,00	0,79	0,71	0,58	0,79	0,67	0,71	0,63	0,71	1
2010	M1	1									
	M2	0,83	1								
	M3	0,67	0,67	1							
	M4	0,54	0,71	0,79	1						
	M5	0,88	0,79	0,63	0,54	1					
	M6	0,75	0,92	0,71	0,71	0,75	1				
	M7	0,67	0,67	0,96	0,79	0,58	0,71	1			
	M8	0,54	0,71	0,79	1,00	0,54	0,71	0,79	1		
	M9	0,67	0,67	1,00	0,79	0,63	0,71	0,96	0,79	1	
	M10	1,00	0,83	0,67	0,58	0,88	0,75	0,67	0,54	0,67	1

These results suggest that different DEA methods are to some extent less consistent in identifying the least efficient universities than they are in identifying the most efficient ones. We also observe moderate to high consistency between different DEA models in identifying the best and worst practice universities. We can comment that, policies targeted at either efficient or inefficient universities can identify different units, depending upon which model has been employed to determine the policy.

5.4.1.4. Stability of Efficiency Scores over Time

The relative stability of the efficiency scores over time can also be an important measure from a regulatory perspective, since it is unlikely that the efficiency rankings of universities will change radically from one year to another. Additionally, even admitting that some units may advance or get worse in their overall performance in the short run, it is improbable that a very efficient unit in one year would become very inefficient in the next year (Bauer et al., 1998). We use the Spearman rank order correlation coefficient between the ten models between each pair of years to examine the year to year stability of the efficiency scores over time (Table 37).

Table 37: Correlations of k-year-apart efficiencies

Years Apart	1	2
Model 1	0.644	0.514
Model 2	0.671	0.567
Model 3	0.765	0.627
Model 4	0.766	0.595
Model 5	0.685	0.523
Model 6	0.767	0.592
Model 7	0.766	0.625
Model 8	0.804	0.650
Model 9	0.660	0.522
Model 10	0.644	0.514

We find that one-year-apart correlations have varied between 0,64 and 0,80 whereas two-year-apart correlations have varied between 0,51 and 0,65. These results indicate that a university's efficiency ranking do not fluctuate up and down dramatically within a one or two year time period. In other words, for all DEA models, many of the best and worst practice universities remain efficient or inefficient over the short-time. We also detect that one-year-apart average correlations are higher for all models, when compared with the two-year-apart averages.

Furthermore, the results illustrate that there is not much difference in the stability of the efficiency scores among different DEA models. On the other hand, the most stable model is found to be the Model 8 in both one and two-year-apart analyses. Since we have only 3 years data, we are unable to comment further on the stability of these models.

To sum up, we analyze distributions, rank order correlations, and stability of efficiency scores, and identify the common best and worst practicing universities in this section. We find that although distributions of efficiency scores have varied among models, high correlations are observed in terms of the rank order of efficiency scores. In addition, the best and the worst performing universities are mostly overlapped in different models. We also observe that efficiency scores are stable over time for all models. From these outcomes, we conclude that DEA provides a solid base to evaluate research efficiency of universities.

5.4.2. Comparison of Similar DEA Models

In the previous section we deduce that using DEA for measuring research efficiency of universities is a proper application. In this section, we will try to scrutinize outputs obtained from different models, and discuss similarities and disparities among them.

Correlations between models that use the same input and output combinations, and same DEA model, but that carry different returns to scale assumption (CRS or VRS) are investigated. Results are given in Table 38.

Table 38: Correlation between CRS and VRS models

Years	**M1-M2**	**M3-M4**	**M5-M6**	**M7-M8**
2008	0,35	0,62	0,74	0.78
2009	0.75	0.74	0.99	0.99
2010	0.96	0.98	0.98	0.99

Correlation coefficients given in Table 38 are very high and significant at 5 % significance level except year 2008 and two of the combinations in the year 2009. For 6 of the combinations, we see that CRS and VRS version of models that use the same input output combinations have diverged from each other. Avkıran (2001) has suggested that if majority of units are assigned different efficiency scores under CRS and VRS assumptions, VRS model should be selected. Our results show that especially for the first year of analyses, correlations between VRS and CRS models are lower, indicating that the scale of the operations has a significant impact on the research efficiency. Thus, using variable returns to scale assumption will be a better option over CRS assumption.

5.4.2.2. Analyses of VRS Models

Similar to CRS models, VRS models provide detailed information about underproduced outputs and underused inputs in addition to calculating efficiency scores for the units of analyses.

M2 and M4 are the basic VRS models implemented in this study. M2 uses faculty members with different academic titles as separate input variables, whereas M4 combines them into a single input variable.

In M2, 18 universities (Aksaray, Amasya, Ankara, Atatürk, Başkent, Bilkent, Fırat, Giresun, Hacettepe, Işık, İstanbul Bilim, İstanbul, Koç, Marmara, MSGSÜ, ODTÜ, Sabancı, TOBB-ETÜ) are found to be efficient in three years. In M4, there are 11 universities that are efficient for all years (Ankara, Başkent, Bilkent, Hacettepe, İstanbul, Koç, Marmara, MSGSÜ, ODTÜ, Sabancı, and TOBB-ETÜ).

In M2, 50 universities are inefficient for all years, and in M4 this number is 66. Similar to the results of CRS models, VRS models also imply that, for Turkish universities being research efficient or research inefficient is usually a continuous phenomenon.

In M2, 14 universities (Adnan Menderes, Beykent, Cumhuriyet, ÇOMÜ, Galatasaray, Haliç, Harran, İstanbul Bilgi, İstanbul Kültür, İstanbul Ticaret, Maltepe, Ordu, Sakarya, Ufuk) continuously receive lower ES compared to the average. This list is highly overlapping with the list of universities that continuously receive lower ES from the average ES in M1.

In M4, 13 universities (Ahi Evran, Beykent, Bozok, Cumhuriyet, Dumlupınar, Erzincan, Haliç, İstanbul Bilgi, İstanbul Kültür, İstanbul Ticaret, Kastamonu, Maltepe, Ordu, and Ufuk) continuously receive lower ES than the average. Most of these universities are common with the universities that continuously receive lower ES than the average ES in M2 and M3.

The total number of slacks obtained in M2 is given in Table 42. Similar to Table 40 (which shows slacks for M1) this table also presents that between 2008 and 2010, a lot of universities have suffered from both input and output slacks.

Table 39: The total number of slacks obtained in M2

	Input Slacks					Output Slacks			
Year	Prof.	Asc. Prf.	Ast. Prf.	Res. As.	SPO Fund	PhD Grd	Prj.	Pub.	Cit.
2008	19	39	56	61	6	26	39	16	50
2009	31	29	58	59	5	24	47	6	39
2010	20	26	49	47	3	21	41	5	39
Total	**70**	**94**	**163**	**167**	**14**	**71**	**127**	**27**	**128**

There are several similarities in terms of input slacks of M1 and M2. First, in both models the most effectively used inputs are the research infrastructure funds allocated by SPO, and the least efficiently used inputs are the research assistants. Moreover, the most efficiently used human resources are the professors in both models.

The difference between slacks of M1 and M2 is that associate professors are among the most inefficiently used inputs in M1, which is not the case in M2.

Apart from M1, M2 indicate that as academic ranks get higher, human resources are used more efficiently in research activities. This situation is expected in the relevant literature since promotion in terms of academic title is a proxy of experience and reputation.

In M3, the highest inefficiencies are observed in TÜBİTAK projects and citations, whereas the most efficiently produced outputs are the publications. These results coincide with the results of M1.

For all years, nearly half of the universities have slacks in terms of TÜBİTAK projects and citations. Moreover, 18 universities have had project slacks, and 22 of them have had citation slacks for all years.

We find that few universities have slacks in terms of publications. Again the results imply that the majority of Turkish universities does not have efficiency problems in terms of writing articles, but they have problems in writing visible and/or high quality articles, relative to research-efficient universities.

In M3, we detect that the fewest slacks occur in 2010. There might be two explanations. First, the efficiency gap in terms of research activities might be converging during the period between 2008 and 2010 among Turkish universities. Secondly, a certain amount of time might be required to discriminate among efficient and inefficient universities since citations, which are selected as output variables, change significantly with time. The duration between our derivation of data and the last year of analyses (which is year 2010) is almost two years, and this duration probably is not enough to capture the real gap between high and low impact articles.

The total number of slacks of the Model 4 is given in Table 43. Similar to the previous three models, this table also depicts that several universities are suffering from both input and output slacks during three years.

Table 40: Number of slacks obtained in M4

	Input Slacks			**Output Slacks**			
	Fclt.	Res. As.	SPO Fund	PhD Grd	Prj.	Pub.	Cit.
2008	18	49	3	21	62	50	41
2009	12	52	3	12	47	61	34
2010	20	43	2	10	52	55	35
Total	**50**	**144**	**8**	**43**	**161**	**166**	**110**

Similar to the results of M1 and M2, the most effectively used inputs are the research infrastructure funds allocated by SPO. Detailed analyses show that throughout the analysis period , 4 universities have slacks in terms of research infrastructure funds (İTÜ, GYTE, İYTE, and Atılım).

Similar to the other models, the least efficiently used inputs are found as the research assistants. On the other hand, the results of M4 show that approximately 20% of the universities have inefficiently employed their faculty members during the analysis period .

Similar to previous 3 models, in M4, the least efficiently produced research outputs are found as TÜBİTAK projects and citations, and the most efficiently produced outputs are the publications. The major difference in terms of output slacks between M4 and other models is that the total number of universities with output slacks is much higher in M4.

In M4, 32 universities have had slacks in terms of TÜBİTAK projects, and 35 universities have had slacks in terms of citation for all years. Again, we see that more than half of the universities that have inefficiencies in terms of citations and TÜBİTAK projects have faced with this situation during three years of analyses.

Like previous three models, few universities have slacks in terms of publications in M4. In addition, the total number of universities that have publication slacks depicts a decreasing pattern during the 2008-2010 period. M4 also points out that the majority of Turkish universities does not have efficiency problems in terms of writing articles, but they have problems in writing visible and/or high quality articles.

The correlation coefficients between two basic VRS models (M2 and M4) are calculated as 0.65 in 2008, 0.94 in 2009, and 0.96 in 2010. These figures imply that combining all faculty members as a single input doesn't significantly change efficiency scores for the last two years of analyses but in 2008, there occur important differences. Thus, we suggest having faculty members with different academic ranks as separate inputs.

5.4.2.1. Analyses of the CRS Models

CRS models provide information about returns to scale conditions, underproduced outputs (output slacks), and underused inputs (input slacks). Analyzing slack values would be helpful to understand the underlying factors of the inefficiencies and provide opportunity to concentrate on the weak points. If it is of critical importance to understand which universities use which inputs inefficiently or underproduce which outputs, then it is better to select either original CRS or original VRS models.

M1 and M3 are the basic CRS models implemented in this study. M1 uses faculty members from different academic degrees as separate input variables, whereas M3 combines them into a single input variable.

The correlation between M1 and M3 efficiency scores (ES) are very high. It is 0,91 in 2008; 0,95 in 2009 and 0,94 in 2010. It means that if CRS models are used, then having faculty members as a single input or three separate inputs will not significantly affect results.

In M1, 11 universities (Aksaray, Ankara, Bilkent, Giresun, Hacettepe, Koç, Marmara, MSGSÜ, ODTÜ, Sabancı, TOBB-ETÜ) are found to be efficient for all of the three years. In M3, there are six all-time efficient universities (Bilkent, Koç, Marmara, ODTÜ, Sabancı, and TOBB-ETÜ) and all of these are listed as efficient in M1 as well.

In M1, 66 universities are inefficient for all years, and in M3 this number is equal to 78. We conclude that, being research efficient or research inefficient is usually a continuous phenomenon for Turkish universities.

In M1, 14 universities (Adnan Menderes, Beykent, Celal Bayar, Cumhuriyet, ÇOMÜ, Haliç, İstanbul Aydın, İstanbul Bilgi, İstanbul Kültür, İstanbul Ticaret, Kocaeli, Maltepe, Muğla, and Ufuk) continuously receive lower ES compared to average ES. In M3, 16 universities (Ahi Evran, Balıkesir, Beykent, Bozok, Cumhuriyet, ÇOMÜ, Erzincan, Haliç, Harran, İstanbul Aydın, İstanbul Kültür, İstanbul Ticaret, Kastamonu, Maltepe, Ordu, and Ufuk) continuously get lower ES compared to the average. 9 universities are common in these lists, whereas almost half of the universities covered in these lists are different.

Returns to scale conditions are given in Table 39. In both models, almost two third of the universities are found to be operating at decreasing returns to scale (DRS) conditions. When compared to M1, in M3 there are less universities operating at constant returns to scale (CRS) conditions, but more universities are operating at increasing returns to scale (IRS) conditions.

Table 41: Returns to Scale Conditions in M1 and M3

	Model 1			Model 3		
Year	**Constant**	**Decreasing**	**Increasing**	**Constant**	**Decreasing**	**Increasing**
2008	16	64	14	10	55	29
2009	18	66	10	12	60	22
2010	20	60	14	9	58	27

In M1, only 19 universities continuously operated at CRS or IRS conditions during the 2008-2010 period. In M3 this number increases to 26. Although there are differences in these lists, more than 60 % of the universities are overlapping. We also identify that the majority of universities that are operating at CRS and IRS conditions are mostly new public or private universities. Namely, there are only 5 established public universities in M1, and 4 established public universities in M3 that are operating at CRS or IRS conditions.

There are 51 universities in M1 and 50 universities in M3 that continuously operate at DRS conditions. Among these universities, established public universities are holding the majority. In M1 there are 42 established public universities, 4 new universities and 7 private universities that continuously operate at DRS. In M3, these numbers are 45, 1 and 4, respectively.

The total number of slacks obtained in M1 and M3 is given in Table 40 and Table 41. Both tables have similarities such that the most inefficiently used inputs are the research assistants. Secondly, the most efficiently produced output is found to be publications, and the highest inefficiencies are observed in TÜBİTAK projects and citations. There is no apparent trend observed regarding input and output slacks in both models.

Table 42: The total number of slacks obtained in M1

	Input Slacks					Output Slacks			
Year	Prof	Asc. Prf.	Ast. Prf.	Res. As.	SPO Fund	PhD Grd	Prj.	Pub.	Cit.
2008	17	44	19	57	8	14	59	47	21
2009	24	31	30	51	9	6	40	49	19
2010	25	26	25	52	2	5	46	44	18
Total	**66**	**101**	**74**	**160**	**19**	**25**	**145**	**140**	**58**

Table 43: The total number of slacks obtained in M3

	Input Slacks			Output Slacks			
Year	Fclt.	Res. As.	SPO Fund	PhD Grd	Prj.	Pub.	Cit.
2008	0	77	2	19	64	55	29
2009	2	63	5	9	47	65	30
2010	1	69	0	14	58	59	25
Total	**3**	**209**	**7**	**42**	**169**	**179**	**84**

The most distinguished difference in terms of slacks between two models is that M3 has very few slacks in terms of faculty members, whereas in M1 several universities are suffering from inefficient use of faculty members. This might be due to the possibility that inefficiencies occurred due to faculty members with one academic degree are compensated by faculty members from other academic degrees.

In M1 the most efficiently used faculty members are professors and assistant professors, whereas the least efficiently used ones are the associate professors.

In M1, nearly half of the universities underproduce TÜBİTAK projects and citations. Among them, 18 have had slacks in terms of TÜBİTAK projects and 22 universities have had slacks in terms of citations, for all years.

In M3, 33 universities have had slacks in terms of projects and citations at the same time for all years.

We identify that both in M1 and in M3, very few universities have slacks in terms of publications. Joint investigation of output slacks of publications and citations indicates that the majority of the Turkish universities does not have efficiency problems in terms of writing articles, but they have problems in writing visible and/or high quality articles, relative to research-efficient universities.

5.4.2.3. Analyses of Assurance Region Models

Assurance Region (AR) models are basically the dual of the CRS and VRS models that allow putting weights on inputs and outputs. They can assume either CRS or VRS conditions. On the other hand, they do not give information on the slacks or returns to scale conditions.

In this study, models 5, 6, 7 and 8 are designed as the AR models. M5 and M7 use faculty members from different academic titles as separate input variables, whereas M6 and M8 combine them into a single variable. M5 and M6 assume constant returns to scale, whereas M7 and M8 assume variable returns to scale.

We detect that a lot of universities that receive lower (better) ES than the average are overlapping in all of the AR models. Namely, 34 universities (AKÜ, Aksaray, Anadolu, Ankara, Atatürk, Başkent, Bilkent, Boğaziçi, Çankaya, Çukurova, Ege, Erciyes, Fırat, Gazi, GYTE, Giresun, Hacettepe, Işık, İstanbul, İzmir Ekonomi, İYTE, Kadir Has, Kafkas, KTÜ, Koç, Marmara, MSGSÜ, OMÜ, ODTÜ, Sabancı, Selçuk, SDÜ, TOBB-ETÜ, and YYÜ) have received efficiency scores lower (better) than the average for all years.

Meanwhile, 9 universities (Beykent, Cumhuriyet, Haliç, İstanbul Aydın, İstanbul Kültür, İstanbul Ticaret, Maltepe, Ordu, and Ufuk) have received efficiency scores higher (worse) than average for all years and for all AR models.

To understand the impact of constraints on inputs, we compare M5 with M1, M6 with M2, M7 with M3, and M8 with M4. For CRS models, the correlation coefficients are above 0.94 for all years.

On the other hand, correlation coefficients are lower in the VRS models in 2008 and 2009. Especially when we compare M2 to M6 (VRS models that use faculty members with different academic degrees as separate inputs), we detect that the correlation coefficients are 0.47 in 2008, and 0,73 in 2009.

We investigate whether or not a certain group of universities has been affected from putting constraints on input variables. We find that all universities that are found efficient in restricted models are also efficient in unrestricted models. On the other hand, we cannot identify a systematic relationship regarding universities that are found efficient in unrestricted models, and inefficient in the restricted models.

Universities that are found efficient in unrestricted models and inefficient in the restricted models are given in Table 44. This table shows that universities that are negatively affected from putting constraints on weights of the inputs have changed by year and specification of the model.

Table 44: Comparison of efficient universities

Condition	2008	2009	2010
Efficient in M1 and inefficient in M5	Hacettepe Hitit İstanbul Okan	Amasya Atılım Hacettepe Kafkas ODTÜ Yeditepe	Ankara Giresun Hacettepe ODTÜ Çankaya Erzincan GYTE
Efficient in M2 and inefficient in M6	Amasya Boğaziçi Çağ Ege Hitit İstanbul Aydın İstanbul Bilim Namık Kemal Okan Uşak Yeditepe	Amasya Atılım İstanbul Aydın İstanbul Bilim Okan	Atatürk Boğaziçi Çankaya Düzce Erzincan Gazi GYTE Işık İstanbul Bilim Uludağ Yeditepe
Efficient in M3 and inefficient in M7	Aksaray	ODTÜ TOBB-ETÜ Yeditepe	TOBB-ETÜ
Efficient in M4 and inefficient in M8	Ege İstanbul Aydın Yeditepe	Amasya İstanbul Aydın Okan	Amasya Gazi İzmir Ekonomi

5.4.2.4. Analyses of Superefficiency Models

If the aim of the efficiency study is discriminating among the efficient universities, superefficiency models should be selected. These models help researchers to identify a couple of highly efficient universities. Since VRS superefficiency models have given infeasible results for some of the universities, we decide to run superefficiency models only with CRS assumption.

In this study, M9 and M10 are designed as the superefficiency models. M9 uses faculty members from different academic titles as separate input variables, whereas M10 combines them into a single variable.

The correlation coefficients between two superefficiency models have varied between 0.90 and 0.95 for the analysis period, which implies a strong correlation. In addition, correlation coefficients between the original CRS models (M1 and M3) and their superefficiency models (M9 and M10) have been higher than 0.99 for all years. This is an expected situation, since superefficiency models only change efficiency scores of the efficient universities, and do not change efficiency scores of inefficient universities in the CRS model.

In both of the models Bilkent University has attained the best (lowest) efficiency score. Moreover, TOBB-ETÜ, Sabancı, Koç, and Marmara have been placed among the top 10 universities in both models and for all years of analyses.

In both superefficiency models, 10 universities (Beykent, Cumhuriyet, ÇOMÜ, Haliç, İstanbul Aydın, İstanbul Kültür, İstanbul Ticaret, Maltepe, Ordu, and Ufuk) have received efficiency scores higher (worse) than the average for all years.

36 universities (AKÜ, Aksaray, Anadolu, Ankara, Atatürk, Başkent, Bilkent, Boğaziçi, Çankaya, Çukurova, Ege, Erciyes, Fırat, Gazi, Giresun, GYTE, Giresun, Hacettepe, Işık, İstanbul, İYTE, İzmir Ekonomi, Kadir Has, Kafkas, KTÜ, Koç, Marmara, MSGSÜ, Niğde, OMÜ, ODTÜ, Sabancı, Selçuk, SDÜ, TOBB-ETÜ, and Uludağ) have received better (lower) efficiency scores than the average for all years.

These results imply that more universities have consistently received efficiency scores better than the average compared to universities that have consistently received efficiency scores worse than the average. In addition, 48 universities (which consist of more than half of the universities) fluctuate in term of their ES relative to the average. In other words, 48 universities have received better ES than the average in some years and worse ES than the average in others.

It is also striking to see that majority of the top and bottom performers (in terms of research efficiency) in both models is private universities.

5.5. Concluding Remarks

This study aims to measure research performance of Turkish universities through 10 different Data Envelopment Analyses models using normalized output variables in terms of scientific fields. In this context, 94 public and private universities that are established in and before 2006 are included in the study. All models are output-oriented, since the aim is increasing the research outputs, while using the same amount of inputs.

This study provides the following insights for using and developing DEA models to measure research efficiency of universities:

We detect that not only citations, but also other research outputs, have significantly differed by scientific fields. Thus, we suggest making field based analyses or field-based normalizations.

To understand the similarities among models, we check rank correlations of efficiency scores obtained in every model. We observe moderate to high positive rank order correlations between the efficiency scores. It means that with similar input and output variables, different DEA models provide similar results.

When we compare correlation coefficients between models that have faculty members with different academic ranks as separate input variables, and models that combine them into a single variable, we detect that combining faculty members under a single variable do not significantly change the results for CRS models and/or for recent years, but there occur important differences in VRS models, especially in the early years of analyses. In addition, the standard deviation of efficiency scores is higher in models, in which faculty members are combined, compared to the models which have faculty members with different academic titles as separate inputs. Since cost of faculty members with different academic ranks are different and studies have been indicating that productivities of faculty members with different academic ranks differ (Dündar and Lewis, 1998, Tien and Blackburn, 1996, Wood, 1990), we suggest having them as separate input variables.

We capture that average efficiency scores are the lowest (best) in 2010, compared to the previous two years for all models. There might be two factors leading to this result. First, research performance of universities might be converging. Secondly, the citation gap between high quality and low-quality articles might be getting visible after a certain time of publication and two years' time period between the derivation of data and publication year is not enough for discriminating high impact articles from others. From these arguments, we suggest that if citations are to be included as output variables in efficiency studies, then publications should be at least 3 years-old to allow sufficient time to discriminate between high-impact and low-impact articles.

In 2008 and 2009, we detect that some of the CRS and VRS versions of the models that use the same input-output combinations are not highly correlated with each other. Avkıran (2001) suggests that if majority of units are assigned different scores under CRS and VRS assumptions, VRS model should be selected. Our results show that CRS and VRS versions of the models that use the same input-output combinations are not highly correlated in 2008 so that we suggest using variable returns to scale assumption for DEA models.

In both CRS models, almost two third of the universities are found to be operating at decreasing returns to scale (DRS) conditions. We identify that the majority of universities that operate at CRS and IRS conditions are mostly new public or private universities, whereas among universities that continuously operate at DRS conditions, established public universities are holding the majority. We comment that in Turkey, as a percentage private universities are more successful in terms of employment policies to perform research activities.

Analyses of slacks show that several universities have inefficiencies in terms of TÜBİTAK projects and citations. Moreover, almost half of the universities that have inefficiencies in terms of these two outputs have consistently repeated this situation during the analysis period. These outcomes point out two important issues: First, research efficiency most probably depends on the inherent abilities, culture and management practices of universities. Secondly, Turkish universities need to develop strategies and actions to enhance their performance in terms of TÜBİTAK Projects and citations. Based on these needs, we suggest Turkish universities to enhance their organizational capacities through establishing project coordination offices and/or research support offices that will be responsible for directing researchers to establish academic networks, finding higher impact journals, and providing editorial support. Additionally, we suggest universities to arrange events and support projects that aim to foster institutional research culture.

Analyses of slacks display that the least efficiently used inputs are the research assistants. This implies that there is a need for Turkish universities to develop strategies that target employing research assistants in research activities more effectively.

We identify that the majority of the universities that perform better than the average in terms of their research efficiency scores are highly overlapping in all DEA models and analyzing data regarding these universities might be very helpful for other universities to enhance their research activities. We identify that established public universities are better in terms of their research performance, while the majority of the new public universities are still struggling in this area. Namely for all three years of analyses, we see that 31 universities have received efficiency scores better than the annual in all of the DEA models. These are: AKÜ, Aksaray, Anadolu, Ankara, Atatürk, Başkent, Bilkent, Boğaziçi, Çankaya, Çukurova, Ege, Erciyes, Fırat, Gazi, GYTE, Giresun, Hacettepe, Işık, İstanbul, İzmir Ekonomi, Kafkas, KTÜ Teknik, Koç, Marmara, MSGSÜ, OMÜ, ODTÜ, Sabancı, Selçuk, SDÜ, and TOBB-ETÜ. 21 of them are established public universities, 2 of them are new public universities and 8 of them are private universities. In other words, 40 % of the established public universities, 13 % of the new public universities and 31 % of the private universities have received efficiency scores better than the average for all years and in every model.

For all years, seven universities (around 7 % of all universities under analyses) have consistently received efficiency scores worse (higher) than the average efficiency scores for all years and in all models. These are: Beykent, Cumhuriyet, Haliç, İstanbul Kültür, İstanbul Ticaret, Maltepe, and Ufuk. Six of these universities are private universities and one of them is established public university. These results imply that ratio of private universities that have consistently received worse (higher) efficiency scores than the average is higher than the public universities.

While putting constraints on input and output variables it is important to refrain from supporting or opposing certain group of universities. In this context, we investigate whether or not a certain group of universities has been affected from our constraints in Assurance Region models. We find no systematic relationship.

In light of these findings, Model 6 is identified as the most preferable DEA model to make further and detailed analyses in terms of measuring research performance of Turkish universities and identifying factors that have an impact on it.

We also apply Model 6 separately for three scientific fields which are (i) health sciences, (ii) social sciences and (iii) basic and applied sciences and calculate an overall efficiency score for each university using the weighted average of efficiency scores obtained for separate fields. The details of field-based DEAs and overall efficiency scores of each university are provided in Appendix B.

CHAPTER 6

DETERMINANTS OF RESEARCH PERFORMANCE OF UNIVERSITIES

6.1. Introduction

Research activity in universities is a process in which several inputs such as human capital, scientific infrastructure, financial resources and intangible resources such as knowledge and networks are used to produce both tangible and intangible outputs such as publications, patents, consulting activities, knowledge accumulation and human resources development (Abramo et al, 2011b).

This chapter aims to investigate internal and external factors that lead to higher research performance among Turkish universities. In this context, we use five different performance measures that are related with research performance of universities: (i) research efficiency (measured by efficiency scores obtained via Data Envelopment Analysis (DEA)), (ii) publications per faculty member (with field-based normalized values), (iii) citations productivity per faculty (with field-based normalized values), (iv) publications per faculty member (with absolute values), (v) citations per faculty member (with absolute values).

The terms productivity and efficiency have been frequently used interchangeably, but they are not the same things. Productivity is defined as the ratio of outputs that were produced to the inputs that were used. Increasing productivity means producing more from the same level of input (Marginson, 1991). On the other hand, efficiency is the comparison of what is actually produced with what can be achieved with the same amount of resources. Efficiency is an important factor in determining the productivity and generally associated with budget cuts and increased workloads.

Our study will contribute to the literature in two main aspects. First of all, we were not able to find any studies in the literature that had analyzed the impact of factors on different measures of research efficiency and productivity at the same time in universities. We suspect that factors that have significant impact on one measure might have insignificant or opposite-directional impact on another measure. Secondly, there were studies that aimed at calculating research efficiency and productivity of Turkish universities, but none of them had scrutinized the factors that would have an impact on research efficiency and productivity at the university level.

We include 94 public and private universities that were established in or before 2006. We use three-year panel data between 2008 and 2010 and investigate the underlying dynamics of research efficiency and research productivity via the use of pooled OLS, fixed effects, and random effects models which have same independent variables.

We use inverse transformation of efficiency scores obtained in DEA Model 6, which was run in Chapter 5. We decide to make inverse transformations of efficiency scores for the ease of interpretation. Since we used an output-oriented DEA model, universities that were found efficient had received a score equal to 1, and inefficient universities had received scores higher than 1. In other words, in output-oriented models, the more a university is efficient; the lower is its score. Getting inverse of the scores makes the relation between score and efficiency level same directional and ease interpretations. From now on the term “efficiency scores” is used for the inverse of the efficiency scores that are obtained in the Model 6 from Chapter 5.

We use both absolute amounts of publications and citations per faculty, and their field-based normalized values as the dependent variables of the productivity models. Consequently, we establish a total of fifteen statistical models where five of them are pooled OLS (POLS), five of them are fixed effects (FE) and five of them are random effects (RE) models. The details of the models are given in Table 45.

Before going further in the analyses, we should make clarifications on terminology used in this study. First of all, public universities that were established in 2006 are named as “new public universities” and other public universities are named as “established public universities”. Totally, there are 53 established public universities, 15 new public universities, and 26 private universities included in this study.

Secondly, academic staff” refers to all faculty members, instructors, and specialists in a university, whereas the term “faculty member” is used only for the professors, associate professors, and assistant professors. The term “teaching staff” denotes only to instructors and specialists, whose main task is teaching but not research.

This chapter is organized as follows. First, we provide summaries of the previous academic studies that had investigated the impact of several internal and external factors on the research performance of universities. In the second step, we explain the specifications of our models. In this respect, we analyze potential factors that can be selected as independent variables for our models, and determine which ones should be included. Finally, we discuss the outputs of the models and attempt to come up with the relevant policy proposals.

Table 45: Descriptions of the models used

Model	Dependent Variable	Abbreviation of Dependent Variable	Model
1	Efficiency scores	ES	Pooled OLS
2	Normalized publications per faculty	NPF	Pooled OLS
3	Publications per faculty	PF	Pooled OLS
4	Normalized citations per faculty	NCF	Pooled OLS
5	Citations per faculty	CF	Pooled OLS
6	Efficiency scores	ES	Fixed Effects
7	Normalized publications per faculty	NPF	Fixed Effects
8	Publications per faculty	PF	Fixed Effects
9	Normalized citations per faculty	NCF	Fixed Effects
10	Citations per faculty	CF	Fixed Effects
11	Efficiency scores	ES	Random Effects
12	Normalized publications per faculty	NPF	Random Effects
13	Publications per faculty	PF	Random Effects
14	Normalized citations per faculty	NCF	Random Effects
15	Citations per faculty	CF	Random Effects

6.2. Review of Literature

Performance studies that targeted at universities have been performed since the early 1970s. Numerous studies have examined factors affecting the productivity of universities, individual academic programs, or faculty members. Summaries of selected studies are given in Table 46.

Table 46: Summary of the selected studies

Author	**Summary of the study**
Abramo et al, 2012a	They analyzed the impact of the size of a department on its research productivity. The analysis was conducted for 183 hard science fields in all 77 Italian universities over the time period between 2004 and 2008. They used field based normalized citations as the productivity measure. The results demonstrated that 106 fields of research were largely characterized by constant returns to size, whereas in 18 fields, there has occurred increasing returns to size.
Abramo et al, 2012b	They investigated whether, and to what extent, scientific performance by academic entrepreneurs was different than that of their colleagues. They included all spin-offs (284 spin-offs from 47 universities) generated by Italian universities over the period 2001–2008. They utilized the total number of publications, normalized citations and article quality index as research performance measure. They found that researcher entrepreneurs reached to better scientific performance than that of their colleagues. In addition, the creation of a spin-off did not seem to have negative effects on the scientific performance of the founders.
Auranen and Nieminen, 2010	They analyzed the impact of funding schemes on the research performance of 8 countries. They used funding per publication as a measure of research performance and found no significant impact of the funding schemes.
Dündar and Lewis, 1998	They measured the impact of size (in terms of faculty members), percentage of faculty who are full professors, ratio of graduate students to faculty, percentage of graduate students who hold research assistantships, institutional control (Public/Private), concentration and the percentage of faculty publishing, institutional library expenditures, the percentage of faculty with research support on departmental level research productivity. They included 1,834 departments in US and used average publications per department as a measure of research productivity. They found that all factors except the ratio of graduate students to faculty had a significant and positive impact on the research performance. Impact of ratio of graduate students to faculty was found to be positive for basic & applied sciences and negative for social sciences
Edgar and Geare, 2013	They analyzed the impact of several management practices and cultural factors on individual level research performance. They applied a survey which was filled by 114 academicians from 7 New Zealand Universities in 2010. They found that autonomy, egalitarianism, strong cultural ethos had a significant and positive impact on the research performance.

Table 46 (cont'd): Summary of the selected studies

Author	Summary of the study
Edgar and Geare, 2010	They analyzed the impact of different cultures and different management practices on the research performance of departments. They used the results of the Performance Based Research Funding exercise which was performed in 2006 for assessing research performance of New Zealand universities. They performed in-depth interviews with 7 academic departments and found that a strong culture comprising collegiality and a quality focus, along with an emphasis on recruiting for high performance and fit, as well as an enabling environment promoting autonomous work habits had a significant positive impact on the research performance.
Goodall, 2009	She investigated the relationship between the scholarly ability of a university president and the performance of that university. She used the outputs of UK research assessment exercise (RAE) and included 157 university presidents and 55 UK research universities. To identify a president's scholarly success, each individual's normalized lifetime citations had been counted. She found that universities, which are led by the more cited vice chancellors performed better in the RAE.
Johnes and Yu, 2008	They measured research efficiency of 109 Chinese regular universities in 2003 and 2004 via DEA. They found that mean research efficiency is higher in comprehensive universities compared to specialist universities, and in universities located in the coastal region compared to those in the western region of China.
Johnes, 1988	She measured the research output of economics departments in British universities. She developed 6 separate indicators based on number of publications in 20 major journals. She analyzed the impact of number of university staff aged over 55 years per thousand staff, student staff ratio, stock of library books, ratio of university staff with external research funding, ratio of full professors, and ratio of full time doctoral research students on research outputs. She found that stock of library books, ratio of university staff with external research funding, ratio of full professors, and ratio of full time doctoral research students had a positive impact on the research performance. Whereas, the ratio of university staff aged over 55 years and the student staff ratio had a negative impact on the research performance.
Jordan et al (1988, 1989)	In both of these studies, they measured the impact of size and ownership on the research performance of departments. They used publications per faculty as a measure of research productivity. They found that private universities performed better than public universities, and size had a positive (but at a diminishing rate) impact on the performance.
Kounetas et al. (2011)	They first assessed the research performance of 18 departments within a single Greek university via DEA and in the second stage of their study, they applied a Tobit model to examine the impact of several environmental factors on efficiency scores. They found that ownership of the buildings, the total amount of departmental facilities and age had a positive influence on research efficiency.
Kutlar and Kartal (2004)	They calculated annual efficiency scores for 8 different faculties of Cumhuriyet University between 2000 and 2004 via DEA. They found that the most efficient faculties were engineering, economic and administrative sciences, and education. The least efficient faculties were medicine, dentistry, theology and fine arts. Faculty of Science and Arts reached to an efficiency level in between.
Levin and Stephan, 1989	They measured the impact of the age on the research performance of individual scientists in 4 different scientific fields. They utilized the results of "Survey of Doctorate Recipients" which was performed in 1977 in US universities. They used publications per scientist as research productivity measure. They found that age had a significant impact on the research performance. In physics and earth sciences older scientists published less than the youngest scientists, and in physiology and biochemistry older scientists published less than the middle-aged scientists.

Table 46 (cont'd): Summary of the selected studies

Author	Summary of the study
Tien and Blackburn, 1996	They measured the impact of years from academic promotion and the rank of faculty members on individuals' research productivity. They used the results of the Carnegie survey performed on 2,586 faculty members in US universities. They used number of publications as a measure of research productivity. They found that full professors published more than assistant and associate professors, but associate professors didn't publish more than assistant professors. They also found that the fewer publications one produced, the longer he/she stayed in the same rank.
Wolszczak -Derlacz and Parteka, 2011	They measured teaching and research efficiency of 259 European public higher education institutions from 7 EU countries using two-stage DEA between 2000 and 2005. Results showed that universities with higher number of different faculties, medical school, and greater share of external source funds were more efficient. Additionally, age and higher share of women in the faculty were also found to be positively and significantly correlated with high efficiency scores.
Wood, 1990	They analyzed the impact of personal characteristics, area of research, availability of funds, equipment and support personnel, colleagues and work environment, availability of postgraduate training departments, the number of PhD students, teaching responsibilities, tenure, and promotion options on the research performance. They performed a survey in an Australian university. They found that the impact of colleagues and work environment and the number of PhD students did not have a significant impact. All factors, except teaching workload were found to have a positive impact on the research performance. Teaching workload had a significant negative impact.

We notice that individual-level productivity studies have mostly focused on personal characteristics of individual scientists (such as age, ability, creativity), and cultural and organizational dimensions. These factors are mostly determined by subjective opinions which are collected through surveys or interviews. On the other hand, studies that analyze departmental or organizational level productivity have investigated factors that are more objectively measurable such as:

- institutional or departmental size,
- institutional control (private versus public ownership),
- annual research spending,
- number of students or students-faculty ratios,
- percentage of faculty who are full professors,
- size of computing facilities and the library,
- availability of secretarial, administrative services, teaching assistance, ratio of research assistants to professors.

From these studies, we capture that personal characteristics such as ability, creativity, motivation, and entrepreneurship; managerial practices and organizational culture that foster autonomy, egalitarianism, strong cultural ethos, working environment promoting autonomous work habits; and institutional characteristics such as larger size, being a private university, having more resources for research activities, such as funds, infrastructure, support staff, research assistants, and lower students per faculty member ratios foster research performance of universities.

6.3. Construction of Models

In this section, we discuss potential factors that might have an impact on the research performance of universities, make preliminary analyses with them, and construct our pooled OLS, fixed effects and random effects models with the same selected variables.

6.3.1. Explanatory Variables

We collect data regarding several potential factors that might have an impact on the research performance of universities. Variables and their definitions are given in Table 47.

Institutional control (owner) is represented by a binary variable, whose value is 1 for public universities, and 0 for private universities. Some studies found that ownership had impact on the research performance and private universities were performing better than public universities (Adams and Griliches, 1998; Dündar and Lewis, 1998; Jordan et al., 1988; Jordan et al., 1989). Consequently, we expect a negative relationship between research performance of universities and institutional control dummy variable.

Having a medical school (medsc) is also characterized by a binary variable. Its value is 1 for universities with medical school, and 0 for others. The results in the literature are mixed in terms of the effect of medical schools on the performance of universities. Wolszczak-Derlacz and Parteka (2011) found that universities with medical schools were both more research and teaching efficient, whereas Thursby and Kemp (2002)'s study showed that universities with medical schools were less efficient in terms of intellectual property licensing. Furthermore, Kutlar and Kartal (2004) had investigated Cumhuriyet University in terms of its departments and found that the Department of

Medicine was among the least efficient ones. Our preliminary analyses in Chapter 4 showed that per faculty productivity terms of different research outputs in health sciences were close to basic and applied sciences, and social sciences. Thus, we do not have an initial expectation regarding the impact of having medical schools on the research performance.

Table 47: Definition of the variables

Factor	Variables used to Measure the Impact of Factor	Name	Expected Impact on Performance*
Ownership	A dummy variable which is 1 for public universities	owner	-
Having medical school	A dummy variable which is 1 for universities with medical school	medsc	?
Type	A categorical variable which is: -1 for established public universities -2 for new public universities -3 for private universities	type	 -/+ - +
Size	Total number of faculty members	size	+
Experience/Age of the university	Age	age	+
Orientation towards PhD programs	Ratio of PhD students per faculty member	rphd	?
Availability of academic support personnel	Total number of research assistants and teaching staff per faculty member	support	+
Students per faculty	Total number of students per faculty member	rstd	-
Average seniority level of faculty members	-Ratio of full professors -Ratio of associate professors -Ratio of assistant professors in total faculty members	rprf rasc rast	? ? ?
Socioeconomic development level	Socio-economic development index	sedi	+
Disciplinary concentration in different scientific disciplines	Ratio of faculty members working in -health sciences -social sciences -basic and applied sciences to all faculty members except the ones working in vocational schools	 phlt psoc psci	 ? ? ?
Concentration in vocational schools	Ratio of faculty members employed in vocational schools	pvoc	–
Scientific heterogeneity	Total number of departments	dept	?
External R&D funds	R&D funds received from TÜBİTAK in the previous year	extfund	+

*+: positive impact, -: negative impact, ?: no initial expectation

Type of universities is a categorical variable. Its value is 1 for established public universities, 2 for new public universities, and 3 for private universities. Studies in the literature had only compared universities in terms of ownership. On the other hand, we prefer to differentiate established public universities from new public universities, because we suspect that in addition to ownership, experience will also have an impact on the performance. Previous studies showed that private universities outperformed public universities (Adams and Griliches, 1998, Dündar and Lewis, 1998, Jordan et al., 1988; Jordan et al., 1989), and age had a significant and positive impact on the research performance (Kounetas et al. (2011); Wolszczak-Derlacz and Parteka (2011)). Consequently, we expect that established public universities perform better than new public universities, but worse than the private universities.

University size (*size*) is measured by the total number of faculty members (who are composed of professors, associate professors, and assistant professors). Previous studies showed that the larger was the size of the university, the higher was the research performance of universities or departments (Dündar and Lewis, 1998; Jordan et al., 1988; Jordan et al., 1999). They explained this phenomenon such that in larger academic units, there were more competition and collaboration opportunities. Thus, we expect a positive relation between the size and the research performance of universities.

Age is used as a proxy for the maturity and experience level of universities. Kounetas et al. (2011), and Wolszczak-Derlacz and Parteka (2011) found that age of departments and universities had a significant and positive impact on their research performance. We also anticipate that older universities are more experienced, establish wider research networks and accumulate more research infrastructure. Consequently, we expect a positive relation between the age of universities and their research performance.[29]

Ratio of PhD students per faculty member (rphd) shows the capacity of a university to open and conduct advanced–level graduate programs. We assume that universities

[29] Some of the universities included in this study were established during the Ottoman Empire. Their establishment year is taken as 1923.

that have enough human resources and research infrastructure capacity tend to open graduate programs. Moreover, more research activities are conducted in graduate programs when compared to undergraduate level programs. On the other hand, previous studies that investigated the impact of PhD students on the research performance had found that it had an insignificant impact on the research performance (Dündar and Lewis, 1998; Wood, 1990). Thus, we do not have an initial expectation regarding the impact of PhD students per faculty member on the research performance.

Availability of academic personnel (support) is approximated with the ratio of the total academic staff except faculty members (which is equal to the sum of teaching staff and research assistants) to the total faculty members. Previous studies showed that availability of academic support personnel and research assistants had a positive and significant impact on the research performance (Dündar and Lewis, 1998; Wood, 1990). We also consider that availability of teaching staff will decrease teaching workload of the faculty members, and consequently, they can devote more time on research activities. Furthermore, we assume that research assistants will provide external support for the research activities of the faculty members and enhance their performance. Based on these arguments, we expect that the ratio of academic support personnel per faculty member will have a positive impact on the research performance.

Students per faculty (rstd) is used as a proxy for the teaching workload of the academic staff, but there are few studies that investigated the impact of this variable on the research performance, and they provide different results. In her study, Wood (1990) found that student to academic staff ratio had no significant impact on the research performance. On the other hand, Johnes's (1998) study showed that student-staff ratio had a negative impact on the research performance. We anticipate that students per faculty member will have a negative impact on the research performance, since faculty members with high student ratios might have higher teaching workloads and can spare less time on their research activities.

Rank of faculty is an indicator that shows the composition of the whole faculty in terms of academic titles. We calculate three separate ratios in this context: Ratio of full professors (rprf), ratio of associate professors (rasc), and the ratio of assistant professors (rast) to all faculty members. Several studies discovered that either the total number or ratio of full professors to other academic staff had a positive and significant impact on the research performance (Dündar and Lewis, 1998; Tien and Blackburn, 1996; Wood, 1990). This might occur due to the possibility that full professors are more experienced and autonomous in research activities and this makes them both more productive and efficient. On the other hand, Johnes (1998) found that the ratio of university staff aged over 55 years had a negative impact on the research performance, and Levin and Stephan (1989) found that in physics and earth sciences older scientists published less than the youngest scientists, and in physiology and biochemistry older scientists published less than the middle-aged scientists. From these arguments, we do not have an initial expectation on the impact of ratio of full professors, associate professors or assistant professors on the research performance.

Socioeconomic development index of the provinces (sedi) is derived from a study performed by the Ministry of Development[30]. This study has developed an index for provinces and regions, using 61 indicators from 8 fields (demographic, employment, education, health, competitiveness and innovation capacity, financial, accessibility, and quality of life) via principal component analyses. Johnes and Yu (2008) found that mean research efficiency scores were higher in universities located in the rich coastal region compared to those located in the poorer western regions of China. We also assume that provinces with better economic, social or employment development will have better research infrastructures, attract more researchers, and attain better industry-academia relations. Thus, we expect a positive relationship between the development index and research performance measures.

Disciplinary concentration is calculated for 3 disciplinary groups which are (i) social sciences, (ii) natural and applied sciences, and (iii) health science. To calculate disciplinary concentration of a university in a specific field, first each faculty member (except the ones working in vocational schools) is assigned to one of the three disciplinary groups according to the department in which she/he is permanently employed for each year. The ratio of faculty members in a specific scientific field is calculated by dividing the total number of faculty members in that field with the total

[30] İllerin ve Bölgelerin Sosyo-Ekonomik Gelişmişlik Sıralaması Araştırması (2011)

number of faculty members of that university, except the ones working in vocational schools (Equation 6.1). The three indicators are: p_{soc}, p_{sci}, and p_{hlt}.

$$p_{ijt} = \frac{\Sigma \text{ Faculty members working in } i^{th} \text{ field in university j, in year t}}{\Sigma \text{ Faculty members} - \sum \text{Faculty members in vocational schools}} \qquad (6.1)$$

where i denotes health sciences, natural applied sciences or social sciences; j denotes universities, and t denotes year.

Adams and Griliches (1998) had discovered differences in terms of the growth pattern of publication and citation productivity across different scientific fields. There are also studies that indicate performance differences in different scientific fields. For example, Abramo et al (2012a) showed that returns to scale (in terms of size) had differed by scientific fields, Levin and Stephan (1989) found that age had different impact on the research performance for different scientific fields. We are interested in whether the concentration of universities in specific disciplines contributes to their research performance because preliminary analyses that were performed in Chapter 4 showed that some disciplines are more productive in terms of different research outputs. Based on these arguments, we do not have an initial assumption regarding the impact of concentration in different scientific disciplines, but we suspect that there will be performance differences across universities that have different concentrations in terms of scientific disciplines.

Concentration in vocational schools (pvoc) is calculated by the ratio of faculty members in vocational schools to all faculty members in a university. Although none of the previous studies that we were able to reach had analyzed the impact of employing faculty members in vocational schools on the research performance, we decide to investigate it since it might provide useful policy insights for the Turkish higher education and R&D systems. As vocational schools concentrate on vocational training, but not research, we anticipate that universities having larger shares of faculty members in these schools will have lower research performance.

Heterogeneity in terms of scientific disciplines (dept) is approximated by the total number of departments in a university. Wolszczak-Derlacz and Parteka (2011) found that universities with higher number of departments had reached to better efficiency scores. Since R&D studies are becoming more interdisciplinary, we also anticipate a positive relationship between number of departments and research performance.

In order to capture the scientific heterogeneity of universities, we also calculated two different indices using the Herfindahl-Hirschman index. Both of these indices were found to have insignificant impact on the research performance measures. Meanwhile, we thought that it would be interesting to see the disciplinary heterogeneity of universities. The details regarding the calculation of the diversity indices and their results are given in Appendix C.

External R&D fund per faculty (extfund) is approximated amount of TÜBİTAK funds received in the previous year per faculty member. The funds were calculated by 2010 prices. Wolszczak-Derlacz and Parteka (2011)'s results showed that universities with a greater share of external research funds were more efficient. Dündar and Lewis (1998) and Johnes (1998) found that percentage of faculty with external research support had a significant positive impact on departmental level research productivity. On the other hand, Auranen and Nieminen (2010) found no significant impact of the funding per publications on the research performance. We assume that external research funds facilitate research activities such that they provide financial and human resources support for the project owners. Thus, we expect a positive relation between external source of research funds and research performance. We decide to take previous years' TÜBİTAK funds per faculty ratios, since academic R&D projects will take at least one year to be completed and outputs will not be available in the year of funding.

6.3.2. Analyses with the Variables

We decide to perform preliminary analyses with both our dependent and independent variables prior to establishing our models. Our analyses regarding dependent variables aim to demonstrate whether there is a productivity shift between 2008 and 2010 period in terms of research outputs. Moreover, we want to understand whether research performance differs by type of universities.

Our analyses regarding independent variables, on the other hand mainly aim to identify which independent variables should be included in the models. We suspect there will be significant correlation between some of the potential independent variables. To avoid multicolinearity, we will exclude the ones that have high correlation with other factors from the model. Meanwhile, we think that analyses of all factors will provide a detailed picture of universities in terms of different organizational and environmental characteristics.

6.3.2.1. Analyses of Dependent Variables

Table 48 provides summary statistics regarding annual research performance of different types of universities.

We first check whether the mean values of the research performance measures change by time. Increasing mean values point out a productivity growth, whereas decreases in the mean values indicate productivity declines.

Mean values for efficiency scores (ES) are very close for 2008 and 2009, whereas we observe a slight increase in 2010. We compare mean values of annual ES via One-way Analysis of Variance (Anova) test and find that they are not statistically different from each other at 5% significance level ($p=0.1085$). As a result, we can say that there is not a statistically significant enhancement in terms of efficiency scores during the analysis period .

Table 48: Summary statistics of the dependent variables

Type of University	Statistics	2008					2009					2010				
		IES	**NPF**	**NCF**	**PF**	**CF**	**IES**	**NPF**	**NCF**	**PF**	**CF**	**IES**	**NPF**	**NCF**	**PF**	**CF**
Established Public Universities	**# of Obs.**	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
	Mean	0.74	0.63	3.54	0.71	3.94	0.76	0.73	3.14	0.77	3.19	0.79	0.74	1.99	0.75	2.24
	Std.Dev	0.19	0.26	1.60	0.25	1.90	0.19	0.27	1.43	0.27	1.64	0.18	0.28	1.08	0.27	1.48
	Min	0.40	0.03	0.23	0.02	0.05	0.38	0.07	0.20	0.04	0.06	0.41	0.07	0.05	0.04	0.04
	Max	1.00	1.68	8.54	1.47	9.81	1.00	1.75	8.05	1.56	9.13	1.00	1.86	5.59	1.51	7.62
New Public Universities	**# of Obs.**	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	Mean	0.64	0.45	2.29	0.56	2.84	0.58	0.79	3.81	0.89	3.47	0.74	0.79	2.12	0.84	1.96
	Std.Dev	0.31	0.27	1.92	0.36	2.43	0.27	0.50	3.50	0.59	2.28	0.23	0.57	2.10	0.63	1.59
	Min	0.11	0.08	0.19	0.11	0.34	0.20	0.18	0.69	0.25	1.01	0.20	0.26	0.48	0.31	0.53
	Max	1.00	1.01	6.89	1.37	8.10	1.00	2.02	13.84	2.27	8.23	1.00	2.52	8.63	2.65	6.63
Private Universities	**# of Obs.**	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
	Mean	0.52	0.78	4.11	0.66	3.60	0.53	0.86	3.67	0.71	3.12	0.62	0.94	2.76	0.67	2.49
	Std.Dev	0.33	0.59	4.38	0.47	3.61	0.37	0.66	3.57	0.47	2.92	0.35	0.62	2.59	0.44	2.48
	Min	0.11	0.04	0.33	0.05	0.05	0.06	0.09	0.12	0.14	0.14	0.05	0.08	0.16	0.04	0.11
	Max	1.00	2.28	16.35	1.71	11.76	1.00	2.25	12.35	1.58	10.13	1.00	2.64	8.84	1.58	7.80
Overall	**# of Obs.**	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
	Mean	0.66	0.64	3.50	0.67	3.67	0.67	0.77	3.40	0.77	3.22	0.73	0.80	2.22	0.75	2.27
	Std.Dev	0.27	0.39	2.73	0.34	2.56	0.28	0.45	2.55	0.40	2.14	0.25	0.45	1.80	0.39	1.81
	Min	0.11	0.03	0.19	0.02	0.05	0.06	0.07	0.12	0.04	0.06	0.05	0.07	0.05	0.04	0.04
	Max	1.00	2.28	16.35	1.71	11.76	1.00	2.25	13.84	2.27	10.13	1.00	2.64	8.84	2.65	7.80

ES: Efficiency scores, NPF: Normalized publications per faculty, NCF: Normalized citations per faculty, PF: Publications per faculty, CF: Citations per faculty

The mean values of the normalized publications per faculty (NPF) are 0.64 in 2008, 0.77 in 2009, and 0.80 in 2010. One-way Anova test results show that the mean values of NPF significantly differ by time at the 5 % significance level (p=0.0306). The Scheffe multiple comparison test indicates that the mean value in 2010 is higher than the mean value in 2008 at the 5% significance level. Meanwhile, no significant difference is detected between the mean values in 2008 and 2009, and between 2009 and 2010. It means that the productivity growth has occurred in terms of NPF between 2008 and 2010.

Mean values for the normalized citations per faculty (NCF) are 3.50 in 2008, 3.40 in 2009, and 2.22 in 2010. One-way Anova test results show that the mean values of NCF differ by time at the 5 % significance level (p=0.0003). The Scheffe multiple comparison test indicates that the mean value in 2010 is significantly less than it isi in 2008 and 2009 at the 5% significance level. Meanwhile, no significant difference is identified between the means of 2008 and 2009. The decrease in the NCF is expected since we made normalizations only by fields and not by time, and it takes time for publications to be cited by other studies.

The mean values for publications per faculty (PF) are 0.67 in 2008, 0.77 in 2009, and 0.75 in 2010. One-Way Anova test results show that the mean values of PF do not significantly differ by year at the 5 % significance level (p=0.1636). Contrary to this situation, we identified a productivity growth in terms of NPF. It means that productivity growth is especially higher in scientific fields in which publications per faculty ratios are lower than the overall publications per faculty ratios[31].

The mean values for citations per faculty (CF) are 3.67 in 2008, 3.22 in 2009, and 2.27 in 2010. One-Way Anova test results show that the mean values of CF differ by time at the 5 % significance level (p=0.0001). The Scheffe multiple comparison test indicates that the mean value of CF is significantly less in 2010 than it is in 2008 and 2009 at the 5% significance level. Meanwhile, no significant difference is detected

[31] As we have explained in Chapter 5, overall publications per faculty ratio is calculated for three years period. It is obtained via dividing three- year- total of number of publications by three- year- total number of faculty members.

between the means of 2008 and 2009. It is meaningful to observe a declining trend in the citations, since it takes time for publications to be cited by other studies.

6.3.2.2. Analyses of Potential Independent Variables

Table 49 provides summary statistics regarding some potential independent variables. Since we have not encountered these figures together in any other study that we were able to reach, we decide to present and discuss them in this chapter.

The average size, which is measured in terms of faculty members is found as 432 for the analysis period . It is 663 for the established public universities, 92 for the new public universities, and 158 for the private universities. Anova test results show that there is significant difference between the mean size of the established public and new public universities, and between the established public and private universities at 5% significance level.

Among all universities, 51 % have medical schools (medsc). One-way Anova test results show that the ratio of universities that have a medical school differs significantly across university types for all pairwise comparisons at the 5 % significance level. Specifically, 74 % of the established public universities, 18 % of the new public universities, and 24 % of the private universities have medical schools.

The average age of universities under analyses is found as 23 years for the analysis period One-way Anova test results show that the mean age of universities significantly differs across university types for all pairwise comparisons at the 5 % significance level. As expected, established public universities have the highest average age with 34 years. Meanwhile, the average age is 3 for the new public universities, and 11 for the private universities.

Table 49: Summary statistics of the independent variables

	Established Public Universities (for 3-year period)			New Public Universities (for 3-year period)			Private Universities (for 3-year period)			Overall (for 3-year period)		
Variable	**NoO***	**Mean**	**Std.Dev**	**NoO***	**Mean**	**Std.Dev**	**NoO***	**Mean**	**Std.Dev**	**NoO***	**Mean**	**Std.Dev**
size	159	663.19	480.72	45	91.73	48.30	78	158.19	128.11	282	432.32	452.10
medsc	159	0.70	0.46	45	0.49	0.51	78	0.23	0.42	282	0.54	0.50
age	159	34.45	22.09	45	3.00	0.83	78	11.46	4.16	282	23.07	21.32
rphd	159	0.91	0.76	45	0.09	0.24	78	0.35	0.47	282	0.62	0.71
support	159	1.48	0.34	45	2.05	0.67	78	1.65	0.69	282	1.62	0.55
rstd	159	47.36	20.66	45	125.99	74.54	78	50.95	40.33	282	60.90	48.64
rprf	159	0.29	0.13	45	0.12	0.06	78	0.37	0.12	282	0.28	0.14
rasc	159	0.20	0.04	45	0.09	0.04	78	0.13	0.06	282	0.16	0.06
rast	159	0.52	0.14	45	0.78	0.07	78	0.50	0.11	282	0.55	0.16
sedi	159	1.13	1.65	45	-0.08	0.44	78	3.78	1.12	282	1.67	1.95
phlt	159	0.29	0.19	45	0.11	0.20	78	0.13	0.27	282	0.22	0.23
psci	159	0.39	0.19	45	0.37	0.25	78	0.36	0.17	282	0.38	0.19
psoc	159	0.32	0.15	45	0.52	0.28	78	0.50	0.19	282	0.40	0.21
pvoc	159	0.06	0.06	45	0.12	0.08	78	0.05	0.08	282	0.07	0.07
dept	159	9.25	3.64	45	3.93	1.03	78	5.54	2.39	282	7.37	3.74
extfund	159	0.00	0.01	45	0.00	0.00	78	0.01	0.01	282	0.00	0.01

*NoO: Number of observations

The average ratio of PhD students per faculty member (rphd) is 0.62 for the whole set of universities. It is 0.91 in the established public universities, 0.09 in the new public universities, and 0.35 in the private universities. One-way Anova test results show that the mean ratio of PhD students per faculty member significantly differs across university types for all pairwise comparisons at the 5 % significance level. These figures show that the most prolific group of universities in terms of PhD-level education is the established public universities, whereas new public universities, on average can reach to only one tenth of the output of established public universities.

The average number of academic support personnel per faculty member (support) is 1.62 for the whole period. It is 1.48 for the established public universities, 2.05 for the new public universities, and 1.65 for the private universities. One-way Anova test results show that the mean ratio of academic support personnel per faculty member significantly differs across university types for all pairwise comparisons at the 5 % significance level.

The average number of students per faculty member (rstd) is 60.90 for the entire set of universities, whereas it is 47.36 for the established public universities, 125.99 for the new public universities and 50.95 for the private universities. One-way Anova test results indicate that it differs significantly between the new public universities and the established public universities and between the new public universities and private universities. The difference between established public and private universities is not significant. Since new public universities are still in the process of employing more faculty members, it might not be proper to draw straightforward conclusions for them at this stage.

We identify that the composition of faculty members in terms of academic titles (rprf, rasc, rast) varies considerably across university types. In the entire set of universities, 28 % of faculty members are full professors, 16 % are associate professors, and 55 % are assistant professors. The ratio of professors is 29 % in established public universities, 12 % in the new public universities and 37 % in the private universities. The ratio of associate professors is 20 % in the established public universities, 9 % in the new public universities and 13 % in the private universities. The ratio of assistant professors is 52 % in the established public universities, 78 % in the new public universities and 50 % in the private universities. These figures lead us to three major conclusions: First of all, assistant professors are holding the majority of faculty members in all types of universities. Secondly, private universities employ more full professors (in percentage) than public universities. Thirdly, new public universities mostly employ assistant professors and percentages of associate and full professors working in these universities are less than the established public and private universities.

The average socioeconomic development index (sedi) score is 1.67 for the entire set of universities, whereas it is 1.13 for the established public universities, -0.08 for the new public universities, and 3.78 for the private universities. One-way Anova test results show that average sedi significantly differs across university types for all pairwise comparisons at the 5 % significance level. We observe that the average sedi is positive for the established public and private universities, and negative for the new public universities. Additionally, it is significantly higher for the private universities, when compared with the public universities. These results altogether show that established public universities and private universities are located in relatively more developed regions compared to the new public universities. Moreover, it is obvious that the private universities are mostly established in the highly developed regions in Turkey and they are not as widespread as the public universities.

Analyses of the disciplinary concentration of universities reveal that, for the entire set of universities, 38 % faculty members are working in the basic and applied sciences, 40 % are working in the social sciences and 22 % are working in the health sciences. In all three types of universities, the ratio of faculty members who are working in the basic and applied sciences is close to each other and varies between 36 % and 39 %. On the other hand, we observe significant differences across different university types in terms of the ratio of faculty members working in the health and social sciences. Namely, in established public universities 32% of the faculty members are working in the social sciences, and 29 % in the health sciences; in new public universities 52% of the faculty members are working in the social sciences, and 11 % in the health sciences; and in private universities 50 % of the faculty members are working in the social sciences and 13 % in the health sciences. These figures show that in the established public universities, faculty members are more homogeneously distributed across three scientific fields, whereas in the private and new public universities, majority of the faculty members are working in social sciences and only 10 to 13 % of the faculty members are working the health sciences.

When we look at the concentration of the faculty members in the vocational schools (pvoc), we observe that for all universities, 7 % of the faculty members are employed in the vocational schools. This ratio is similar in the established public and private universities, and equal to 6.3 % and 5.2 %, respectively. On the other hand, we find that in the new public universities, 12 % of the faculty members are employed in the vocational schools.

The mean value of the total number of departments (dept) is 7.37 for the entire set of universities and Anova test results show that it differs considerably across all university types at the 5 % of significance level. The highest mean is observed in the established public universities (9.25) and it is followed by the private universities (5.54), and new public universities (3.93).

The mean value of the previous year's TÜBİTAK funds per faculty member[32] (extfund) is 4,773 TL for the whole panel data and Anova test results show that at 5 % significance level, the mean values of extfund for new public universities (1,503 TL) is significantly less than the established public universities' (5,205 TL) and private universities' (5,778 TL) mean values. These results show that the mean value of project funds per faculty member is the highest for private universities, whereas one-way Anova test show that the difference between the established public universities and private universities is not statistically significant.

6.3.2.3. Correlation between Potential Independent Variables

In this section, we calculate the correlations between the potential independent variables. The complete correlation matrix is given in Table 50 and correlation coefficients that are insignificant at the 5 % significance level are written in italic characters.

[32] All values are calculated in 2010 prices.

Table 50: Correlation matrix of the potential independent variables

	owner	**size**	**medsc**	**type**	**age**	**rphd**	**support**	**rstd**	**rprf**	**rasc**	**rast**	**sedi**	**phlt**	**psci**	**psoc**	**pvoc**	**dept**	**extfund**
owner	1.00																	
size	0.38	1.00																
medsc	0.38	0.45	1.00															
type	-0.91	-0.52	-0.41	1.00														
age	0.34	0.78	0.17	-0.52	1.00													
rphd	0.24	0.52	*0.00*	-0.38	0.63	1.00												
support	*-0.04*	-0.31	-0.18	0.18	-0.31	-0.16	1.00											
rstd	0.13	-0.33	-0.14	*0.12*	-0.38	-0.34	0.54	1.00										
rprf	-0.36	0.44	*0.05*	0.17	0.41	0.38	-0.16	-0.35	1.00									
rasc	0.29	0.37	0.31	-0.49	0.34	0.39	-0.20	-0.43	*0.09*	1.00								
rast	0.21	-0.53	-0.17	*0.05*	-0.50	-0.49	0.22	0.48	-0.92	-0.47	1.00							
sedi	-0.67	*0.06*	-0.35	0.52	0.22	0.25	-0.15	-0.30	0.63	*-0.08*	-0.52	1.00						
phlt	0.23	0.39	0.73	-0.33	0.15	*-0.04*	-0.22	-0.28	0.22	0.36	-0.34	-0.24	1.00					
psci	*0.06*	-0.15	-0.40	*-0.06*	*0.08*	0.29	*0.01*	*-0.07*	*-0.09*	*0.01*	*0.07*	*0.10*	-0.54	1.00				
psoc	-0.31	-0.29	-0.45	0.42	-0.25	-0.23	0.23	0.38	-0.16	-0.42	0.31	0.17	-0.61	-0.34	1.00			
pvoc	0.15	-0.16	*-0.11*	*-0.02*	-0.25	-0.25	0.13	0.41	-0.29	-0.27	0.36	-0.21	-0.17	*-0.05*	0.24	1.00		
dept	0.30	0.83	0.51	-0.48	0.64	0.37	-0.29	-0.32	0.30	0.43	-0.43	*-0.05*	0.42	-0.18	-0.29	-0.18	1.00	
extfund	*-0.07*	*0.07*	-0.20	*0.00*	*0.12*	0.48	*-0.03*	-0.21	*0.11*	0.24	-0.19	0.17	-0.20	0.35	*-0.10*	-0.20	0.00	1.00

These figures display several important facts. First, correlation between age, size and number of departments (dept) are high indicating that they increase or decrease in parallel.

Secondly, the ratio of PhD students per faculty member (rphd) is highly and positively correlated with the age of the university with a correlation coefficient of 0.63. On the other hand, correlation between rphd and the size is lower with a value of 0.52.

Third, the correlation between the ownership and socioeconomic development index (which equals to -0.67) points out that private universities are mostly concentrated in socioeconomically developed provinces. In addition, the correlation between the ratio of full professors and socioeconomic development index is found to be negatively and significantly associated with each other, with a coefficient of -0.63.

Fourth, the ratio of full professors (rprf) and the ratio of assistant professors (rast) have very high but negative correlation with a value of -0.92. It means that when the ratio of professors increases in a university then the ratio of assistant professors decreases.

Fifth, the ratio of faculty members working in the health sciences is positively correlated with having a medical school, which is an expected situation.

These analyses show that it may not be statistically correct to include all potential independent variables that have high correlation with each other in our models. In the next section, we will select among these variables to prevent any multicorrelation problems.

6.3.3. Model Specifications

To select among the variables, we performed preliminary analyses with them. We decide to use:

- *size* instead of *age* and *total number of departments*,
- *type* instead of *ownership*,
- *phlt* instead of *having a medical school*.

We decide to select the same independent variables for all models to be able to assess the impact of factors on the research outputs within the same model settings. This way we can determine whether a factor that has a significant impact on one measure has also significant and same-directional impact on another measure. The independent variables selected for all models are selected as follows:

- Type (type),
- Size (size),
- PhD students per faculty (rphd),
- Academic support personnel per faculty (support),
- Total students per faculty (rstd),
- Ratio of associate professors (rasc),
- Ratio of assistant professors (rast),
- Socio-economic development index (sedi),
- Faculty concentration in basic and applied sciences (psci),
- Faculty concentration in health sciences (phlt),
- Ratio of faculty members in vocational schools (pvoc),
- Previous year's TÜBİTAK fund per faculty (extfund),
- 2 year dummies for 2009 and 2010 (y09, y10).

The purpose of the year dummies is to take into account the effects that may influence all cases in a given year to the same amount. This can help to eliminate a possible source of spuriousness due to common trends in the observed variables.

The final specification of the pooled OLS model is given in Equation 6.2. "y_i" in the equation represents one of the following performance measures: (i) efficiency scores, (ii) normalized publications per faculty (NPF), (iii) normalized citations per faculty (NCF), (iv) publications per faculty (PF), or (v) citations per faculty (CF).

$$y_{it} = \beta_0 + \beta_1 newpub_{it} + \beta_2 priv_{it} + \beta_3 size_{it} + \beta_4 rphd_{it} + \beta_5 support_{it} + \beta_6 rstd_{it} + \beta_7 sedi_{it} + \beta_8 rasc_{it} + \beta_9 rast_{it} + \beta_{10} phlt_{it} + \beta_{11} psci_{it} + \beta_{12} pvoc_{it} + \beta_{13} extfund_{it} + \beta_{14} y09 + \beta_{15} y10 + e_i \quad (6.2)$$

In Equation 6.2, i denotes the cross-sectional unit, t denotes the time period, β_is denote coefficients of constant and factors, an e_i denotes the error term.

The final specification of the fixed effects model is given in Equation 6.3. Again "y_i" represents the performance measures, i denotes the cross-sectional unit, and t denotes the time period.

$$y_{it} = \beta_0 + \beta_1 size_{it} + \beta_2 rphd_{it} + \beta_3 support_{it} + \beta_{4r} rstd_{it} + \beta_5 rasc_{it} + \beta_6 rast_{it} + \beta_7 phlt_{it} + \beta_8 psci_{it} + \beta_9 pvoc_{it} + \beta_{10} extfund_{it} + \beta_{11} y09 + \beta_{12} y10 + a_i + u_i \quad (6.3)$$

Different than Equation 6.2, we have two error terms in the fixed effects model: a_i and u_i. The a_i term is the unobserved effect which is assumed to be fixed over time, and u_i is the idiosyncratic error which varies with time. In other words, u_i represents the unobserved factors that change with time and affect the dependent variable. We do not include dummy variables regarding type of universities in Equation 6.3, since fixed effects models control for all time-invariant differences between entities. As a result, estimated coefficients of the fixed effects models are not biased due to omitted time-variant characteristics.

The final specification of the random effects model is given in Equation 6.4. "y_i" represents the performance measures, i denotes the cross-sectional unit, and t denotes the time period. a_i represents the unobserved effect, which is assumed to be fixed over time, and u_i is the idiosyncratic error which varies with time.

$$y_{it} = \beta_0 + \beta_1 newpub_{it} + \beta_2 priv_{it} + \beta_3 size_{it} + \beta_4 rphd_{it} + \beta_5 support_{it} + \beta_6 rstd_{it} + \beta_7 sedi_{it} + \beta_8 rasc_{it} + \beta_9 rast_{it} + \beta_{10} phlt_{it} + \beta_{11} psci_{it} + \beta_{12} pvoc_{it} + \beta_{13} extfund_{it} + \beta_{14} y09 + \beta_{15} y10 + a_i + u_i \quad (6.4)$$

Apart from the fixed effects model, the random effects model assumes that the unobserved effect "a_i" is uncorrelated with the explanatory variables and allows using time-invariant characteristics.

For the POLS and the fixed effects models we check for the heteroscedasticity and find that each of them suffers from the heteroscedasticity. In the POLS model chi2 values of Breusch-Pagan/Cook-Weisberg test, and in the fixed effects models, chi2 values of Modified Wald test indicate that all fixed effects models are affected from the heteroscedasticity. Thus, we give robust command, while making regressions.

6.4. Results and Discussions

The outputs of the POLS models are presented in Table 51, the fixed effects models are presented in Table 52, and the random effects models are presented in Table 53.

When we investigate R-squared values of the pooled OLS models, we see that almost half of the variations among units are explained by the selected independent variables. R-squared value is 0.44 for the efficiency model, 0.50 for the normalized publications model, 0.46 for the normalized citations model, 0.49 for the publications model, and 0.51 for the citations model (Table 51).

Table 51: Results of the Pooled OLS Models

	MODEL 1 (Efficiency)	MODEL 2 (Normalized Publications Per Fclt.)	MODEL 3 (Normalized Citations Per Fclt.)	MODEL 4 (Publications Per Fclt.)	MODEL 5 (Citations Per Fclt.)
Number of obs.	282	282	282	282	282
Number of grp.	94	94	94	94	94
F(15, 266)	21.47	18.95	12.45	27.5	22.95
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.439	0.5016	0.4637	0.4855	0.5138
Root MSE	0.20713	0.31531	1.8492	0.27944	1.6225
Factors					
new public	-0.0952*	0.214***	1.012**	0.2255***	0.8827**
	(0.0530)	(0.0767)	(0.4632)	(0.0791)	(0.4104)
Private	-0.0796	0.4245***	1.7779***	0.2175***	1.2869***
	(0.0639)	(0.1012)	(0.5788)	(0.0822)	(0.4903)
size	0.0002***	0	0.0003	0	0.0001
	(0.0000)	(0.0001)	(0.0003)	(0.0000)	(0.0003)
rphd	0.1057***	0.1069**	0.2753	0.0646**	0.3193
	(0.0358)	(0.0443)	(0.2673)	(0.0332)	(0.2082)
support	0.1444***	0.2672***	1.2244***	0.1364*	0.6884*
	(0.0543)	(0.0932)	(0.4201)	(0.0797)	(0.4150)
rstd	0.001***	0.0011	0.0072	0.0022**	0.0071**
	(0.0003)	(0.0009)	(0.0063)	(0.0009)	(0.0039)
sedi	-0.014	-0.0262	-0.0952	-0.0242	-0.1584
	(0.0130)	(0.0167)	(0.1189)	(0.0143)	(0.0948)
rasc	2.8856***	5.2567***	34.1053***	3.3359***	22.3425***
	(0.7254)	(1.3153)	(8.8089)	(1.0051)	(5.6428)
rast	1.2917***	0.7707	5.3627*	0.1177	1.0043
	(0.3558)	(0.5321)	(2.8106)	(0.4634)	(2.7413)
phlt	0.1104	0.2325*	0.089	0.7412***	1.5462**
	(0.0860)	(0.1227)	(0.8585)	(0.1124)	(0.6538)
psci	-0.0124	0.1049	0.203	0.6212***	2.9738***
	(0.0971)	(0.1531)	(0.9280)	(0.1627)	(0.8527)
pvoc	-0.8723***	-0.91**	-5.8014***	-1.0107***	-4.729***
	(0.1868)	(0.3607)	(2.0544)	(0.3595)	(1.6536)
extfund	0.0044***	0.0226***	0.1223***	0.0172***	0.1151***
	(0.0014)	(0.0048)	(0.0319)	(0.0036)	(0.0251)
y09	-0.0187	0.1082**	-0.2124	0.0846**	-0.5507**
	(0.0296)	(0.0463)	(0.2904)	(0.0409)	(0.2598)
y10	0.0574*	0.1754***	-1.1715***	0.068	-1.4002***
	(0.0314)	(0.0465)	(0.3034)	(0.0430)	(0.2728)
_cons	-0.2562	-0.6963**	-3.372*	-0.4355	-1.7018
	(0.2124)	(0.3426)	(1.9533)	(0.3024)	(1.5988)

Robust standard errors in parentheses
***p<0.01, **p<0.05, * p<0.1

Table 52: Results of the Fixed Effects Models

Factors	MODEL 6 (Efficiency)	MODEL 7 (Normalized Publications Per Fclt.)	MODEL 8 (Normalized Citations Per Fclt.)	MODEL 9 (Publications Per Fclt.)	MODEL 10 (Citations Per Fclt.)
Number of obs.	282	282	282	282	282
Number of grp.	94	94	94	94	94
R-sq. within	0.1370	0.3421	0.2621	0.3944	0.4339
R-sq. between	0.0697	0.0001	0.0385	0.0000	0.0291
R-sq. overall	0.0389	0.0020	0.0579	0.0015	0.0570
Factors					
size	-0.0003	-0.0012**	-0.0009	-0.0009**	-0.0025
	(0.0004)	(0.0005)	(0.0041)	(0.0004)	(0.0027)
rphd	0.0481	0.0043	-0.2817	0.0025	-0.089
	(0.0450)	(0.0537)	(0.4436)	(0.0410)	(0.2950)
support	0.0735	-0.1487	1.2247	-0.0835	1.2773**
	(0.0934)	(0.1114)	(0.9210)	(0.0851)	(0.6125)
rstd	0.0006	0.0032***	0.0052	0.0032***	0.006
	(0.0007)	(0.0008)	(0.0068)	(0.0006)	(0.0045)
rasc	0.3598	-0.3299	5.5056	-1.8797	4.6821
	(1.3016)	(1.5524)	(12.8334)	(1.1857)	(8.5351)
rast	0.032	-0.962	11.7012	-1.1003	9.3323*
	(0.8235)	(0.9822)	(8.1198)	(0.7502)	(5.4002)
phlt	-0.1982	-0.0352	-1.8123	0.255	0.4946
	(0.3316)	(0.3955)	(3.2697)	(0.3021)	(2.1746)
psci	0.2167	0.229	6.1234*	0.1419	2.9894
	(0.3221)	(0.3842)	(3.1759)	(0.2934)	(2.1122)
pvoc	-0.2818	-0.4114	-6.3266*	-0.7633**	-6.5138***
	(0.3560)	(0.4246)	(3.5100)	(0.3243)	(2.3344)
extfund	0.0021	-0.0022	0.0052	-0.0005	0.0116
	(0.0027)	(0.0033)	(0.0269)	(0.0025)	(0.0179)
y09	0.0096	0.1438***	-0.0099	0.1176***	-0.3523**
	(0.0244)	(0.0291)	(0.2405)	(0.0222)	(0.1600)
y10	0.0996***	0.2124***	-1.2337***	0.1381***	-1.2132***
	(0.0344)	(0.0411)	(0.3397)	(0.0314)	(0.2259)
_cons	0.5572	1.3881**	-2.6901	1.2938***	-0.9117
	(0.4705)	(0.5612)	(4.6388)	(0.4286)	(3.0851)
sigma_u	0.3579	0.7018	2.6298	0.5711	2.4987
sigma_e	0.1399	0.1669	1.3798	0.1275	0.9177
Rho	0.8674	0.9465	0.7841	0.9525	0.8811
F test that all ui=0	0.0000	0.0000	0.0000	0.0000	0.0000

Robust standard errors in parentheses
***p<0.01, **p<0.05, * p<0.1

Table 53: Results of the Random Effects Models

Factors	MODEL 11 (Efficiency)	MODEL 12 (Normalized Publications Per Fclt.)	MODEL 13 (Normalized Citations Per Fclt.)	MODEL 14 (Publications Per Fclt.)	MODEL 15 (Citations Per Fclt.)
Number of obs.	282	282	282	282	282
Number of grp.	94	94	94	94	94
R-sq.within	0.0936	0.2223	0.1761	0.3083	0.3841
R-sq. between	0.5166	0.4853	0.5712	0.4192	0.5067
R-sq.overall	0.4307	0.438	0.4533	0.4043	0.4789
Wald chi2(15)	104.09	122.37	137.96	140.79	194.65
Factors					
new public	-0.0718	0.0979	0.8528	0.0722	0.443
	(0.0717)	(0.1178)	(0.6080)	(0.1056)	(0.5881)
private	0.0648	0.414***	1.8629***	0.1466	1.1809*
	(0.0798)	(0.1315)	(0.6775)	(0.1184)	(0.6558)
size	0.0002***	0	0.0005	0	0.0004
	(0.0001)	(0.0001)	(0.0005)	(0.0001)	(0.0005)
rphd	0.0892***	0.1264***	0.3449	0.0811**	0.402*
	(0.0316)	(0.0452)	(0.2935)	(0.0359)	(0.2320)
support	0.137**	0.0846	1.3126***	0.0166	0.9519**
	(0.0564)	(0.0847)	(0.5039)	(0.0694)	(0.4311)
rstd	0.0009**	0.0025***	0.0052	0.0033***	0.0066**
	(0.0004)	(0.0006)	(0.0040)	(0.0005)	(0.0033)
sedi	-0.0153	-0.0359	-0.1036	-0.0271	-0.1212
	(0.0174)	(0.0287)	(0.1466)	(0.0258)	(0.1430)
rasc	2.413***	3.2232***	28.5487***	0.9115	15.3543***
	(0.7787)	(1.1541)	(7.0486)	(0.9397)	(5.8859)
rast	0.9968**	-0.0289	7.0368*	-0.4814	4.3769
	(0.4371)	(0.6697)	(3.8528)	(0.5578)	(3.3946)
phlt	0.1134	0.2164	0.2333	0.6585***	1.6038*
	(0.1191)	(0.1900)	(1.0258)	(0.1646)	(0.9548)
psci	0.0772	0.3346*	1.0832	0.6604***	3.582***
	(0.1212)	(0.1931)	(1.0431)	(0.1668)	(0.9706)
pvoc	-0.6698***	-1.0119***	-5.86***	-1.2851***	-6.6787***
	(0.2230)	(0.3235)	(2.0526)	(0.2596)	(1.6566)
extfund	0.0039**	0.0106***	0.0915***	0.007***	0.0649***
	(0.0020)	(0.0028)	(0.0185)	(0.0022)	(0.0145)
y09	-0.0148	0.1001***	-0.1998	0.082***	-0.5346***
	(0.0212)	(0.0278)	(0.2160)	(0.0209)	(0.1448)
y10	0.0585**	0.1522***	-1.2409***	0.0657***	-1.4478***
	(0.0230)	(0.0309)	(0.2301)	(0.0238)	(0.1601)
_cons	-0.1712	-0.1436	-3.7025*	0.1159	-2.3413
	(0.2450)	(0.3771)	(2.1573)	(0.3160)	(1.9089)
sigma_u	0.1584	0.2595	1.1827	0.2490	1.3452
sigma_e	0.1399	0.1669	1.3798	0.1275	0.9177
Rho	0.5618	0.7073	0.5235	0.7923	0.6824

Robust standard errors in parentheses
***p<0.01, **p<0.05, * p<0.1

In the fixed effects models, values of rhos(ρ), which measure the differences occur due to the unobserved effects (or abilities), range between 0,78 and 0.95 meaning that the majority of the variation in all research performance measures occurs due to universities' unobserved abilities and/or institutional culture (Table 52).

In the random effects models, values of "ρ"s are found less than the values obtained in the fixed effects models. They range from 0.52 to 0.79. These values still indicate that more than half of the variation in all research performance measures occurs due to universities' unobserved abilities and/or institutional culture (Table 53).

In all fixed effects models, within variation is found to be greater than the between variation, whereas in all random effects model it is vice versa. Fixed effects model indicates that the variation among a university's performance in different years is more than the variation of all universities' performances in a specific year. On the other hand, the random effects models indicate that the variation among a university's performance in different years is less than the variation of all universities' performances in a specific year.

6.4.1. Selection among POLS, Fixed Effects and Random Effects Models

We can see that each model provides different results from each other such that some variables that are found significant in one model are found insignificant in the other. Thus, it is important to select the most appropriate model.

First, we perform Breusch and Pagan Lagrangian multiplier test to decide whether we should select the POLS method against the random effects or the fixed effects model. In all models, we find that Prob > chibar2 is equal to 0 indicating that POLS should not be preferred.

Afterwards, we perform Hausman test to select between the random effects and the fixed effects models. Hausman test is used to assess the null hypothesis that the extra orthogonality conditions enforced by the random effects estimator are valid. Fixed effects estimator, which does not impose any orthogonality conditions, is consistent irrespective of the independence of the individual effects. But they are inefficient if the independence assumption is warranted. On the other hand, random effects estimator is efficient under the assumption of independence, but inconsistent otherwise. Hausman test statistics at 1 % significance level show that we are able to reject the hypothesis that states differences in coefficients are not systematic. Consequently, using random effects model is found to be more preferable in this study. In the next section, we will discuss the outputs of the random effects models in the next section. Additionally, According to Baltagi (2008) cross-sectional dependence is a problem in macro panels that have long time series such as over 20-30 years, and it is not much of a problem in micro panels that have few years.

6.4.2. Results and Comparison of the Random Effects Models

When we compare the models that use field-based-normalized dependent variables with the models that use simple form of them, we see that for the majority of the factors, magnitudes and significance level of coefficients are different, meaning that making field-based normalizations have an impact on the estimates.

First of all, simple form of publication and citation productivity ratios show that universities that concentrate in the basic and applied sciences and the health sciences are significantly more productive than the ones that concentrate in the social sciences, whereas this is not the case in the models that use normalized values.

Secondly, the coefficient of the private university categorical variable is positive and significant in all models, but it is higher in the normalized models, compared to the unnormalized models. It means that if we take field based productivity differences into account, then the productivity gap between the private and public universities becomes larger, in favor of the private universities.

Third, the coefficients of the ratio of associate professors are positive and significant in all models, but they are higher in the normalized models, compared to the unnormalized models. It means that if we take field-based productivity differences into account, the productivity gap between the associate professors and full professors becomes larger, in favor of the associate professors.

Fourth, similar to above incidences, the coefficient of the academic support personnel per faculty member is positive and significant in all models, but it is higher in the normalized models than the unnormalized models. In other words, the importance of the availability of academic support personnel on the research performance increases in the normalized models.

Fifth, field-based normalization leads to an increase on the impact of the ratio PhD students per faculty on the publication productivity, whereas it causes a decrease on the citations received.

Based on these findings, we suggest using normalized values of dependent variables in the models. Otherwise, field-based productivity differences might cause disturbances on the estimators.

Similar to the findings of Adams and Griliches (1998), Dündar and Lewis (1998), and Jordan et al. (1988, 1989) the results of RE model show that the private universities perform better than both established and new public universities in five of the performance measures. On the other hand, in contrast of the results of Kounetas et al. (2011), and Wolszczak-Derlacz and Parteka (2011) which find significant and positive impact of age on the research performance, we do not find a significant difference between the established and the new public universities in any of the models.

Contrary to our expectations and results of the previous studies (Dündar and Lewis,1998; Jordan et al.; 1988, Jordan et al., 1999), outputs of our RE models show that the size of universities does not have a significant impact on neither the publication nor the citation productivity. On the other hand, we find a significant positive impact of size on the research efficiency, but the coefficient is very small. Namely, one unit increase in the total number of faculty members leads to a 0.0002 unit increase in the efficiency scores.

Previous studies that investigated the impact of PhD students on the research performance discovered that it had a insignificant impact (Dündar and Lewis, 1998; Wood, 1990). On the other hand, four of the models that we run (except the model that has normalized citations per faculty member as dependent variable) show that the ratio of PhD student to faculty members has a significant positive impact on the research performance. In other words, Turkish universities that give importance on PhD level education are expected to be more research efficient and research more productive in terms of publications and citations.

Dündar and Lewis (1998), and Wood (1990) observed that the availability of the support personnel and research assistants had a positive and significant impact on the research performance. Our results also reveal that the availability of the academic support personnel has a significant positive impact on the research efficiency and citation productivity, whereas it doesn't have a significant impact on the publication productivity.

Unlike Wood (1990) who found that student to academic staff ratio had no significant impact on the research performance, and Johnes (1998) who identified that student staff ratio had a negative impact on the research performance, in four of our models (except the one that uses normalized citations per faculty member) we observe a significant and positive relationship between students per faculty and the research performance. It might be due to the possibility that more successful universities are attracting more students and have higher student per faculty ratios.

Apart from the previous studies that found a positive and significant impact of the ratio of full professors on the research performance (Dündar and Lewis, 1998; Tien and Blackburn, 1996; Wood, 1990), our results show that the research efficiency, and research productivity in terms of normalized publications, normalized citations and citations is increasing with the increase in the ratio of associate professors and the decrease in the ratio of full professors (ceteris paribus). In addition, we find that the research efficiency, and research productivity in terms of normalized citations is increasing with the increase in the ratio of assistant professors and the decrease in the ratio of full professors (ceteris paribus). Moreover, coefficients of the associate professors are higher than that of the assistant professors in all models. These results altogether show that the most research productive and efficient faculty group in terms of their academic titles is the associate professors. Associate professors might be more experienced than the assistant professors and have higher motivation for academic promotion compared to professors. On the other hand, we see that full professors have lower research performance even from the assistant professors in terms of the research efficiency and NCF. Similar to our results, Johnes (1998) found that the ratio of university staff aged over 55 years had a negative impact on the research performance, and Levin and Stephan (1989) found that in physics and earth sciences older scientists published less than the youngest scientists, and in physiology and biochemistry older scientists published less than the middle-aged scientists.

Contrary to outcomes of Johnes and Yu (2008) who found that mean research efficiency scores were higher in universities located in the rich regions compared to those in the poorer regions of China, we find that socioeconomic development level of the provinces do not have significant impact on neither of the research performance measures. In addition, the coefficients are found to be negative in all models. One reason might be that private universities that are not research-oriented are mostly established in the big cities. Another reason might be that faculty members working in new public universities, which are mostly located in cities with lower socio-economic development index, might have higher academic motivation to make publications, which are among the most important academic promotion criteria in the Turkish higher education system.

Since previous studies found performance differences in different scientific fields (Adams and Griliches, 1998; Abramo et al., 2012b) we expect that there will be performance differences across universities that have different concentrations in scientific disciplines. Our analyses suggest that coefficients of phlt and psci are positive for all models but there is no significant performance difference among 3 different scientific disciplines in terms of the research efficiency and NCF. On the other hand, faculty members working in basic and applied sciences are found to be better in terms of NPF compared to other disciplines. In addition, when we investigate PF and CF ratios we observe that faculty members who are both working in basic and applied sciences, and health sciences are more productive compared to the ones working in social sciences. This outcome coincides with our field-based analyses which were performed in Chapter 4.

As we expected, we find that universities that employ higher ratios of their faculty members in vocational schools perform significantly worse than the others, in all models. The impact is the highest on citation productivity, followed publication productivity and the research efficiency.

Parallel to the results of Wolszczak-Derlacz and Parteka (2011), Dündar and Lewis (1998) and Johnes (1998), we detect that TÜBİTAK funds per faculty member have positive and significant impact on the research performance in all models. The impact is the highest on NPF and the lowest for the research efficiency.

Once we check coefficients of the year dummies, we find that the research efficiency and publication productivity are higher in 2010, whereas citations per faculty ratios are lower than the 2008 values. ES and NCF do not significantly differ in 2008 and 2009. Nevertheless, the coefficients of the year dummies show that both NPF and PF are higher, and NCF and CF are lower in 2009 compared to 2008 values.

6.5. Concluding Remarks

This chapter aims to investigate factors that lead to higher or lower research performance in Turkish universities. In this context, we calculate five different performance measures that are related with the research efficiency and research productivity, and investigate the impact of selected factors on these measures. The first performance measure (dependent variable) is selected as the inverse of the efficiency scores obtained via DEA. Among 4 other measures, two of them measure publications per faculty members and two of them measure citations per faculty member.

We include publications per faculty and citations per faculty ratios in two different forms. In the first form, we calculate these ratios after making field-based normalizations, such that first, we make field based normalizations with the number of publications and citations for 3 separate scientific fields. Afterwards for each university, we add the normalized outputs from 3 separate scientific fields annually and obtain an overall value for each year. Than we divide this normalized total by the total number of faculty members of that university. Meanwhile, in the second form we simply calculate these ratios by dividing the aggregate number of publications and citations of a university in a specific year, with its total number of faculty members in that year.

Previous studies that we were able to find and that analyzed the impact of different factors on the research performance had used only one dependent variable in their models, and this variable was generally selected as the publications. On the other hand, we hypothesize that a factor that has a significant and positive impact on one research output might have negative or insignificant impact on the other.

In compliance with our hypotheses, we find that some factors that are found to have a significant impact on one measure have an insignificant impact on other measures. Whereas, we find that the coefficient of all factors have the same sign in five of the models except for the ratio of assistant professors (rast). The coefficient of rast is positive for the research efficiency and citation productivity models, but it is found negative in the publication productivity model. Meanwhile, the negative coefficient is found to be insignificant at 10 % significance level. Based on this result, we comment that individual institutions or governments can develop more effective policies towards enhancing research performance of universities if they handle multiple research outputs together, instead of focusing on a single measure. This way, they can better identify the factors that have the most significant and wide-ranging impact on the research performance of the universities.

We distinguish that private universities have superior research performance in terms of efficiency, publication per faculty and citation per faculty than public universities. In other words, private universities operate more efficiently in their research activities, their faculty members make more publications and receive more citations compared to their peers working in the public universities. Underlying factors leading to higher performance in Turkish private universities needs further investigations. It is probable that private universities have more flexibility to specialize to a greater extent than are public universities. If this is the case, than we can propose universities that target higher research performance to specialize in certain subjects. For further studies, we suggest studying private universities in terms of their management practices, organizational culture, and working environment to identify the most important factors that lead to higher research performance.

We observe that the ratio of PhD students, availability of academic support personnel, and amount of external research funds have a significant positive impact on most of the research performance measures. Consequently, we suggest universities that target higher research performance to enlarge their PhD programs, enhance support services for their faculty members, and promote their faculty members to obtain more research funds from the external sources. In this respect, establishing project coordination offices and/or research support offices will be helpful to enhance the institutional research performance.

We distinguish that the ratio of faculty members employed in the vocational schools has a negative impact on the research performance of universities. It indicates that faculty members employed in vocational schools need a special support (either technical or motivational) for their research activities. Implementing special programs that will provide technical support for these faculty members (such as networking and editorial support.) or perform events to enhance their motivation towards research activities (such as academic panels, seminars, etc.) might be helpful. In addition, universities can initiate programs that aim to increase cooperative activities among their vocational schools and private sector. We all know that research activities are not limited with publications, citations or academic R&D projects. Cooperation with the private sector through projects or providing consulting services to them are also important research outputs (Abramo et al., 2011b).

We notice that the size has no significant impact on the publication and citation productivity, whereas it has a small positive impact on the efficiency. In line with these findings, we identified that the majority of the universities are operating at the decreasing returns to scale in Chapter 5. These results show that universities do not benefit from economies of scale. As Dündar and Lewis (1999) and Wolszczak-Derlacz and Parteka (2011) found, universities with higher number of different faculties had reached to better research efficiency and they attribute this result to R&D studies becoming more interdisciplinary. From this point of view, we suggest universities and related governmental organizations to give higher priority to support interdisciplinary research activities.

As opposed to our initial expectations, students per faculty member ratio has positive coefficients, and socioeconomic development index has negative coefficients in all models. These results should be scrutinized by the future studies to understand the dynamics.

Our findings also point out that the concentration in different scientific fields does not have an impact on the research efficiency and publications and citations when field-based differences are taken into account. On the other hand, if we use PF and CF instead of NPF and NCF, then we find that universities that concentrate in the health sciences and basic and applied sciences have better performance than universities that concentrate in the social sciences. For this reason, we propose that research evaluation studies should carefully identify field-based performance differences and design their methodologies accordingly. In this respect, evaluations should be either applied separately for each scientific field or field-based differences should be reflected into the models.

We notice that the research performance of professors is lower than the associate professors for all measures, and lower than the assistant professors in terms of research efficiency and citation productivity. Thus, we suggest developing new performance criteria to enhance motivation of all faculty members towards the research activities for the Turkish higher education system. In our opinion, the current academic promotion and wage system has to change in a way that provides more incentives for faculty members who are more active in research activities. Meanwhile, the research activities under evaluation should not be limited to publications and should cover a wide range of research outputs from participation to international R&D projects to industry cooperation activities, and patents.

We strongly suggest developing a national performance evaluation system for the Turkish Higher Education system, which will measure the performance of universities in terms of their teaching and research activities and their contributions to society. National evaluation systems serve for two main purposes. The first is to enhance the efficiency of the funds, whereas the second is to increase their accountability and transparency in terms of distributing those funds. They also serve information about the strengths and capabilities of universities, which will be quite useful for researchers, students and companies in their decisions to select universities that they want to study in or work with. University administrators generally develop internal incentive systems as a response to evaluation systems, especially when there are financial incentives or penalties. In this context, they may require faculty members to conform to the performance criteria set by the evaluation process and may link promotion or resource allocation systems to evaluation results. Consequently, performance-evaluation schemes influence researchers and the work they produce. Governments can select different sets of evaluation criteria to influence and direct universities. For example, evaluating the outputs of a limited number of researchers per university may support goals of reinforcing centers of excellence, whereas evaluating all the researchers in universities supports goals of raising the performance level of all faculty members (Abramo et al., 2011a).

Our findings illustrate that more than half of the variation in all research performance measures occur due to their unobserved abilities and institutional culture. For this reason, we comment that fostering management practices and institutional culture which supports research activities in universities is important. In this respect, establishing project coordination offices and research centers, promoting academic networks, and supporting interdisciplinary research activities will be beneficial.

Finally, we would like to express that this chapter uses only bibliometric information to determine factors effecting research performance of universities. We suggest further studies that apply structured surveys or in-depth interviews to elaborate more on the attributes of high-performance researchers and universities, and the impact of organizational culture and management practices on the research performance of universities.

CHAPTER 7

EVALUATION OF RESEARCH PERFORMANCE OF TURKISH UNIVERSITIES USING STOCHASTIC FRONTIER ANALYSIS

7.1. Introduction

Universities are among the key actors in national innovation systems since they play a crucial role in training highly skilled human resources necessary for enhancing countries' innovation capabilities. Additionally, they provide necessary research infrastructure both for the public institutions and the private sector.

In several countries an elitist system of higher education has been overtaken by a system of mass higher education. Consequently, the total numbers of universities, amount of university students and funds allocated for higher education have increased considerably. With increased number of universities, growing enrollment of students and limited funding resources, universities found themselves in competition for resources, students and reputation.

The competition among universities has fostered both national and international level performance evaluation studies, especially during the last two decades. Several parametric and nonparametric methods have been used to measure the performance of universities. Stochastic Frontier Analyses (SFA) which is a parametric method, and Data Envelopment Analysis (DEA) which is a nonparametric method are among the most frequently used methods in measuring the efficiency of universities.

In Chapter 5, we have evaluated the research performance of universities via DEA, and in Chapter 6 we have analyzed the factors leading to higher research efficiency, and publication and citation productivity per faculty member.

This chapter aims to implement two SFA models (which will take field-based productivity differences into account) to measure research efficiency of Turkish universities and identify factors leading to higher efficiency for the 2008-2010 period. Afterwards we will compare the results of SFA and the results obtained in the previous chapter.

Our study will contribute to the literature in three main aspects. First, none of the previous studies that we were able to reach have used SFA to measure solely the research efficiency of universities like we do in this study. Rather, they have evaluated the overall teaching and research efficiency together. Moreover, all of these studies have used cost-function form of SFA and used the total expenditures as the dependent variable, whereas we run a production function and include the total publications and citations as the dependent variables.

Secondly, we will implement SFA models that take field-based differences into account while measuring research efficiency of Turkish universities. Similar to what we have done in the previous chapters, we propose to use the sum of field-based normalized outputs, rather than simply summing outputs from different fields.

Thirdly, we will evaluate research efficiency of both public and private Turkish universities for three consecutive years, which to our knowledge, has not been done in any other academic study. All of the related studies that we were able to reach had evaluated the overall teaching and research performance of universities, and none of them had focused solely on research efficiency. In addition, some studies either concentrated on only public or private universities, and majority of them made analyses only for one year.

This chapter is structured from four sections. In the first section, we will provide brief information about empirical studies that used SFA to measure efficiency of universities. In the second section, we will discuss our methodology. In this context, we will briefly explain SFA models to be used, define our input and output variables, and describe the models. Third, results of SFA models are put forward, and comparisons of SFA and DEA models are provided. Finally, we will provide recommendations for policy implications.

7.2. Literature Review

Table 54 provides summaries of selected studies that focus on measuring performance of universities using SFA.

Table 54 Summary of the selected studies

Author	Summary of the Study
Agasisti and Johnes (2010)	They applied both random parameters stochastic frontier model and random effects model to measure performance of 57 Italian universities over a three year period from 2001 through 2003.They used number of students from two different scientific disciplines, number of PhD students, and grants for external research and consultancy as outputs, and current costs as the dependent (cost) variable. The correlation between the efficiencies obtained from random effects estimation and those yielded by the random parameters estimation were found to be high. Their results suggested that random parameters stochastic frontier model was preferable to random effects model.
Castano and Cabanda (2007)	They evaluated the performance of 30 private Philippine universities over the time period 1999-2003 using both DEA and stochastic frontier analysis (SFA). They used number of faculty members, property, plant and equipment, and operating expenses as inputs and included. They used number of students, graduates per year and the total revenue as outputs in the DEA model, and only operating expenses in SFA. They did not compare outputs of DEA and SFA, instead they used two models to analyze different concepts. From SFA, they found that age and ownership had a positive and significant effect on technical inefficiency; and from DEA they found that higher technological progress had boosted the productivity growth in the majority of the universities.
Izadi et al. (2002)	They employed SFA with constant elasticity of substitution technique to estimate cost inefficiency of 99 British universities for the year 1994-1995. They used the total expenditures as the dependent variable, whereas they used undergraduate students in arts and humanities, undergraduate students in sciences, graduate students, and research grants as independent variables of cost function. They found that returns to scale for undergraduate students are slightly less than unity, and returns to scale for graduate students and research grants are higher than the unity. They also reported that there occurred significant inefficiencies in the Britain's higher education system. But they couldn't find a clear pattern for best and worst performing universities.
Kuo and Ho (2008)	They used SFA to measure the cost efficiency of the University Operation Funds (UOF) on Taiwan's public universities. They analyzed 34 public universities over the years 1992-2000.They used number of graduate and undergraduate students, and research expenditures as outputs; faculty salaries as input prices; the existence of the master program, doctoral program, and research activity, diversity of academic program, and orientation towards engineering and science as organizational characteristics in the cost function. They included the total enrollment, time and adaptation to budget reform in the cost inefficiency function. They found that adopting the UOF had a significant negative effect on cost efficiency. Furthermore, they found that higher undergraduate teaching load led to lower the research program output, universities that performed research activity and that had higher orientation towards engineering and science had cheaper cost structures, whereas diversity in the academic field increased the costs.

Table 54 (cont'd) Summary of the selected studies

Author	Summary of the Study
McMillan and Chan (2006)	They determined efficiency scores for 45 Canadian universities for the year 1992-1993 using both DEA and SFA methods and compared the results. The variables that were used as outputs of the DEA model (undergraduate students in science, undergraduate students in other fields, master students, PhD students, sponsored research expenditure, average salary of faculty, % of faculty with grants, and existence of PhD program) are used as independent variables in SFA. The total operating expenditures was selected as the input variable in DEA and as the dependent variable in SFA. They also included the number of students in universities within 200 km, the ratio of graduates from undergraduate programs to the total undergraduate students, ratio of part-time students to full time students, and proportion of 3rd and 4th year classes with less than 26 students as environmental control variables in both models. They found a significant divergence in the efficiency scores and rankings among methods and specifications.
Mensah and Werner (2003)	They evaluated the impact of financial flexibility (the ratio of unrestricted net assets to the total assets) on cost efficiency using multiple-output flexible fixed-cost quadratic function. They used dummy variables for Carnegie Foundation classification, the total number of undergraduate students, the total number of graduate students, the total amount of sponsored research revenues generated by the institution, average graduation rate of undergraduates, academic reputation of the institution, ratio of part-time undergraduate students to the total undergraduate population, ratio of Unrestricted Net Assets to Total Net Assets as the explanatory variables of the cost function. Their results suggested that, for private universities, greater financial flexibility led to lower overall efficiency.
Robst (2001)	He examined cost efficiency of 440 four-year public universities that were classified as Research, Doctoral, Masters, and Baccalaureate universities in the Carnegie classifications via one-stage SFA. He used the total expenditures as the dependent variable; the total number of undergraduate students, the total number of graduate students, the total amount of research expenditures as outputs; compensation rate as input prices; dummy variables for Carnegie Foundation classification, State appropriations and tuition revenues as the explanatory variables of the cost function. His results suggested that universities with smaller revenues from state appropriations were no more cost efficient than universities with higher revenue share from state appropriations. In addition, he found that institutions with a smaller decline in state support had increased cost efficiency more than institutions with a larger decline in state support.
Stevens (2005)	He examined the costs and efficiency of 80 English and Welsh universities using the SFA method over four years from 1995 to 1999. He also investigated the impact of staff and student characteristics on inefficiency. He used the total expenditures as the dependent variable, science undergraduates, arts undergraduates, postgraduates and research income as outputs, average staff costs as input prices and developed 3 different SFA models. He detected diseconomies of scope between undergraduate teaching and research activities and economies of scope between graduate teaching and research activities. He found no trade-off in terms of costs between quality and quantity in undergraduate teaching, in fact costs were found lower in universities that pursue education and research goals together. The time trend had a significant negative coefficient implying that universities had become more efficient over the period. The proportion of staff who were over 50 years old, and proportion of students achieving first-class and upper-second-class degrees had a negative effect on efficiency. On the other hand, the proportion of staff with professorial or senior lecturer grade or who were research-active, and the proportion of non-white staff had a positive effect on efficiency. He found no significant relationship between efficiency and the gender composition of the staff, the gender composition of students or number of arts students.

Table 54 (cont'd) Summary of the selected studies

Author	Summary of the Study
Zoghbi et al. (2013)	They estimated efficiency of 164 Brazilian universities via 6 different SFAs for the year 2007. They used the difference between the scores of last-year and first-year students in ENADE (a national-level exam) as output, and the number of professors per student, number of computers per students, and the existence of a pedagogical plan as inputs. They analyzed the impact of several internal and external factors on the inefficiency measure. In all the models private institutions were found more efficient than public institutions. On the other hand, they detected low productivity in both private and public institutions. They also found that % of students working, % of nonwhite students, % of students with educated mothers, average age of students, and % of female students did not have a significant impact on neither cost function or on the inefficiency function.

While there is a large literature on performance indicators to measure efficiency of universities, there is little agreement about which methodology or which set of indicators is the best. Since the goals of evaluations and availability of data sets vary from one study to another, different agencies may come up with quite different criteria (Geuna and Martin, 2003).

We identify that all of the studies that were presented in Table 54 had used cost function form of SFA, and they evaluated both teaching and research efficiency together. Numbers of undergraduate students, number of graduate students, amount of research funds are the most frequently used outputs, whereas average wage of faculty members was the most commonly used input prices. Meanwhile, each study had used different sets of explanatory variables for the inefficiency term.

7.3. Methodology

In this section, we start with providing a brief theoretical background on SFA methodology that will be used in this study. Afterwards, we will describe our input and output variables and finally we will define specifications of 2 different SFA models that will be implemented in this study.

7.3.1. Stochastic Frontier Analyses (SFA)

As we have discussed in Chapter 5, there are two main approaches to deal with the measurement of efficiency. The first one is data envelopment analysis and the second one is the stochastic frontier analysis. Both of these methods require the computation of a production possibilities frontier of the most efficient type. We have already provided detailed information about Data Envelopment Analyses in Chapter 5, so we will provide brief information regarding the stochastic frontier analysis in this chapter.

Let's consider a production function:

$$y_i = \alpha + x_i'\beta - u_i \tag{7.1}$$

$u_i \sim F$,

y_i represents the logarithm of the output, x_i represents vector of inputs, β is the vector of technology parameters and u_i represents the non-negative inefficiency effects which is a one-sided disturbance.

The production frontier covers $x_i \beta$ portion of the function. This function is bounded from above because all the inefficiency terms are subtracted from $x_i \beta$ portion of the function.

Here all the errors turn out to be attributed to inefficiency and no measurement error term is allowed. On the other hand, DEA does not have a random component in the production function, and consequently, it provides a non-stochastic frontier.

DEA is prone to the outlier observations' effect. Since outliers are treated like the other observations, the frontier is significantly dependent on their impact. Any deviation from the frontier is attributed to inefficiency due to the absence of a random error term. Thus, the accuracy of the data in DEA plays an important role in robust estimation of the efficiency scores. On the other hand, data envelopment analysis has more than one output, whereas stochastic frontier analysis has one output or a weighted average of multiple outputs (Kalaycı, 2012).

Stochastic frontier analysis was introduced by Aigner et al. (1977) and Meeusen and van den Broeck (1977). It allows for the inclusion of a random error term in the production function given in Equation 7.1. The production function can be written as follows:

$y_i = \alpha + x_i'\beta + \varepsilon_i$, $i = 1,\ldots,N$ (7.2)

$\varepsilon_i = v_i - u_i$,   (7.3)

$v_i \sim N(0, \sigma_v^2)$,

$u_i \sim F$,

In this stochastic frontier (SF) model v_i is a normally distributed error term, which can take on either negative or positive values. Its expected value is 0 and it stands for all specification and measurement errors. When this stochastic error term is included in the production function, the frontier becomes bounded from above by the random variable ($v_i - u_i$).

The assumption about the distribution of the inefficiency term is required to compute the model. Aigner et al (1977) assumed a half-normal distribution, while Meeusen and van den Broeck (1977) selected an exponential distribution. Other commonly used distributions are truncated normal (Stevenson 1980) and gamma distributions (Greene 1980, 2003).

Kumbhakar and Lovell (2000) suggested that different distributional assumptions do not make much of a difference as far as the efficiency rankings of firms are concerned and they recommended to use the more simple distribution such as half normal and exponential over the truncated normal and gamma.

We can also apply OLS to estimate the production function. However, if some units are not technically efficient and produce outputs below the production frontier line, the OLS will come up with a downward biased intercept coefficient (Coelli et.al 2005). In other words, the error component of OLS is assumed to have a zero mean, whereas with the frontier function, inefficiency error term is assumed to have a non-zero mean.

The stochastic frontier analysis uses maximum likelihood estimates and assumes $v_i \sim$ iid $N(0, \sigma_v^2)$ and $u_i \sim$ iid $N^+(0, \sigma_u^2)$. It means that the v_is are independently and identically distributed with zero mean and constant variance. Moreover, u_is are independently and identically distributed half normal random variable meaning that the error term can only take on positive values.

The u_i term, which stands for the inefficiency of a single unit is used to compute technical efficiency. The equation is given as follows:

$$TE_i = \frac{q_i}{\exp(x_i\beta+v_i)} = \frac{\exp(x_i'\beta+v_i-u_i)}{\exp(x_i'\beta+v_i)} = \exp(-u_i) \quad (7.4)$$

The availability of a richer set of information in panel data allows to relax some of the assumptions and to consider a more realistic characterization of the inefficiencies.

Pitt and Lee (1981) were the first to extend Model 7.2 to longitudinal data. They proposed the maximum likelihood estimation of the following normal-half normal stochastic frontier model. They first predicted unit-level efficiencies using this model and then they regressed the predicted efficiencies upon firm-specific variables.

$$y_{it} = \alpha + x_{it}'\beta + \varepsilon_{it}, \quad i = 1,\ldots,N, \quad t = 1,\ldots, T_i \quad (7.5)$$

$$\varepsilon_{it} = v_{it} - u_{it}, \quad (7.6)$$

$$v_{it} \sim N(0, \sigma_v^2),$$

$$u_i \sim N^+(0, \sigma_u^2),$$

On the other hand, this kind of two-stage estimation procedure is inconsistent in its assumption regarding the independence of the inefficiency effects. This problem was addressed by Kumbhakar et al. (1991) and Reifschneider and Stevenson (1991) who proposed SF models in which the u_is were expressed as an explicit function of a vector of unit-specific variables and a random error.

Battese and Coelli (1995) has developed a model which is equivalent to the Kumbhakar et al. (1991), with the exception that allocative efficiency is imposed, first-order profit maximizing conditions removed, and panel data is allowed. This model assumes that the second error term (u_{it}) is independently distributed with a truncated normal distribution.

Among panel data models, the inefficiency specification used by Battese and Coelli (1995) is the most frequently used one (Kumbhakar et al., 2014). This model is expressed as follows:

$y_{it} = \alpha + x'_{it}\beta + \varepsilon_{it}$, i = 1,…,N , t= 1,…., T_i (7.7)

$\varepsilon_{it} = v_{it} - u_{it}$, (7.8)

$v_{it} \sim N(0, \sigma_v^2)$,

$u_i \sim N(m_{it}, \sigma_u^2)$,

$m_{it} = z_{it}\delta$, (7.9)

z_{it} is a (p x1) vector of variables which may influence the efficiency of a unit; and δ is a (1xp) vector of parameters to be estimated.

7.3.2 The Model

We choose to use the Battese and Coelli (1995)'s production function model in which the production function and the inefficiency effects are simultaneously estimated in this model.

Meanwhile, we see that the previous studies that analyze the efficiency of universities through SFA, prefer to use the cost function model which allows for incorporating multiple outputs into the model and they used the amount of total expenditures as the dependent variable.

We could not use a cost function model due to unavailability of data. Because neither the total expenditures of private universities, nor research expenditures of public and private universities were available. As a result, we decided to implement production function models separately for individual outputs.

The computer program FRONTIER Version 4.1 (developed by Tim Coelli) is used to simultaneously estimate the parameters in the production function and the inefficiency effects model via the maximum likelihood estimation method.

7.3.2.1 Production Function Variables:

The two main inputs of production function are capital and labor. We use the natural logarithm of the number of professors, associate professors, assistant professors and research assistants as labor inputs, and research infrastructure funds allocated via Ministry of Development as capital inputs[33]. These input variables were also used as inputs in DEA models which were established in Chapter 5.

We estimate the following translog model as the stochastic production function which is defined as:

$$\begin{aligned}
\mathrm{lny_{it}} = {} & \alpha_0 + \alpha_1 \mathrm{lnprf_{it}} + \alpha_2 \mathrm{lnasc_{it}} + \alpha_3 \mathrm{lnast_{it}} + \alpha_4 \mathrm{lnra_{it}} + \alpha_5 \mathrm{lnSPO_{it}} + \\
& \tfrac{1}{2}\,[\alpha_6 \ln(\mathrm{prf_{it}})^2 + \alpha_7 \ln(\mathrm{asc_{it}})^2 + \alpha_8 \ln(\mathrm{ast_{it}})^2 + \alpha_9 \ln(\mathrm{ra_{it}})^2 + \alpha_{10} \ln(\mathrm{inf_{it}})^2] + \\
& \alpha_{11} \mathrm{lnprf_{it}lnasc_{it}} + \alpha_{12} \mathrm{lnprf_{it}lnast_{it}} + \alpha_{13} \mathrm{lnprf_{it}lnra_{it}} + \alpha_{14} \mathrm{lnprf_{it}lninf_{it}} + \\
& \alpha_{15} \mathrm{lnasc_{it}lnast_{it}} + \alpha_{16} \mathrm{lnasc_{it}lnra_{it}} + \alpha_{17} \mathrm{lnasc_{it}lninf_{it}} + \alpha_{18} \mathrm{lnast_{it}lnra_{it}} + \\
& \alpha_{19} \mathrm{lnast_{it}lninf_{it}} + \alpha_{20} \mathrm{lnra_{it}lninf_{it}} + \mathrm{v_{it}} - \mathrm{u_{it}} \qquad (7.10)
\end{aligned}$$

In the above model, i stands for universities and t stands for the time. The variables prf, asc, ast, ra and inf stand for professors, associate professors, assistant professors, research assistants and research infrastructure funds allocated by SPO.

The dependent variable y_{it} is the natural logarithm of the total normalized publications in Model 1, and the total normalized citations in the Model 2.

The v_{it} are assumed to be identically and independently distributed random errors with a N(0, σ_v^2) distribution. u_{it} are assumed to be a non-negative, independently distributed and truncated normal random variable, with a mean equal to ($\mu_{it}\,\alpha$) and it captures the inefficiency effects .

Since we use translog production function, we have to include interaction variables of inputs. When using interaction terms mean centering (which can be described as

[33] As it takes time to build laboratories, buy equipment and install them, we prefer to use total amount of research infrastructure funds given in the previous three years. Total amount of funds are calculated in real terms using 2010 prices.

subtracting the mean from a variable) is advised since it makes the computation of the marginal effects more practical (Brambor et al., 2006).

When the mean of the transformed variable is taken, it turns out as zero. This makes it so the intercept term is interpreted as the expected value of the dependent variable when the predictor values are set to their means. Otherwise, the intercept is interpreted as the expected value of the dependent variable when the predictors are set to 0, which may not be a realistic or interpretable situation. Centering variables also helps to remove high correlations between the random intercept and slopes, and high correlations between first- and second-level variables and cross-level interactions (Kreft and de Leeuw, 1998).

For these reasons, all inputs have been centered at the mean of the sample before computing cross-products so that first order coefficients can be interpreted as average elasticities.

After making mean-centering, the intercept and the first-order parameters have adjusted to the new units of measurement, whereas the second-order parameters, the variance parameters, and the efficiency estimates have remained nearly unchanged.

7.3.2.2 Efficiency Effects Variables

To be able to compare the results of SFA models with our previous analyses performed in Chapter 5 and Chapter 6, we prefer to select similar variables in the efficiency function of the SFA models. The final efficiency effects model is provided in Equation 7.11.

$$u_{it} = \beta_0 + \beta_1 newpub + \beta_2 priv + \beta_3 rstd + \beta_4 sedi + \beta_5 phlt + \beta_6 psci + \beta_7 pvoc + \beta_8 support + \beta_9 rphd + \beta_{10} extfund + \beta_{11} t09 + \beta_{12} t10 + e_{it} \quad (7.11)$$

In Equation 7.11, **newpub** is the dummy variable that represents whether a university is a new public university, **priv** is the dummy variable that represents whether the university is a private university, **rstd** is the number of students per faculty member, **sedi** represents economic development indice of the province in which the university is located, **phlt** and **psci** indicates the percentage of faculty members working in the health sciences and the applied and natural science respectively, **pvoc** is the percentage of faculty members employed in the vocational schools, **support** is the academic support personnel (research assistants plus teaching staff) per faculty member, **rphd** is the PhD students per faculty member, **extfund** is the TÜBİTAK project funds per faculty member, and **t09** and **t10** are the year dummies for years 2009 and 2010. e_{it} is defined by the truncation of the normal distribution with zero mean and variance.

Variables used in the efficiency model, their definitions and expected impact on the efficiency are given in Table 55.

Table 55: Definition of variables used in SFA models

Factor	**Explanation**	**Abbreviation**	**Expected Impact on Efficiency***
New public university	Dummy variable which equals to 1 for new public universities	newpub	0
Private university	Dummy variable which equals to 1 for private universities	priv	+
Students per faculty	Total number of students per faculty member	rstd	-
Socioeconomic development level	Socio-economic development index	sedi	?
Concentration in health sciences	Ratio of faculty working in health sciences to all faculty members except the ones working in vocational schools	phlt	+
Concentration in basic and applied sciences	Ratio of faculty working in health sciences to all faculty members except the ones working in vocational schools	psci	+ (Model 1) 0 (Model 0)
Concentration in vocational schools	Ratio of faculty members employed in vocational schools	pvoc	+ (Model 1) 0 (Model 0)
Availability of academic support personnel	Total number of research assistants and teaching staff per faculty member	support	+
Orientation towards PhD programs	Ratio of PhD students per faculty member	rphd	+
External R&D funds	Per faculty R&D funds received from TÜBİTAK in the previous year	extfund	+

*+: positive impact, -: negative impact, ?: no initial expectation; 0: no impact

Different from the analyses performed in Chapter 6, we do not include the ratio of professors, ratio of associate professors, ratio of assistant professors and the total number of faculty members in the efficiency function because these variables are highly correlated with the variables included in the production function.

The variance parameters of the error terms regarding the SF model can be expressed in terms of the following equations:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{, and} \tag{7.12}$$

$$\gamma = \sigma_u^2/\sigma^2 \tag{7.13}$$

Gamma (γ) takes values between 0 and 1. Both σ^2 and γ are computed from maximum likelihood estimates. As σ_u^2 represents the variance of the error term of the inefficiency effects, its magnitude with respect to the variance of the frontier function's error gives the size of the inefficiency as opposed to statistical noise. Consequently, high and significant values of γ implies that a substantial part of the error term's variance has occurred due to technical inefficiency of production, and the stochastic frontier model is the appropriate approach.

As the first and second efficiency effect variables we include two dummy variables that indicate whether a university is a new public university (newpub) or private university (priv). Previous studies showed that private universities outperformed public universities (Adams and Griliches, 1998; Dündar and Lewis, 1998; Jordan et al., 1988; Jordan et al., 1989), and age had a significant and positive impact on the research performance (Kounetas et al., 2011; Wolszczak-Derlacz and Parteka, 2011). Our analyses in Chapter 6 also showed that in terms of normalized publication per faculty, normalized citations per faculty and efficiency scores, private universities performed better than both established and new public universities, but no significant difference between established and new public universities were detected. From these findings, we expect that in both models private universities will be more efficient than public universities, but no significant difference will occur among new public and old public universities.

The third efficiency effect variable is selected as students per faculty (rstd). It is used as a proxy for teaching workload of academic staff. In her study, Wood (1990) found that student to academic staff ratio had no significant impact on the research performance, whereas Johnes (1998) identified that student-staff ratio had a negative impact on the research performance. In Chapter 6, we found that rstd had a significant positive impact on the efficiency scores and publication per faculty, but no significant impact was found on normalized citations per faculty. Nevertheless, we anticipate that students per faculty member will have a negative impact on the efficiency levels in both models, since faculty members with high student ratios might have higher teaching workloads and can spare less time on their research activities.

Socioeconomic development indices (sedi) of the provinces in which the universities are located is the fourth efficiency effect variable. Johnes and Yu (2008) found that mean research efficiency was higher in universities that were located in the rich coastal region compared to those in the poorer western regions of China. On the other hand, our results provided in Chapter 6 showed that the economic development level of the provinces had a significant but negative impact on the publication and citation productivity. Consequently, we do not have an initial expectation regarding the effect of sedi on the total publication and citation productivity.

The fifth and sixth variables are phlt and psci which show the ratio of faculty members working in health sciences and applied and natural sciences, respectively. Our previous analyses suggested that there is no significant performance difference among 3 different scientific disciplines in terms of efficiency scores and citations per faculty member. On the other hand, faculty members working in social sciences are found to be less productive in terms of publications compared to faculty members working in basic and applied sciences and health sciences. From these findings, we expect that phlt and psci have a positive impact on the efficiency in Model 1, but have no significant impact in Model 2.

We also include the ratio of faculty members working in the vocational schools into the efficiency effect model. Our analyses in the sixth chapter showed that employing faculty members in the vocational schools had a significant negative impact on the research efficiency, publications per faculty, and citations per faculty member. As vocational schools are concentrated on the vocational training, but not research, we anticipate that pvoc will have a negative impact on efficiency in both models.

Availability of academic support personnel (support), which is approximated with the ratio of the total academic staff except faculty members (sum of teaching staff and research assistants) to the total faculty members is selected as the eighth efficiency effect variable. Previous studies showed that the availability of the academic support personnel and research assistants had a positive and significant impact on the research performance (Dündar and Lewis, 1998; Wood, 1990). Our results in Chapter 6 also revealed that the availability of the academic support personnel had a significant positive impact on the research efficiency and citations per faculty, whereas it did not have a significant impact on the publications per faculty. We consider that availability of teaching staff will decrease the teaching workload of the faculty members and research assistants will provide external support for the research activities of the faculty members and enhance their performance. Based on these arguments, we expect that the ratio of academic support personnel per faculty member will have a positive impact on the research efficiency in both models.

The ninth variable in the efficiency effect model is the PhD students per faculty member, and it aims to proxy the orientation of universities towards PhD programs. Previous studies that investigated the impact of PhD students on the research efficiency found that its impact was insignificant (Dündar and Lewis, 1998; Wood, 1990). Nevertheless, our analyses provided in Chapter 6 showed that orientation towards PhD programs had a positive and significant impact on the research efficiency, publications per faculty and citations per faculty. As a result, we expect a positive relationship between the efficiency levels and rphd in both models.

The tenth variable included in the efficiency analyses is the project funds per faculty. We use natural logarithm of this variable, and amount of funds are calculated with 2010 prices. Parallel to the results of Wolszczak-Derlacz and Parteka (2011), Dündar and Lewis (1998) and Johnes (1998), in Chapter 6 we detected that TÜBİTAK funds per faculty member had a positive and significant impact on the efficiency, publications per faculty, and citations per faculty. We assume that the research funds facilitate research activities and consequently research outputs. Thus, we expect a positive relation between the amount of the research funds per faculty member and efficiency in both models.

Finally, two year dummies are introduced for the years 2009 and 2010 to accommodate the macroeconomic factors common to all universities.

7.3.2.3. Construction of Data Set

94 universities that were established in and before 2006 are included in the study. Public universities that were established in 2006 will be called as “new public universities” and public universities that were established in and before 1992 will be called as “established public universities”. In total, there are 53 established public universities, 15 new public universities, and 24 private universities included in the analyses. Data used in the study has covered 3 separate years from 2008 to 2010.

Data is collected from several different sources. Number of university staff and students are obtained from annual statistics of Assessment, Selection and Placement Center. Funds allocated to universities by TÜBİTAK are obtained from TÜBİTAK - Academic Research Funding Program Directorate. The total number of publications and the total number of citations received by these publications are derived from WoS database which is an online academic citation index provided by Thomson Reuters.[34] Socioeconomic development indices of provinces was derived from the Ministry of Development. All expenditures are transformed into 2010 prices using deflators provided by the Ministry of Development.

Within the context of this study, we establish two separate SF models. In the first model, we use the total normalized publications as the dependent (production) variable, and in the second model, we use the total normalized citations as the dependent (production) variable. [35]

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[34] Web of Science is designed for providing access to multiple databases, cross-disciplinary research, and in-depth exploration of specialized subfields within an academic or scientific discipline. It covers full text publications, reviews, editorials, chronologies, abstracts, proceedings, technical papers, and patents. It has indexing coverage from the year 1900 to the present and more than 12.000 journals, 30.000 books, and 148.000 conference proceedings in approximately 256 fields are covered in WoS.

[35] The normalization procedure was explained in the fifth chapter, so we will not discuss it again in this chapter.

7.3.2.4. Hypothesis Testing

We have two different hypothesis tests to decide if our SFA models are robust. To test these hypotheses we use a likelihood-ratio test (LR test). The likelihood ratio test compares the likelihood of the data under the alternative hypothesis against the likelihood of the data under a more restricted null hypothesis. The aim is to see whether the alternative has support over the null. The test is performed by the computation of two likelihoods values, and calculated as maximum values of the log likelihood function under the null and the alternative hypotheses. Then the difference between the likelihoods is multiplied by -2 in order to make its distribution similar to that of the Chi-square distribution. The test statistic is then compared to the Chi-square's critical values. The degrees of freedom equals to the difference in the number of parameters that are estimated in the null and alternative hypothesis. The test equation is given in Equation 7.14. Moreover, the list of hypotheses tested is given in Table 56.

$$\lambda = -2\{\log[\mathrm{L}(\mathrm{H}_0)] - \log[\mathrm{L}(\mathrm{H}_1)]\} \qquad (7.14)$$

Our first null hypothesis states that Cobb Douglas production function should be used, whereas the alternative is the translog production function. LR ratio is computed as 141.64 for Model 1, and 94.74 for Model 2 both of which are significantly greater than the critical Chi square value of 25.00 with 15 degrees of freedom at the 5% significance level. Relying on this statistic, we reject the null hypothesis, and favor the translog specification over the Cobb Douglas representation in both models.

Our second null hypothesis asserts that there is no technical inefficiency; whereas the alternative states technical inefficiency does exist. This null hypothesis requires all coefficients of the technical inefficiency model are zero. When we impose this restriction, we get a LR test statistic of 94.70 for Model 1 and 146.06 for Model 2. Both statistics are greater than the critical value of the mixed Chi square test statistic of 21.74 for 13 degrees of freedom[36]. Consequently, we reject the null hypothesis and accept that there is technical inefficiency for both models.

[36] This value taken from Kodde and Palm, 1986 who provide the critical values of the likelihood ratio test when distributions are mixed

Table 56: List of Hypothesis Tested

Models	Null Hypotheses	Log Likelihood	Test Stat	Critical Value*	Decision
Model 1	Cobb Douglas function is proper $H_0 : \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = \alpha_9 = 0$	-157.56	141.64	25.00	Reject H_0
	There is no inefficiency $H_0 : \beta_0 = \beta_1 = ... = \beta_{11} = \gamma = 0$	-184.09	194.7	21.74	Reject H_0
Model 2	Cobb Douglas function is proper $H_0 : \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = \alpha_9 = 0$	-251.06	94.74	25.00	Reject H_0
	There is no inefficiency $H_0 : \beta_0 = \beta_1 = ... = \beta_{11} = \gamma = 0$	-276.72	146ç06	21.74	Reject H_0

*: Critical values are obtained from the appropriate chi-square distribution, except fort the test of hypothesis involving $\gamma = 0$ for technical efficiency effects (Kodde and Palm, 1986)

7.4 Results and Discussions

The estimates of two models are given in Table 57. In the top section of the table, estimates of production function are given. Results reveal that 11 coefficients in Model 1 and 10 coefficients in Model 2 are found significantly different from zero at 1 %, 5% and 10 % significance levels. Moreover, in both models, seven coefficients that represent interaction variables are found to be statistically different than zero, which supports the rejection of the Cobb-Douglas production function in favor of the Translog production function.

Since all inputs are mean-centered, the constant terms of production functions in both models can be interpreted as the expected values of the dependent variables when all of the predictor values are set to their means. According to this, expected value of the ln (total publications) is 5.42 and ln (total citations) is 7.12 when all of the predictor values are set to their means, and these values are statistically significant at %1 level.

Table 57: Stochastic Frontier Estimations

		MODEL 1 Normalized Publications		MODEL 2 Normalized Citations	
Variables	**Parameter**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
I. Production Frontier					
Constant	c1	5.42***	0.08	7.12***	0.10
ln prf (professors)	Prf	0.06	0.07	0.12	0.09
ln asc (associate professors)	Asc	0.27***	0.06	0.31***	0.10
ln ast (assistant professors)	Ast	0.11	0.07	0.06	0.12
ln ra (research assistants)	Ra	0.06	0.05	0.003	0.09
ln inf (infrastructure funds)	inf	0.05***	0.01	0.07***	0.02
ln prf x ln prf	prf2	-0.17***	0.05	-0.12	0.08
ln asc x ln asc	asc2	0.04	0.07	0.44***	0.12
ln ast x ln ast	ast2	-0.12*	0.07	-0.15	0.12
ln ra x ln ra	ra2	0.05***	0.02	0.06***	0.03
ln inf x ln inf	inf2	0.01***	0.00	0.00	0.01
in prf x ln asc	Prfasc	0.33***	0.12	-0.04	0.18
ln prf x ln ast	Prfast	0.06	0.09	0.10	0.15
ln prf x ln ra	Prfra	0.06	0.08	0.25***	0.11
ln prf x ln inf	Prfinf	0.06**	0.03	0.04	0.03
ln asc x ln ast	Ascast	-0.01	0.16	-0.16	0.25
ln asc x ln ra	Ascra	-0.12	0.09	-0.37***	0.14
ln asc x ln inf	Ascinf	-0.14***	0.03	-0.16***	0.04
ln ast x ln ra	Astra	-0.08	0.09	-0.06	0.13
ln ast x ln inf	Astinf	0.04	0.03	0.07*	0.04
ln ra x ln inf	Rainf	0.02*	0.01	0.05***	0.02
II: Inefficiency Effects					
Constant	c2	0.93*	0.47	1.58***	0.61
new public university	Newpub	1.14***	0.30	0.37	0.39
private university	Priv	-1.13***	0.40	-0.38	0.40
socio-economic dev. İndex	Sedi	0.36***	0.12	0.22**	0.09
ratio of faculty in health	Phlt	-5.09***	1.71	-2.63***	0.71
ratio of faculty in sciences	Psci	-0.55	0.40	-0.66	0.60
ratio of faculty in vocat.sc.	Pvoc	1.51	1.06	0.49	0.98
students per faculty	Rstd	0.00	0.00	0.005**	0.00
PhD students per faculty	Rphd	-0.73***	0.28	-0.76***	0.30
TÜBİTAK funds per faculty	Extfund	-0.06***	0.01	-0.09***	0.01
Support personnel per fclt	Support	-0.13	0.15	-0.57**	0.23
Year 2009	y09	-0.65***	0.17	-0.04	0.24
Year 2010	y10	-0.83***	0.21	0.88***	0.23
III: Variance Parameters					
Sigma squared (σ_s^2)	$\sigma_v^2 + \sigma_u^2$	0.52***	0.11	0.77***	0.15
Gamma (γ)	σ_u^2 / σ_s^2	0.94***	0.02	0.95***	0.02
Log-likelihood ratio		-86.74		-203.69	
Mean Technical Efficiency		0.70		0.55	

***p<0.01, **p<0.05, * p<0.1

In both models, as the coefficients of five input quantities (professors, associate professors, assistant professors, research assistants and research infrastructure) are positive, we can say that the monotonicity condition is fulfilled at the sample mean. However, the coefficients of the professors, assistant professors, and research assistants are not statistically significantly different from zero. Therefore, we cannot be sure that these inputs have significant positive effect on the output quantities.

We observe that the output elasticity of professors, associate professors, assistant professors, research assistants and research infrastructure is 0.06, 0.27, 0.11, 0.06 and 0.05, respectively, at the sample means in Model 1, and they are 0.12, 0.31, 0.06, 0.003 and 0.07, respectively at the sample means in Model 2. The highest output elasticity is associated with the associate professors in both models. Similarly, our results in Chapter 6 showed that the most research productive and efficient faculty group in terms of their academic titles were the associate professors. Associate professors might be more experienced than the assistant professors and have higher motivation for academic promotion compared to professors.

When we analyze coefficients of the quadratic terms in Model 1, we identify that professors squared (ln prf x ln prf) and assistant professors squared (ln ast x ln ast) give negative and significant results at 1% and 10% significance levels indicating that the effect of these inputs increases at a diminishing rate. On the other hand, research assistants squared (ln ra x ln ra) and research infrastructure squared (ln inf x ln inf) give positive and significant results at 1% significance level indicating that the effect of these two inputs increases at an increasing rate. Lastly, the coefficient of associate professors squared (ln asc x ln asc) is found to be positive but insignificant.

When we investigate the coefficients of the quadratic terms in Model 2, we identify that professors squared (ln prf x ln prf) and assistant professors squared (ln ast x ln ast) give negative but insignificant results. Meanwhile, coefficients of associate professors squared (ln asc x ln asc) and research assistants squared (ln ra x ln ra) are positive and significant, indicating that total citation productivity increases increasingly with these two inputs. Coefficient of the research infrastructure squared (ln inf x ln inf) is found to be insignificant.

Negative signs on the interaction terms of any two inputs would imply that a substitution effect exists between them, whereas positive signs imply there are production complementarities.

In Model 1, interaction terms between the professors and the associate professors, professors and research infrastructure funds, and research assistants and research infrastructure funds have positive coefficients. These indicate that there are complementarities in publication production between these input pairs.

On the other hand, the interaction term between associate professors and research infrastructure has a negative coefficient indicating that existence of research infrastructure results in a decrease in the effect of associate professors on publication output or vice versa.

In Model 2, interaction terms between professors and research assistants, assistant professors and research infrastructure funds, and research assistants and research infrastructure funds have positive coefficients. These indicate that there are complementarities in citation productivity between these input pairs.

Interaction terms between the associate professors and research assistants, as well as assistant professors and research infrastructure funds have negative coefficients, indicating that existence of research assistants results in a decrease in the effect of associate professors, and existence of research infrastructure results in a decrease in the effect of assistant professors on citation output.

In the second section of the Table 57, estimates of the efficiency function are given. This function is used to estimate impact of the factors on the inefficiency level, thus negative signs indicate a positive impact on the efficiency, whereas positive signs indicate a negative impact on the efficiency.

When we investigate this section, we see that out of 12 efficiency variables, 8 coefficients in Model 1, and 7 coefficients in Model 2 are significantly different from zero.

As we expected, the results show that established public universities are more efficient than the new public universities, but less efficient than the private universities in terms of publication productivity at 1 % significance level. On the other hand, we detect no significant difference among three types of universities in terms of the total citation productivity.

Contrary to the outcomes of Johnes and Yu (2008) who found that the mean research efficiency scores were higher in universities that were located in the rich regions compared to those in the poorer regions of China, we see that universities that are located in less socioeconomically developed regions, have less inefficiency in terms of both publication production (at 1 % significance level) and citation production (at 5% significance level). On the other hand, these results coincide with the results of panel data analyses that we performed in Chapter 6. One reason might be that private universities that are not research-oriented are mostly established in the big cities. Another reason might be that the faculty members working in new public universities, which are mostly located in cities with lower socioeconomic development scores, might have higher academic motivation to make more publications to get an academic promotion

Since previous studies found performance differences in different scientific fields (Adams and Griliches, 1998; Abramo et al., 2012b) we expect that there will be performance differences across universities that have different concentrations in scientific disciplines. The results of SFA reveal that universities that are concentrated in the health sciences are significantly more efficient than universities that are concentrated in the social sciences in terms of both total publications and total citations at 1 % significance level. The results also indicate that coefficients of psci are negative in both models (indicating positive relation between efficiency and psci), but it is not statistically significant. We interpret that having more faculty members in the basic and applied sciences and less faculty members in the social sciences (or vice versa) do not statistically improve efficiency in terms of the total publication and citation productivity.

As we expected, the ratio of faculty members employed in the vocational schools has positive coefficients in both models, indicating that it has an adverse impact on the efficiency of publication and citation production. Meanwhile, its impact is not significant at the 10 % significance level.

We find that students per faculty has no significant impact on the total publication productivity, but it has a very small (but statistically significant) negative impact on the efficiency in terms of the total citations productivity.

Parallel to our initial expectations and analyses results of Chapter 6, we find that the ratio of PhD students per faculty member, and TÜBİTAK funds per faculty member have a positive and significant impact on the efficiency in both models.

In aligned with our prior anticipations, the coefficient of the academic support personnel per faculty member has negative coefficients in both models, indicating that it has a positive impact on the efficiency. On the other hand, this impact is statistically significant in terms of the total citation productivity (at the 5 % significance level) but not in terms of the total publication productivity. We interpret that academic support personnel is important in terms of the quality of the publications but it has no significant impact on the total amount of publications.

When we investigate coefficients of year dummies in Model 1, we see that the coefficients are negative and statistically significant at 1 % significance level and the coefficient of year 2010 is higher than that of year 2009. It means that efficiency in terms of the total publication productivity is increasing during the 2008-2010 period.

In Model 2, the coefficient of the year 2009 is not statistically significant, meaning that the efficiency levels in terms of citation productivity in 2008 and 2009 are not statistically different from each other. On the other hand, we see that the coefficient of the year 2010 is positive and statistically significant at the 1 % significance level. It means that the efficiency level in terms of the citation production is lower in 2010 compared to 2008. This result is expectable because citations increase cumulatively, and as time passes publications have more chance to receive additional citations.

The log-likelihood value is parameterized in terms of gamma (γ). It is equal to 0.94 in Model 1, and 0.95 in Model 2, and statistically significant at the 1 % significance level in both models. It means that much of the variation in the composite error term is due to the inefficiency component and using stochastic frontier model is appropriate for both production functions.

Technical efficiency scores obtained by each university are given in Table 58. In Model 1, the average efficiency score is 0.62 in 2008, 0.72 in 2009, and 0.75 in 2010. We see that the average technical efficiency scores in terms of publication productivity is enhancing during the 2008-2010 period.

In Model 2, the average efficiency score is 0.61 in 2008, 0.60 in 2009, and 0.55 in 2010. The results show that the average efficiency score in terms of citation productivity is decreasing between 2008 and 2010 period, which is an expected situation since we have only performed field-based normalizations, but not year based normalizations for citations.

Table 58: Efficiency scores of universities obtained by SFA

	Model 1 (Total Publications)				**Model 2 (Total Citations)**			
University	**2008**	**2009**	**2010**	**3-Year Average**	**2008**	**2009**	**2010**	**3-Year Average**
AİBÜ	0.75	0.89	0.81	0.82	0.79	0.67	0.31	0.59
Adıyaman	0.21	0.53	0.78	0.51	0.33	0.39	0.62	0.45
A.Menderes	0.69	0.79	0.86	0.78	0.48	0.45	0.41	0.45
Afyon	0.95	0.94	0.63	0.84	0.91	0.88	0.28	0.69
Ahi Evran	0.31	0.52	0.59	0.47	0.44	0.71	0.38	0.51
Akdeniz	0.70	0.90	0.90	0.83	0.72	0.84	0.44	0.67
Aksaray	0.31	0.50	0.75	0.52	0.76	0.62	0.37	0.58
Amasya	0.03	0.17	0.22	0.14	0.03	0.67	0.38	0.36
Anadolu	0.60	0.83	0.91	0.78	0.84	0.56	0.37	0.59
Ankara	0.79	0.87	0.88	0.85	0.83	0.69	0.46	0.66
Ataturk	0.82	0.91	0.93	0.89	0.84	0.86	0.58	0.76
Atılım	0.40	0.75	0.58	0.58	0.29	0.36	0.26	0.30
Bahcesehir	0.51	0.51	0.93	0.65	0.66	0.52	0.59	0.59
Balıkesir	0.44	0.64	0.59	0.56	0.31	0.47	0.19	0.33
Başkent	0.94	0.94	0.92	0.93	0.92	0.84	0.39	0.72
Beykent	0.45	0.34	0.44	0.41	0.42	0.10	0.20	0.24
Bilkent	0.90	0.92	0.94	0.92	0.92	0.92	0.81	0.88
Boğaziçi	0.91	0.91	0.91	0.91	0.92	0.84	0.82	0.86
Bozok	0.19	0.25	0.49	0.31	0.44	0.47	0.52	0.48
C.Bayar	0.62	0.82	0.85	0.76	0.82	0.48	0.36	0.56
Cumhuriyet	0.52	0.59	0.61	0.57	0.42	0.45	0.21	0.36
Çağ	0.22	0.46	0.44	0.37	0.06	0.18	0.84	0.36
ÇOMÜ	0.71	0.83	0.82	0.79	0.62	0.50	0.33	0.48
Çankaya	0.72	0.77	0.94	0.81	0.84	0.84	0.81	0.83
Çukurova	0.86	0.87	0.88	0.87	0.82	0.70	0.48	0.67
Dicle	0.83	0.85	0.71	0.80	0.85	0.56	0.31	0.57

Table 58 (cont'd): Efficiency scores of universities obtained by SFA

	Model 1 (Total Publications)				Model 2 (Total Citations)			
University	**2008**	**2009**	**2010**	**3-Year Average**	**2008**	**2009**	**2010**	**3-Year Average**
Doğuş	0.70	0.65	0.91	0.75	0.46	0.49	0.74	0.56
DEÜ	0.80	0.88	0.74	0.81	0.82	0.74	0.36	0.64
Dumlupınar	0.52	0.69	0.84	0.69	0.47	0.68	0.37	0.51
Düzce	0.79	0.87	0.93	0.86	0.91	0.67	0.72	0.77
Ege	0.82	0.84	0.85	0.83	0.86	0.79	0.55	0.73
Erciyes	0.89	0.94	0.94	0.92	0.91	0.89	0.66	0.82
Erzincan	0.10	0.15	0.43	0.23	0.22	0.20	0.33	0.25
E.Osmangazi	0.78	0.84	0.85	0.82	0.89	0.68	0.43	0.67
Fatih	0.89	0.76	0.91	0.85	0.82	0.66	0.45	0.65
Fırat	0.88	0.91	0.93	0.90	0.92	0.90	0.58	0.80
Galatasaray	0.42	0.42	0.41	0.42	0.54	0.38	0.21	0.38
Gazi	0.83	0.89	0.89	0.87	0.81	0.80	0.50	0.70
Gaziantep	0.89	0.90	0.89	0.89	0.91	0.79	0.53	0.74
Gaziosmanpasa	0.89	0.90	0.88	0.89	0.94	0.87	0.57	0.79
GYTE	0.68	0.91	0.93	0.84	0.91	0.92	0.83	0.89
Giresun	0.13	0.31	0.75	0.40	0.41	0.57	0.12	0.37
Hacettepe	0.92	0.93	0.93	0.93	0.92	0.89	0.67	0.82
Halic	0.35	0.21	0.53	0.36	0.20	0.08	0.10	0.12
Harran	0.83	0.87	0.87	0.86	0.61	0.71	0.43	0.58
Hitit	0.07	0.15	0.18	0.13	0.02	0.16	0.08	0.09
Işık	0.92	0.89	0.71	0.84	0.85	0.65	0.33	0.61
İnönü	0.77	0.69	0.85	0.77	0.59	0.39	0.29	0.42
İstanbul Aydin	0.04	0.12	0.17	0.11	0.09	0.04	0.06	0.06
İstanbul Bilgi	0.52	0.58	0.48	0.52	0.58	0.35	0.10	0.34
İstanbul Bilim	0.88	0.94	0.94	0.92	0.74	0.88	0.52	0.71
İstanbul Kültür	0.35	0.59	0.48	0.47	0.36	0.34	0.12	0.27
İTÜ	0.64	0.71	0.72	0.69	0.81	0.82	0.60	0.74
İstanbul Ticaret	0.36	0.20	0.35	0.30	0.22	0.04	0.07	0.11
İstanbul	0.78	0.85	0.90	0.84	0.81	0.84	0.66	0.77
İzmir Ekonomi	0.56	0.92	0.94	0.81	0.51	0.89	0.62	0.67
İYTE	0.48	0.75	0.74	0.66	0.60	0.80	0.57	0.66
Kadir Has	0.54	0.60	0.81	0.65	0.42	0.32	0.23	0.32
Kafkas	0.92	0.93	0.85	0.90	0.81	0.66	0.42	0.63
KSÜ	0.69	0.91	0.83	0.81	0.55	0.64	0.29	0.49
KTÜ	0.81	0.90	0.94	0.88	0.82	0.91	0.75	0.83
Kastamonu	0.16	0.35	0.30	0.27	0.23	0.28	0.07	0.19
Kırıkkale	0.87	0.90	0.88	0.88	0.77	0.53	0.33	0.54
Kocaeli	0.71	0.82	0.92	0.82	0.65	0.72	0.68	0.68
Koç	0.90	0.87	0.85	0.87	0.92	0.63	0.40	0.65
Maltepe	0.64	0.58	0.72	0.65	0.37	0.31	0.19	0.29
Marmara	0.68	0.86	0.92	0.82	0.72	0.70	0.45	0.62
M.Akif	0.47	0.69	0.63	0.60	0.22	0.34	0.23	0.26
Mersin	0.79	0.71	0.73	0.74	0.65	0.42	0.31	0.46
MSGSÜ	0.05	0.10	0.09	0.08	0.08	0.07	0.02	0.06
Muğla	0.51	0.76	0.81	0.70	0.63	0.83	0.25	0.57
MKÜ	0.84	0.93	0.92	0.90	0.79	0.82	0.60	0.74

Table 58 (cont'd): Efficiency scores of universities obtained by SFA

	Model 1 (Total Publications)				Model 2 (Total Citations)			
University	**2008**	**2009**	**2010**	**3-Year Average**	**2008**	**2009**	**2010**	**3-Year Average**
NKÜ	0.37	0.65	0.61	0.55	0.28	0.78	0.26	0.44
Nigde	0.64	0.78	0.86	0.76	0.65	0.65	0.29	0.53
Okan	0.79	0.73	0.85	0.79	0.43	0.49	0.15	0.36
OMÜ	0.89	0.95	0.94	0.93	0.83	0.83	0.75	0.80
Ordu	0.21	0.36	0.30	0.29	0.11	0.26	0.13	0.17
ODTÜ	0.91	0.94	0.94	0.93	0.93	0.93	0.84	0.90
Pamukkale	0.87	0.90	0.91	0.89	0.83	0.79	0.43	0.68
Rize	0.21	0.46	0.81	0.49	0.60	0.60	0.47	0.56
Sabancı	0.89	0.91	0.88	0.89	0.90	0.86	0.68	0.81
Sakarya	0.41	0.68	0.67	0.58	0.42	0.50	0.34	0.42
Selçuk	0.68	0.91	0.92	0.84	0.81	0.86	0.78	0.82
SDÜ	0.86	0.88	0.88	0.87	0.87	0.68	0.46	0.67
TOBB-ETÜ	0.54	0.73	0.90	0.72	0.30	0.34	0.52	0.39
Trakya	0.77	0.82	0.76	0.78	0.64	0.49	0.29	0.48
Ufuk	0.65	0.81	0.84	0.77	0.54	0.46	0.30	0.44
Uludağ	0.75	0.86	0.85	0.82	0.58	0.66	0.29	0.51
Uşak	0.10	0.31	0.21	0.21	0.07	0.16	0.15	0.13
Yasar	0.71	0.71	0.92	0.78	0.20	0.85	0.90	0.65
Yeditepe	0.69	0.91	0.89	0.83	0.73	0.72	0.45	0.63
YTÜ	0.53	0.71	0.70	0.65	0.54	0.67	0.37	0.53
YYÜ	0.84	0.89	0.92	0.88	0.61	0.61	0.49	0.57
ZKÜ	0.91	0.88	0.87	0.89	0.86	0.64	0.78	0.76
Average	**0.62**	**0.72**	**0.75**	**0.70**	**0.61**	**0.60**	**0.43**	**0.55**

The first 10 universities in terms of the 3-year average technical efficiency scores in Model 1 are ODTÜ, Başkent, Hacettepe, OMÜ, Erciyes, İstanbul Bilim, Bilkent, Boğaziçi, Kafkas, and Fırat University.

The first 10 universities in terms of the 3-year average technical efficiency scores in Model 2 are ODTÜ, GYTE, Bilkent, Boğaziçi, Çankaya, KTÜ, Hacettepe, Erciyes, Selçuk and Sabancı University. We see that ODTÜ, Bilkent, Boğaziçi, Hacettepe, and Erciyes University are common in the two top-ten lists.

We calculate the Spearman rank correlations for assessing the changes in the annual rank orders of the universities for two models separately. The results are provided in Table 59.

Table 59: The Spearman rank correlation statistics by year

	MODEL 1 (Publication Productivity)			MODEL 2 (Citation Productivity)		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**
2008	1.00			1.00		
2009	0.86*	1.00		0.73*	1.00	
2010	0.68*	0.76*	1.00	0.57*	0.70*	1.00

*: significant at 5 % significance level

The lowest rank correlation is 0.68 in Model 1, and 0.57 in Model 2, which indicate a moderate to strong correlation between the annual technical efficiency rankings of universities, in both SFA models suggesting that there is not much movement in rankings between consecutive years. Meanwhile, we see that rankings of efficiency scores for citation production is more prone to changes compared to the publication production.

We also compare the rank orders of universities in terms of their efficiency scores, which are obtained via two SFA models and the DEA Model 6 (from Chapter 5) for each year. The results are provided in Table 60.

Table 60: The Spearman rank correlation statistics by models

	2008			2009			2010		
	SF1	**SF2**	**DEA**	**SF1**	**SF2**	**DEA**	**SF1**	**SF2**	**DEA**
SF1	1.00			1.00			1.00		
SF2	0.84*	1.00		0.78*	1.00		0.77*	1.00	
DEA	0.47*	0.56*	1.00	0.59*	0.59*	1.00	0.46*	0.53*	1.00

*: significant at 5% significance level.

The coefficients that measure the rank order correlations between the efficiency scores of the three models are significant at the 5 % significance level. But the coefficients vary between 0.46 and 0.84. The rank correlation between the efficiency scores obtained in the two SFA models is higher than the rank order correlations between the efficiency scores of SFA and the DEA model.

These comparisons show that even using similar input and output variables SFA and DEA will provide different rankings. This is mainly due to the DEA's advantage of having multiple outputs in the production function. Owing to this flexibility, units of analyses can produce very little or even none from one output and can still be efficient in the DEA. In addition, DEA may assign different weights for inputs and outputs in the production function for each unit of analyses, whereas in SFA one production function is valid for all units.

We also run two DEA models using the same inputs and constraints with the DEA Model 6, but this time we use a single output. In the first model (called as DEA 6.1), we use normalized publications and in the second model (called as DEA 6.2) we use normalized citations as the output. Our aim is to understand whether using a single output, instead of multiple outputs in the DEA models leads to an increase in the rank correlation between the efficiency scores obtained in SFA and DEA. The Spearman rank correlations between the efficiency scores of single-output DEA and SFA are given in Table 61.

Table 61: The Spearman rank correlations between single output DEA & SFA models

Pairs of Comparison	2008	2009	2010
DEA 6.1 vs SF1	0.61*	0.67*	0.63*
DEA 6.2 vs SF2	0.76*	0.78*	0.85*
DEA 6.1 vs DEA 6.2	0.85*	0.89*	0.77*

*: significant at 5% significance level.

From Table 61, we see that the Spearman rank correlations between the single-output DEA models and SFA models are significantly higher than the coefficients that measure rank order correlations between the multiple-output DEA scores and SFA scores.

7.5 Concluding Remarks

This chapter aims to use SFA to measure research efficiency of Turkish universities and investigate factors that lead to higher or lower research performance. In this context, we implement two different SFA models with the different dependent variables, but the same explanatory variables. The first model uses the total number of publications and the second model uses the total number of citations as the dependent variable. Both of the dependent variables are normalized by scientific fields to reflect the field-based productivity differences. We also compare the results obtained through SFA with the results obtained through the DEA that was performed in the previous chapter.

We choose to use the Battese and Coelli (1995)'s production function model which calculates production function and the inefficiency effects simultaneously.

We find that the log-likelihood value, which is parameterized in terms of gamma is equal to 0.94 in Model 1, and 0.95 in Model 2, and statistically significant at the 1 % significance level in both models. In other words, much of the variation in the composite error term is occurred due to the inefficiency component and consequently, using stochastic frontier model in favor of OLS models is determined to be more appropriate for both production functions.

Due to the lack of data, we were obliged to run two separate models, instead of integrating both research outputs in one model. If we had known research expenditures realized by each university, we would have used cost function form of SFA, which allows using multiple outputs. In this point, we strongly suggest developing a national performance evaluation system for the Turkish Higher Education system, which will provide reliable data sets on both the research and teaching activities and the expenditures of universities for the researchers working in this field.

In compliance with our analyses performed in Chapter 6, we find that some factors that have significant impact on one performance measure have insignificant impact on the others. Whereas, we find that the coefficient of all inefficiency factors have the same sign in both models except for the year dummies. Based on these observations, we comment that individual institutions or governments can develop more effective policies towards enhancing research performance of universities, if they handle multiple research outputs together, instead of focusing on a single measure.

We observe that the highest output elasticity belongs to the associate professors in both models. Similarly, our results in Chapter 6 showed that the most research productive and efficient faculty group in terms of their academic titles was the associate professors. Moreover, the negative coefficients for the quadratic terms of professors and assistant professors indicate that their effect on publication production is increasing at a decreasing rate.

We observe that the private universities have significantly higher efficiency in terms of the total publications compared to the public universities. Underlying factors leading to higher performance in the Turkish private universities needs further investigations. For further studies, we suggest analyzing private universities in terms of their management practices, organizational culture, and working environment to identify factors that lead to higher research productivity.

Similar to what we have found in Chapter 6, we observe that the ratio of PhD students and the amount of external research funds per faculty member have a significant positive impact on the efficiency of both total publication and total citation productivity. The availability of the academic support personnel significantly enhances the efficiency in terms of the total citation productivity. Consequently, we suggest universities that target higher research performance to enlarge their PhD programs, enhance support services for their faculty members, and promote their faculty members to obtain more research funds from external sources.

As opposed to our initial expectations, but in aligned with what we have found in Chapter 6, we observe that the socioeconomic development level has a positive significant impact on the efficiency scores. This condition should be scrutinized by the following studies to understand the underlying dynamics.

We find that the overall efficiency score for the three year period is 0.70 for the publication production and it is 0.55 for the citation production model. We can draw two implications from these scores: First, universities have serious efficiency problems in terms of citation productivity when compared to publication productivity. Second, Turkish universities have ample room to enhance their performances in terms of their publication and citation performance. Turkish universities can enhance their research performance through establishing research support offices that will be responsible for directing researchers to establish academic networks, finding higher impact journals, and providing editorial support.

The Spearman rank correlations of annual efficiency scores of universities for both SFA models indicate moderate to strong correlations, suggesting that there is not much movement in the rankings between consecutive years. Similar to what we have observed in Chapter 5, we again see that the research efficiency most probably depends on the inherent abilities, culture and management practices of universities. As a result, we comment establishing management practices and a institutional culture which will support research activities in universities. In this respect, establishing project coordination offices and academic support offices, promoting academic networks, and supporting interdisciplinary research activities are thought to be beneficial.

The coefficients that measure the Spearman's rank correlations between the two SFA models and the DEA Model 6 (which utilizes multiple outputs) have varied between 0.46 and 0.59. On the other hand, we see that the Spearman's rank correlation coefficients between the single-output DEA models and SFA models are significantly higher than these values. Namely, they vary between 0.61 and 0.67 for the models that use normalized publications as the output, and between 0.76 and 0.85 for the models that use normalized citations as the output.

These results show that the DEA and SFA models that use the same single-output and similar inputs provide similar rankings. On the other hand, when the DEA model utilize multiple outputs, the SFA and the DEA models provide different rankings. Since research activities of universities cover a wide range of outputs, we comment that measuring their research performance based on a single output might be misleading to understand their overall research performance. Consequently, we suggest using multiple-output DEA models instead of using SFA models that applies production function assumption.

One of the major insights obtained from this study is that measuring research performance of universities is a complicated issue, such that application of different methodologies and selection of input and output variables might significantly change the results. On the other hand, we support the idea that determining common problematic areas, best performers and worst performers of different models might be useful, while developing the policies in the higher education sector.

CHAPTER 8

CONCLUSION

The purpose of this thesis is to employ different methodologies for evaluating research performance of Turkish universities, compare their results, provide an insight into the factors influencing research performance, and discuss the STI policy implications of this research. Within this context, we investigate research performance of 94 public and private Turkish universities for the period between 2008 and 2010.

Our main motivation to focus on evaluating research performance of Turkish universities is that although these institutions are very important actors of the Turkish STI system, there hasn't been implemented a national-level evaluation system that solely focus on evaluating their research or teaching performance. Moreover, there are very few academic studies that focus on this issue.

During the last decades, an elitist system of higher education has been overtaken by a system of mass higher education in several countries and consequently, both the total number of universities and university students have increased considerably.

With increased number of universities and growing enrollment of students, international ranking schemes have become popular, several governments have launched national-level performance evaluation programs, and academic studies regarding measuring performance of universities have become increasingly more popular.

Universities are realizing that gaining an academic reputation necessitates being a pioneer in knowledge production, fostering innovation, and having reputable researchers. As a result, research performance becomes one of the most important factors for assessing the overall performance of a university.

Performance evaluation studies regarding universities have received an increasing attention not only from governments but also from several different parties such as university managers, academicians, students, and researchers for the last three decades.

Research evaluation studies may use different instruments and indicators depending on the aim, coverage and owner of the study. However, as discussed in Chapter 2, peer review and bibliometric analyses are the most frequently used instruments. Similarly, indicators related to academic publications, graduate students, projects realized by external funds, and entrepreneurial activities are among the most frequently used outputs of the research performance.

Performance of universities should be investigated carefully in Turkey, since these institutions are among the major actors in terms of the research and development (R&D) activities in the country. As presented in Chapter 3, 43.9 % of R&D expenditures are realized by universities and 38.2% of full-time equivalent research personnel are employed by them (TURKSTAT, 2013).

We decide to measure research performance of 94 public and private Turkish universities for the period between 2008 and 2010 through employing both data envelopment analysis and stochastic frontier analysis methods. In addition, we try to identify the impact of selected factors on the research performance through panel data analyses and finally come up with policy proposals to foster research performance across Turkish universities.

Within this context, Section 8.1 presents the main findings of the quantitative analyses. In Section 8.2 we discuss the STI policy implications to improve quality and quantity of research activities performed in Turkish universities. Finally, Section 8.3 presents some limitations of the research and proposes some directions for further research.

8.1. Overall Findings

In Chapter 4, we investigate whether productivity per faculty member in terms of publication, citations, TÜBİTAK projects, and PhD graduates differ by scientific fields and the results we obtained show that per faculty productivity has differed significantly across scientific fields for each of these research outputs.

First of all, we observe that publication per faculty member is the highest for basic sciences (1.44) and it is followed by health sciences (0.84), engineering sciences (0.73), and AFVS (0.41). The lowest ratio is obtained for social sciences (0.15), such that publication per faculty member in the social sciences is almost one tenth of that of basic science.

Next, we find that the highest citations per faculty member is realized in basic sciences (1.81). This ratio is almost twice higher than it is in health sciences (0.62) and engineering sciences (0.75). Meanwhile, the lowest ratios are observed in social sciences (0.09), and AFVS (0.20).

Third, we find that the most productive field in terms of TÜBİTAK projects per faculty member is again basic sciences. Namely, for three-year period, projects per faculty member in basic sciences (0.051) is almost twice of the ratio for AFVS (0.026) and engineering sciences (0.025), and it is almost 9 times higher than the ratios in health sciences (0.005) and social sciences (0.006).

Fourth, we identify that the most productive fields in terms of PhD graduates per faculty member is natural and applied sciences (0.14) and it is followed by social sciences (0.13), and health sciences (0.06).

These productivity differences in terms of research outputs indicate that it will be biased to consider the contribution (or value) of outputs from different scientific fields are equally the same with each other. For example, one article in social sciences should be considered as nearly 10 articles from basic sciences. To handle field-based productivity differences, some scholars prefer to make performance analyses separately for each scientific field. On the other hand, we want to evaluate the overall research performance of universities and decide to apply a different methodology. In this context, we propose to use the sum of field-based normalized outputs, rather than simply summing outputs from different scientific fields to alleviate biases that occur due to field-based performance differences in both DEA and SFA.

In Chapter 5, we implement 10 different DEA models to measure research efficiency of 94 Turkish universities for the period between 2008 and 2010 and try to identify the best fitting model. Basically, we run two CRS models, two VRS models, four assurance region models and two superefficiency models. In five of the models, we use professor, associate professors, and assistant professors as separate input variables. In the other five models we combine all these variables and handle the total amount of faculty members as a single input variable.

Following the methodology developed by Bauer et al. (1998), we compare these models on the basis of four consistency conditions. Although the distributions of efficiency scores vary, rank order correlations of efficiency scores between different models are found high. In addition, the best and the worst performing universities highly overlap in different models. We also observe that efficiency scores are stable over the analysis period for all models. From these outcomes, we conclude that DEA provides a solid base to evaluate research efficiency of universities.

To understand the similarities across models, we calculate rank correlations of efficiency scores and observe moderate to high correlation coefficients. It means that with similar input and output variables, different DEA models provide similar rankings.

Analyses of slacks in the CRS models show that several universities have inefficiencies in terms of TÜBİTAK projects and citations. Moreover, almost half of the universities that have inefficiencies in terms of these two outputs are found as inefficient for the whole analysis period. Meanwhile, the most ineffectively used input is found as the research assistants, and the most effectively used input is found as the funds allocated for research infrastructure.

In both CRS models, almost two third of the universities are found to be operating at decreasing returns to scale conditions. We identify that majority of universities that operate at constant or increasing returns to scale conditions are new public or private universities, whereas among universities that continuously operate at DRS conditions, established public universities hold the majority.

When we compare efficiency scores of models that have faculty members with different academic ranks as separate inputs, and models that combine them into a single input variable, we detect that results of CRS models are very similar, whereas there occur important differences among VRS models, especially in the early years of analyses. In addition, the standard deviation of efficiency scores is higher in models, in which faculty members are combined, compared to the models which have faculty members with different academic titles as separate inputs. Since the cost of faculty members with different academic ranks are different and previous studies have found that productivity of faculty members from different academic ranks differ, we suggest including them as separate input variables into the DEA models.

We capture that average efficiency scores are the lowest (best) in 2010, compared to the previous two years for all models. There might be two factors leading to this result. First, research performance of universities might be converging. Secondly, the citation gap between high quality and low-quality articles might be getting visible after a certain time of publication and two years' time period between the derivation of data and publication year is not enough for discriminating high impact articles from others. From these arguments, we suggest that if citations are to be included as output variables in efficiency studies, then publications should be at least 3 years-old to allow sufficient time to discriminate highly-cited articles from the others.

Avkıran (2001) suggests that if majority of units are assigned different scores under CRS and VRS assumptions, VRS model should be selected. Our results show that correlation coefficients for efficiency scores obtained through CRS and VRS models that use the same input-output combinations are not high in the previous years, so we suggest using variable returns to scale assumption for DEA models.

While putting constraints on input and output variables it is important to refrain from supporting or opposing certain group of universities that have similar characteristics such as age, size, location, ownership, having medical school, etc. In this context, we investigate whether or not a certain group of universities has been affected from the constraints that we put in the assurance region models. We find no systematic relationship. Since we know that experience level and wage of faculty members is increasing with academic promotion, we suggest putting constraints on weights of human resources so that the weight of professors should be higher than the weight of associate professors, the weight of associate professors should be higher than the weight of assistant professors, and the weight of assistant professors should be higher than the weight of research assistants.

In light of these findings, Model 6 is identified as the most preferable DEA model to make further and detailed analyses in terms of measuring research efficiency Turkish universities and identifying factors that have an impact on it. In summary, this model assumes variable returns to scale conditions, integrates faculty members from different academic degrees as separate outputs, and imposes weight restrictions on human resources inputs.

In Chapter 6, we try to identify factors that lead to higher or lower research performance among Turkish universities through panel data analyses. In this context, we utilize five different performance measures as dependent variables. The first dependent variable is selected as the efficiency scores obtained via DEA Model 6 which is applied in Chapter 5. Among four other measures, two of them measure publications per faculty members and the remaining two measure citations per faculty member. We include publications per faculty and citations per faculty ratios in two different ways. In the first way, we calculate these ratios after making field-based normalizations and secondly, we calculate these ratios without making any normalizations.

Previous studies that we were able to reach and that analyzed the impact of different factors on the research performance had used only one dependent variable in their models, and this variable was generally selected as the publications per faculty member of publications per university. On the other hand, we hypothesize that a factor that has a significant and positive impact on one research output might have a negative or insignificant impact on other research output. In compliance with our hypotheses, we find that some factors that are found to have a significant impact on one measure are found to have insignificant impact on other measures.

The results of the panel data analyses indicate that private universities have superior research performance in terms of efficiency scores, publications per faculty and citations per faculty compared to the public universities. In addition, we observe that size has no significant impact on neither publication, nor citation productivity per faculty member. However, it has a small positive impact on the efficiency scores.

We observe that increasing the ratio of professors while decreasing ratio of associate professors lead to a decrease in efficiency scores, publications per faculty and citations per faculty. In addition, increasing ratio of professors while decreasing ratio of assistant professors cause a decrease in the efficiency scores and citations per faculty. These results show that associate professors provide the highest contribution in the research performance of universities.

Parallel to our initial expectations, our results show that the ratio of PhD students, availability of academic support personnel, and amount of external research funds have a significant positive impact on the efficiency scores, publications per faculty and citations per faculty; whereas the ratio of faculty members employed in vocational schools is found to have a negative impact on these research outputs.

On the other hand, as opposed to our initial expectations, students per faculty member has positive coefficients, and socioeconomic development index has negative coefficients in all models. We make some predictions on these results, but these hypotheses should be tested through further studies to be approved. First, we make a reasoning that universities that show better research performance might be preferred by higher number of students and this might be the cause of the positive coefficients of students per faculty. Second, new public universities are mostly located in the provinces with lower socioeconomic development index and these universities have more vacant academic positions. Since academic promotion in Turkish universities, highly depends on the publication performance, faculty members working in these universities might have higher motivation to make more publications and immediately obtain higher academic ranks.

We find that concentration in different scientific fields does not have an impact on the efficiency scores and publications and citations in models that take field-based differences into account. On the other hand, in models that use the sum of publications and citations from different scientific fields without making normalizations, we see that universities that focus on the health sciences and basic and applied sciences have achieved better performance than universities that focus on social sciences. In other words, we find that evaluation studies that will not take field-based productivity differences into account will favor universities that concentrate on health sciences and basic and applied sciences and punish universities that concentrate on social sciences.

In Chapter 7, we implement two different SFA models to measure the research efficiency of 94 Turkish universities for the 2008-2010 period, using similar input and explanatory variables with the DEA models that we run in Chapter 5. We include the total amount of publications and citations after making field-based normalizations similar to what we have done in DEA. In the first model we use the total number of normalized publications, and in the second model we use the total normalized citations as the dependent variable.

We use the Battese and Coelli (1995)'s production function stochastic frontier model, which allows for technical efficiency effects to change in time. The production function and the inefficiency effects are simultaneously estimated in this model.

The log-likelihood value is 0.94 in Model 1 and 0.95 in Model 2, and they are statistically significant at 1 % significance level in both models. These high ratios indicate that much of the variation in the composite error term is occurred due to the inefficiency component and using stochastic frontier model in favor of OLS models is appropriate for both production functions.

The Spearman rank correlation coefficients that compare annual efficiency rankings of universities of both SFA models indicate strong correlations, suggesting that there is not much movement in the efficiency rankings between consecutive years.

We detect a lot of similarities between the results of the panel data analyses that we perform in Chapter 6 and SFA that we perform in Chapter 7. First of all, we observe that private universities have higher efficiency in terms of the total number of publications compared to public universities. Secondly, we find that the ratio of PhD students, availability of academic support personnel, and amount of external research funds have a significant positive impact on the research performance. Finally, we observe that socioeconomic development index is negatively correlated with the efficiency scores.

Results of SFA show that output elasticity is the highest for the associate professors compared to the professors and the assistant professors. Moreover, negative coefficients of quadratic interaction terms of the professors and the assistant professors indicate that they are working at decreasing returns to scale.

We compare rankings obtained from SFA models, with the rankings obtained from DEA Model 6 that was constructed in Chapter 5. In addition, instead of using multiple outputs, we twice run DEA Model 6 with one output and the 5 inputs. In the first run, we use normalized publications per faculty member and in the second run, we use normalized citations per faculty member as the output.

The coefficients that show the Spearman's rank correlations between the two SFA models and the original DEA Model 6 have varied between 0.46 and 0.59 during the analysis period. On the other hand, we see that the Spearman's rank correlation coefficients between the single-output DEA models and SFA models are significantly higher than these values. Namely, they have varied between 0.61 and 0.67 for the models that use normalized publications as the output and between 0.76 and 0.85 for the models that use normalized citations as the output.

These results show that DEA and SFA models that use the same output and input combinations provide similar rankings. On the other hand, we find that multiple output DEA model and single output SFA models provide different rankings.

Since research activities of universities cover a wide range of outputs, we comment that measuring their research performance based on a single output might be misleading to understand their overall research performance. Consequently, we suggest using multiple-output DEA models instead of using SFA models that apply production function assumption and utilize a single output.

8.2. Policy Implications

Developing and implementing national-level R&D strategies serve several functions in government policy making. First, they state the government's vision regarding the contribution of research activities to the social and economic development of that country. Second, they define priorities for public investments and identify the main targets of government reforms.

Based on the findings and compiling of this dissertation, we develop some policy recommendations for enhancing the research performance of Turkish universities. A summary of these policy recommendations and measures to be utilized while realizing these policies are given in Table 62.

8.2.1. Developing a national performance evaluation system for universities

As the first policy recommendation, we suggest developing and implementing a national performance evaluation system for the Turkish Higher Education sector, which will measure performance of universities over a wide-ranging set of activities from teaching to research activities and even to their contributions to society. Furthermore, we suggest this system to have an open-access database for the researchers working in the related academic fields. Evaluation results may lead to a re-positioning of policies and programs, shape the allocation of public funding and inform the development of national STI strategy (OECD, 2012b).

The role of institutional or departmental level evaluation is to generate information about the appropriateness and effectiveness of the units of analyses and this information can be used: (i) to assess performance of different units, (ii) to make comparisons between units, (iii) to identify the problems or areas of improvements, (iv) to enhance quality, (v) to allow policy makers to account for public spending choices.

Table 62: Summary of the policy recommendations and measures

Policy	**Measures**
A national performance evaluation system for the Turkish Higher Education sector should be executed.	Utilize different methodologies and crosscheck their results to enhance accountability of the system. Make evaluations separately for each scientific field (or make the field based normalizations with the outputs). Base evaluations upon a wide-ranging set of activities instead of focusing on a single output. Provide an open-access database for the use of universities and researchers.
Organizational and management capacities of Turkish universities in terms of their research activities should be enhanced.	Associate some portion of the research funds allocated to universities with their research performance. Establish project coordination offices and/or research support offices. Promote interdisciplinary research activities. Provide incentives for faculty members to perform research activities. Employ research assistants in research activities more effectively. Provide extra support services for research activities of faculty members who are employed in vocational schools. Foster institutional research culture.
World-class research universities should be cultivated.	Develop objective and accountable criteria for selection of the research universities. Promote graduate level programs in the research universities. Improve support services for faculty members for both their teaching and research activities in the research universities. Provide adequate level and continuous funding for both basic and applied R&D projects for the research universities. Allow higher management autonomy for research universities.

The outcomes of university research performance evaluation system will shed light on issues such as whether there exist important differences between universities, whether such differences have been increasing or decreasing, whether research should be further concentrated in certain universities. Universities can be classified using these studies and instead of coming up with unilateral policies, different regulations and incentives can be developed for different university types that have different needs. In addition, the government can use these results to allocate research funds to universities.

Other than the government, the results of the evaluation system can also serve for the directors and academic staff of the universities. University managers can use them in setting academic targets, enhancing their institutional reputation and allocating resources. Additionally the selected criteria and related weights used in evaluation processes might provide a motivational direction for universities to enhance their capacities as to get higher points from the exercises. Based on the findings of this study, we come up with four policy measures related to the first policy proposal.

First of all, we understand that measuring research performance of universities is a complicated issue, such that the application of different methodologies and selection of input and output variables might significantly change the results. For example, the coefficients that measure rank order correlations between the two SFA models and DEA models are found significant but they vary between 0.46 and 0.59. It means that even using similar input and output variables SFA and DEA provide different rankings. Based on these results we suggest using different methodologies and checking their robustness to increase accountability of the evaluation studies.

Secondly, we detect that not only citations, but also publications, projects and PhD graduates per faculty member have significantly differed by scientific fields. As a result, we argue that it will be biased to compare absolute values of outputs in the evaluation studies. For example, if we use absolute number of publications per faculty and citations per faculty instead of their normalized values, then universities that concentrate in health sciences and basic and applied sciences will reach to better performance than universities that concentrate in social sciences. Consequently, we propose making performance analyses separately for each scientific field, rather than making an overall assessment or making field based normalizations before implementing the evaluation study.

Third, we find that some factors that are found to have significant impact on one research output are found to have insignificant impact on other outputs. We propose that governments can enhance the power of their policy interventions towards higher education sector when they handle multiple research outputs together, instead of focusing on a single output. Dealing with multiple-outputs will help policy makers to identify factors that have the most significant and widespread impact on the research performance of the universities.

Fourth, from the literature review performed in Chapter 2, we see that the results obtained from the evaluation exercises provide insights not only for the governments but also for the directors and academic staff of the universities, and for the researchers who are working in the related fields. Thus, we propose that the metadata collected during the evaluation study as well as the outputs obtained should be available for the interested parties.

8.2.2. Enhancing institutional research capacity of Turkish universities

Results of DEA, SFA, and panel data analyses show that research performance is closely related to the organizational culture and inherent capabilities of the universities.

In this context, outcomes of the panel data analyses indicate that more than half of the variation in all research performance measures occur due to unobserved abilities and institutional culture of universities. Secondly, results of DEA show that almost half of the universities that have inefficiencies in terms of TÜBİTAK projects and citations have consistently repeated this situation during the analysis period. Third, SFA results indicate that more than half of the variation of inefficiency that occur in both publication productivity and citation productivity of universities occur due to their unobserved abilities and institutional culture.

Based on these results, our second policy proposal states that organizational and management capacities of Turkish universities in terms of their research activities should be enhanced. Under this policy proposal, we come up with seven policy measures.

First of all, we suggest that some portion of the research funds allocated to universities should be associated with their performance because we think that that linking additional research funds with predetermined performance criteria will reduce waste or inefficiency that occurred in terms of research funds.

Secondly, we suggest universities to establish project coordination offices and/or research support offices that will be responsible for providing support for faculty members in their research activities. These offices might guide researchers to edit academic publications, prepare project proposals, establish academic networks, and find higher impact journals.

Third, we recommend to promote interdisciplinary research activities in universities. In the panel data analyses we observe that size has no significant impact on publication and citation productivity, whereas it has a small positive impact on efficiency scores. We also identify that majority of the universities are operating at decreasing returns to scale in DEA. These two results together show that universities are not benefiting from economies of scale. Dündar and Lewis (1999) and Wolszczak-Derlacz and Parteka (2011) have found that universities with higher number of different faculties have reached to better efficiency scores and they attribute this result to R&D studies becoming more interdisciplinary. In this respect, promoting interdisciplinary research culture in Turkish universities may help them to benefit more from economies of scale. Special programs that will support interdisciplinary projects can be launched, publication that cover multiple scientific disciplines can be rewarded and interdisciplinary graduate-level programs can be opened.

Fourth, our results show that there is a need to enhance motivation of the faculty members towards performing research activities. In panel data analyses we observe that the research performance of the professors in terms of efficiency scores, publication per faculty and citation per faculty is lower than the associate professors, and lower than the assistant professors in terms of efficiency scores and citation productivity. Similarly, the results of the SFA show that both publication and citation productivity are more sensitive to changes in the number of associate professors. Within this scope, we suggest developing new performance criteria to enhance motivation of faculty members towards research activities. In our opinion, the current academic promotion system in Turkey, which is mainly based on publication performance, has to change in a way that provides more incentives for faculty members who are more active in research activities. Meanwhile, research activities under the evaluation should not be limited to publications, but rather they should cover a wide range of research outputs from participation in international R&D projects to industry cooperation activities, and ownership of patents.

Fifth, slacks obtained in DEA display that the least efficiently used inputs are the research assistants and we suggest that there is a need for Turkish universities to develop strategies that target employing research assistants in research activities more effectively. In this context, providing trainings that will enhance research performance of research assistants (such as academic writing, networking, statistical analyses, research methodologies, and etc.) is thought to be beneficial. In addition, universities can develop rewarding mechanisms for research assistants who prepare outstanding projects or dissertations, or whose academic studies are published in the high-impact journals. The rewarding systems must not necessarily be monetary, but they can also be honorary.

Sixth, we deduct that universities that employ higher share of their faculty members in vocational schools are less research efficient. Within this framework, we propose that implementing special programs that will provide extra support for research activities of faculty members who are employed in vocational schools will be beneficial. We all know that research activities are not limited to publications, citations or academic R&D projects. Cooperation with the private sector through projects or providing consulting services to them are important research outputs as well. From this point of view, we propose that universities can initiate programs that support establishing networks between vocational schools and private sector and implementing joint research and development activities.

Finally, we suggest universities to arrange scientific events such as workshops, conferences, and trainings regularly to foster institutional research culture.

8.2.3. Identifying and supporting research universities

Our third policy proposal is to cultivate world-class research universities, which will provide the key link between global science and scholarship and national STI system in Turkey.

Research universities are elite and complex institutions that realize multiple academic and societal roles simultaneously. They produce new information that leads to both significant developments in technology and contributes to better understanding of the humanity, society and environment through the social sciences and humanities (Altbach, 2011).

As national institutions, research universities serve only a smaller section of undergraduate students, and employ best faculty members. They are the main source of educating students at the doctoral level and produce the majority of the research output and form the minority of the total tertiary education institutions. For instance, in the US, approximately 150 out of its 4,800 universities; in India 10 out of its 18,000 universities, and in China 100 out of its 5,000 universities can be considered as global research universities (Altbach, 2011).

We see that several nations have developed their own classification schemes to support research universities in a more targeted way. In this respect, China approved a special funding program to build research universities as part of its 985 project in 1998. In 1999, South Korea initiated the "Brain Korea 21" program and in 2002 the Japanese government launched the "Center of Excellence" program. Similarly, in 2005 Germany has adopted a special project to build competitive research universities. Countries that have adopted these programs have also observed rapid increases in terms of research productivity of scholars at the selected universities. For instance, research productivity of faculty members who were working in the selected universities were found to be increased in China, South Korea, Singapore, and Taiwan (Balan, 2007; King, 2004; Leydesdorff and Zhou, 2005; Shin, 2009b).

In Turkey, there is an initiative called as The Entrepreneurial and Innovative University Index that aim to evaluate entrepreneurial and innovative capacity of

Turkish universities. But there isn't any study implemented to classify or rank them according to their research potential and capacity.

To promote quantity, quality and industrialization of research activities that are realized in the universities, we suggest introducing the concept of "research universities" in the Turkish Higher Education sector. We set up five measures under this policy proposal based on the findings of our analyses.

First of all, the selection of the research universities should be based on objective criteria that will be widely acclaimed by the actors of the higher education sector. Due to their unique academic mission, these universities require continuous support and favorable working conditions for the researchers. Consequently, their budgets are larger and their brand values are higher than other universities. Since being classified as "Research University" will provide additional opportunities, there is risk for several universities to claim that they are "research universities". For example, in South Korea, soon after the initiation of the Brain Korea 21 project, a lot of controversy was occurred about which universities to be selected as research universities. In the end, the Korean government decided to allocate research funds to all universities that had PhD-level programs (Shin, 2009b).

Secondly, research universities should be supported to open graduate level programs. Because both panel data analyses and SFA results show that the ratio of PhD students per faculty member has a significant positive impact on the efficiency scores, publications per faculty member and citations per faculty member. In this respect, common graduate level programs among different universities can be promoted and availability of online courses can be enhanced.

Third, we suggest to improve support services for faculty members for both their teaching and research activities in the research universities. Our analyses show that ratio of academic support personnel per faculty member has a significant positive impact on the efficiency scores, publications per faculty member and citations per faculty member.

Fourth, we suggest continuously allocating adequate level of funds for the basic and applied research activities of the research universities. Our analyses indicate that external project funds per faculty member has a significant positive impact on the efficiency scores, publications per faculty member and citations per faculty member.

Fifth, we propose that research universities should have higher management autonomy to set their academic targets for reaching academic excellence. Several studies, as well as our study, find that private universities are more research efficient and productive than the public universities. This situation is attributed to private universities having more managerial autonomy and flexibility to specialize in certain subjects compared to the public universities.

8.3. Limitations of the research and directions for further research

This study has a number of limitations resulting mainly from the lack of data. First of all, the data regarding publications were limited with publications that were indexed by Web of Science (WoS) in this study. Meanwhile, books and publications that were indexed by national scientific journals, but not indexed by WoS were not included.

Secondly, data regarding the graduates of PhD programs were available in terms of graduate institutes, but not available in terms of individual PhD programs. Since graduates from basic sciences, applied and engineering sciences, and AFVS were listed together under the Science Institute, we performed our analyses in terms of only three scientific fields for PhD graduates.

Thirdly, data regarding the number of faculty members, and students was available as of the beginning of the academic calendar and these numbers change during the year. Since we were not able to track movements of faculty members and students, we made our analyses based on the initial records.

We made our analyses based on quantitative data to determine impact of factors on the research performance of universities. We suggest further studies to apply structured surveys or in-depth interviews to elaborate more on the attributes of high-performance researchers and universities, and to assess the impact of organizational culture and management practices on the research performance of universities.

For example, in the panel data analyses, we distinguish that private universities have superior research performance in terms of efficiency, publication per faculty and citation per faculty than public universities. In SFA, we observe that private universities have higher efficiency in terms of the total publications compared to public universities. In other words, private universities operate more efficiently in their research activities, their faculty members write more publications and receive more citations compared to their peers working in public universities.

We strongly suggest further studies to investigate private universities in terms of their management practices, organizational culture, and working environment to identify the most important factors that lead to higher research performance. We think that these studies might help developing policy tools for enhancing the research performance of the overall higher education system and they might also provide insight on the unexpected results that were obtained in both DEA and SFA.

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Appendix A: Efficiency Scores Of DEA Models

University	Model 1			Model 2			Model 3			Model 4			Model 5		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
AİBÜ	1,899	1,702	1,975	1,698	1,330	1,453	2,887	2,659	3,178	2,425	2,105	2,352	1,918	1,744	1,989
Adıyaman	1,537	1,000	1,486	1,000	1,000	1,281	2,561	1,148	3,223	1,000	1,000	3,201	1,721	1,000	1,520
A.Menderes	2,259	2,501	2,381	1,936	1,930	1,641	3,294	3,102	2,407	2,348	2,104	1,702	2,349	2,562	2,431
AKÜ	1,125	1,258	1,000	1,000	1,067	1,000	2,423	2,296	1,914	1,910	1,740	1,000	1,153	1,425	1,000
Ahi Evran	1,965	1,819	1,227	1,564	1,633	1,221	4,872	3,747	2,740	4,644	3,618	2,629	2,053	2,034	1,279
Akdeniz	3,093	2,013	1,460	2,018	1,128	1,000	3,189	2,146	1,689	2,414	1,226	1,000	3,225	2,206	1,692
Aksaray	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,354	1,000	1,000	1,238	1,000	1,000	1,000	1,000
Amasya	6,899	1,000	1,000	1,000	1,000	1,000	23,545	1,325	1,026	10,215	1,000	1,000	9,202	1,297	1,000
Anadolu	1,426	1,604	1,388	1,404	1,390	1,068	2,067	2,177	1,744	1,810	1,646	1,317	1,449	1,635	1,419
Ankara	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,260	1,000	1,000	1,000	1,000	1,000	1,294
Ataturk	1,191	1,183	1,652	1,000	1,000	1,000	1,484	1,394	1,788	1,094	1,023	1,094	1,239	1,219	1,696
Atılım	2,111	1,000	1,957	2,008	1,000	1,709	3,846	2,386	2,284	3,660	2,368	2,196	3,196	1,920	2,256
Bahcesehir	2,760	2,827	1,224	2,544	2,658	1,120	3,638	4,217	1,572	3,510	4,154	1,528	3,622	4,224	1,481
Balıkesir	2,441	1,703	1,969	2,218	1,641	1,547	4,575	3,397	3,179	3,955	3,091	1,570	2,521	1,857	2,009
Başkent	1,403	1,165	1,373	1,000	1,000	1,000	1,576	1,258	1,408	1,000	1,000	1,000	1,446	1,238	1,451
Beykent	2,931	6,913	4,466	2,844	5,221	3,760	8,824	14,046	8,188	8,574	14,018	7,874	7,948	13,191	6,631
Bilkent	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Boğaziçi	1,093	1,264	1,105	1,000	1,127	1,000	1,101	1,359	1,156	1,086	1,240	1,046	1,145	1,413	1,204
Bozok	2,221	3,234	1,187	1,656	2,710	1,180	6,431	5,418	2,959	5,561	5,191	2,667	2,271	3,300	1,246
CBÜ	2,688	2,889	2,535	1,356	1,907	1,624	2,880	2,905	2,606	1,408	2,289	1,948	2,896	2,956	2,655

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 1			Model 2			Model 3			Model 4			Model 5		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
Cumhuriyet	2,329	3,473	3,102	2,287	2,658	2,270	3,589	3,569	3,247	3,320	2,871	2,641	2,510	3,576	3,176
Çağ	3,266	2,409	1,000	1,000	1,612	1,000	8,385	3,589	1,000	2,200	1,751	1,000	7,793	3,463	1,000
ÇOMÜ	2,470	2,685	2,523	1,986	1,882	1,492	3,639	3,680	2,978	2,339	2,302	2,002	2,478	2,773	2,785
Çankaya	1,499	1,570	1,000	1,215	1,569	1,000	2,004	2,354	1,181	1,888	2,225	1,019	2,110	2,352	1,054
Çukurova	1,453	1,393	1,350	1,163	1,191	1,262	1,490	1,587	1,528	1,430	1,352	1,394	1,548	1,627	1,542
Dicle	2,686	1,891	3,778	1,788	1,418	2,095	3,303	2,180	3,848	1,996	1,634	2,470	2,715	1,904	3,827
Doğuş	1,807	1,900	1,214	1,775	1,900	1,204	2,564	3,146	1,553	2,308	3,104	1,344	2,680	3,194	1,495
DEÜ	1,451	1,705	1,880	1,287	1,184	1,297	1,514	1,744	1,951	1,491	1,246	1,611	1,546	1,772	2,015
Dumlupınar	1,546	1,288	1,541	1,344	1,252	1,255	3,585	2,702	2,819	3,438	2,578	2,513	1,572	1,343	1,808
Düzce	1,553	2,288	1,114	1,522	1,363	1,000	3,113	2,649	1,364	3,074	2,475	1,290	2,153	2,554	1,168
Ege	1,348	1,631	1,409	1,000	1,000	1,054	1,483	1,712	1,584	1,000	1,010	1,083	1,520	1,741	1,627
Erciyes	1,846	1,316	1,144	1,456	1,035	1,000	1,916	1,468	1,211	1,592	1,056	1,032	2,065	1,557	1,255
Erzincan	5,255	4,652	1,000	4,521	4,319	1,000	13,434	12,757	4,074	12,185	12,312	3,865	5,656	5,558	1,159
ESOGÜ	1,481	1,533	1,917	1,081	1,029	1,074	1,687	1,671	2,175	1,269	1,031	1,105	1,496	1,598	2,258
Fatih	1,600	2,609	1,633	1,440	1,783	1,147	2,034	2,921	1,658	1,805	2,373	1,455	1,631	2,794	1,728
Fırat	1,111	1,642	1,221	1,024	1,003	1,000	1,440	1,719	1,268	1,215	1,073	1,000	1,128	1,727	1,260
Galatasaray	2,425	2,018	2,118	2,423	1,957	1,988	2,552	2,051	2,286	2,500	2,046	2,261	2,600	2,143	2,423
Gazi	1,404	1,433	1,482	1,051	1,000	1,000	1,425	1,439	1,589	1,059	1,000	1,000	1,455	1,440	1,589
Gaziantep	1,750	1,937	2,192	1,586	1,367	1,414	1,951	1,991	2,259	1,822	1,689	1,665	1,780	2,095	2,284
G.osmanpasa	1,442	2,246	1,835	1,308	1,514	1,283	2,914	2,912	2,333	2,180	2,181	2,059	1,530	2,347	1,926

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 1			Model 2			Model 3			Model 4			Model 5		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
GYTE	1,072	1,217	1,000	1,064	1,191	1,000	1,706	1,498	1,188	1,610	1,498	1,168	1,121	1,368	1,221
Giresun	1,000	1,000	1,000	1,000	1,000	1,000	3,121	1,000	1,589	1,632	1,000	1,000	1,000	1,000	1,044
Hacettepe	1,000	1,000	1,000	1,000	1,000	1,000	1,001	1,209	1,130	1,000	1,000	1,000	1,071	1,270	1,176
Halic	3,214	11,200	3,262	3,003	7,315	2,795	6,254	16,212	5,173	5,714	16,174	4,640	5,635	15,834	4,742
Harran	2,317	2,784	1,737	1,978	1,894	1,490	3,671	3,411	2,591	2,707	2,497	1,890	2,399	2,841	1,782
Hitit	1,000	3,825	4,195	1,000	3,311	4,145	1,548	6,849	6,260	1,492	6,428	5,738	1,118	4,376	4,413
Işık	1,000	1,000	1,264	1,000	1,000	1,000	1,000	1,000	1,860	1,000	1,000	1,124	1,000	1,000	1,696
İnönü	1,293	3,219	2,906	1,154	2,359	1,651	2,081	3,565	3,122	1,562	2,862	1,970	1,367	3,321	3,122
İst. Aydin	17,295	12,713	11,239	1,000	1,000	10,683	32,950	23,756	17,418	1,000	1,000	17,047	54,678	23,962	19,19
İstanbul Bilgi	2,308	2,225	3,269	2,258	1,968	2,991	2,556	2,894	3,508	2,490	2,767	3,497	2,744	2,764	3,467
İst. Bilim	1,497	1,107	1,259	1,000	1,000	1,000	3,497	2,388	2,374	2,589	2,217	2,068	3,736	2,414	2,439
İst. Kültür	5,567	3,334	3,344	3,352	2,319	2,616	5,803	3,814	4,326	3,812	3,417	3,600	5,906	3,882	4,363
İTÜ	2,246	1,777	1,854	1,477	1,296	1,333	2,343	1,840	1,958	1,570	1,342	1,333	2,297	1,914	2,007
İst.Ticaret	4,458	8,265	4,243	3,835	8,022	3,477	8,136	12,560	6,459	6,848	12,138	5,625	8,422	12,560	6,544
İstanbul	1,000	1,016	1,181	1,000	1,000	1,000	1,401	1,399	1,700	1,000	1,000	1,000	1,452	1,444	1,758
İz. Ekonomi	1,290	1,000	1,000	1,242	1,000	1,000	1,872	1,000	1,052	1,702	1,000	1,000	1,339	1,000	1,000
İYTE	1,756	1,508	1,371	1,727	1,506	1,255	2,401	1,837	1,599	2,252	1,793	1,448	1,847	1,585	1,436
Kadir Has	1,660	1,036	1,000	1,626	1,012	1,000	1,972	1,087	1,000	1,742	1,049	1,000	1,678	1,121	1,000
Kafkas	1,000	1,000	1,626	1,000	1,000	1,422	1,448	1,507	1,741	1,425	1,506	1,647	1,000	1,025	1,683
KSÜ	2,541	1,597	2,628	2,255	1,399	1,685	4,073	2,433	2,779	3,420	2,140	2,134	2,690	1,692	2,779

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 1			Model 2			Model 3			Model 4			Model 5		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
KTÜ	1,762	1,461	1,566	1,160	1,000	1,000	1,885	1,474	1,722	1,241	1,000	1,000	1,843	1,508	1,807
Kastamonu	1,944	1,865	1,813	1,092	1,724	1,811	5,416	3,431	3,049	4,083	3,207	2,173	2,242	2,455	1,956
Kırıkkale	1,809	2,496	2,250	1,604	1,659	1,475	2,759	3,003	2,459	2,014	2,252	1,868	1,882	2,527	2,321
Kocaeli	2,500	2,199	1,862	1,942	1,552	1,139	3,371	2,740	2,143	2,681	1,786	1,345	2,523	2,217	1,872
Koç	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Maltepe	2,283	6,036	4,189	1,982	3,030	2,643	4,963	8,419	5,831	3,685	7,275	5,490	5,135	8,409	5,338
Marmara	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Mehmet Akif	1,062	1,333	1,248	1,036	1,314	1,247	2,714	2,801	2,321	2,400	2,713	2,247	1,275	1,583	1,346
Mersin	2,319	3,341	1,537	1,806	2,282	1,070	3,788	3,813	1,948	2,010	2,522	1,070	2,514	3,400	1,562
MSGSÜ	1,000	1,000	1,000	1,000	1,000	1,000	1,592	1,000	1,138	1,000	1,000	1,000	1,000	1,000	1,000
Muğla	2,945	2,605	2,500	2,069	1,557	1,594	3,783	2,803	2,570	2,201	1,864	1,993	3,045	2,623	2,523
MKÜ	1,997	1,953	1,847	1,659	1,249	1,052	3,326	2,769	2,351	2,306	1,764	1,585	2,021	2,033	2,022
NKÜ	1,057	1,508	2,084	1,000	1,190	1,571	1,709	1,925	2,778	1,090	1,829	1,864	1,066	1,617	2,107
Nigde	1,744	1,230	1,227	1,412	1,190	1,021	3,264	2,454	2,269	3,101	2,357	2,070	1,747	1,306	1,279
Okan	1,000	1,176	2,687	1,000	1,000	1,882	2,871	3,606	3,980	1,312	1,000	3,857	2,762	3,508	3,501
OMÜ	1,540	1,601	1,575	1,241	1,080	1,000	2,017	1,653	1,674	1,443	1,247	1,078	1,568	1,634	1,647
Ordu	1,898	2,478	2,022	1,825	2,361	2,022	5,072	3,788	3,935	3,910	3,704	3,395	2,711	2,676	2,086
ODTÜ	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,118	1,051
Pamukkale	2,296	2,563	1,579	1,342	1,321	1,222	2,845	2,744	2,207	1,683	1,802	1,516	2,329	2,632	1,581
Rize	1,288	2,409	1,126	1,204	2,119	1,043	4,309	2,873	1,294	3,140	2,722	1,085	1,367	2,621	1,135

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 1			Model 2			Model 3			Model 4			Model 5		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
Sabancı	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Sakarya	1,743	1,913	1,707	1,739	1,762	1,631	2,852	2,906	2,728	2,746	2,194	2,169	1,834	2,028	1,798
Selçuk	1,606	1,593	1,689	1,378	1,016	1,000	1,956	1,682	1,787	1,726	1,170	1,004	1,615	1,602	1,780
SDÜ	1,217	1,217	1,420	1,102	1,187	1,163	1,963	2,114	2,044	1,650	1,724	1,424	1,265	1,308	1,508
TOBB-ETÜ	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Trakya	1,831	2,087	2,105	1,359	1,791	1,253	2,652	2,577	2,921	1,852	2,242	1,356	1,882	2,114	2,137
Ufuk	2,790	2,668	1,944	2,398	2,580	1,650	6,452	6,084	3,868	5,985	6,043	3,517	6,894	6,285	4,202
Uludağ	1,543	1,339	1,181	1,372	1,117	1,000	1,716	1,885	1,944	1,427	1,284	1,195	1,794	1,959	2,025
Uşak	1,911	2,003	1,000	1,000	1,506	1,000	7,465	3,769	2,398	7,412	3,636	1,810	4,333	2,281	1,000
Yasar	1,143	2,103	1,208	1,072	1,820	1,000	5,646	3,234	1,743	4,706	3,129	1,661	5,586	3,283	1,778
Yeditepe	1,335	1,000	1,905	1,000	1,000	1,021	1,335	1,000	2,042	1,000	1,000	1,021	1,761	1,320	2,242
YTÜ	1,909	1,489	2,456	1,839	1,342	1,647	2,315	1,694	2,470	2,252	1,623	2,048	2,050	1,492	2,496
Yuzuncuyıl	1,597	2,113	1,820	1,398	1,599	1,227	2,554	2,277	2,054	2,388	1,940	1,607	1,642	2,130	1,842
ZKÜ	1,590	2,291	1,573	1,376	1,689	1,014	2,925	3,623	1,988	2,430	2,805	1,472	1,692	2,455	1,798

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 6			Model 7			Model 8			Model 9			Model 10		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
AİBÜ	1,748	1,371	1,562	2,974	2,693	3,224	2,433	2,119	2,360	2,887	2,659	3,178	2,382	2,551	2,647
Adıyaman	1,000	1,000	1,519	2,640	1,155	3,297	1,000	1,000	3,283	2,561	1,148	3,223	1,136	0,799	2,606
A.Menderes	1,973	1,945	1,643	3,363	3,123	2,434	2,348	2,133	1,709	3,294	3,102	2,407	2,542	2,672	2,166
Afyon	1,000	1,162	1,000	2,488	2,340	1,963	1,930	1,746	1,000	2,423	2,296	1,914	1,847	2,046	1,494
Ahi Evran	1,658	1,825	1,273	4,972	3,752	2,810	4,743	3,657	2,703	4,872	3,747	2,740	2,868	3,223	2,192
Akdeniz	2,026	1,133	1,000	3,309	2,180	1,737	2,456	1,228	1,000	3,189	2,146	1,689	2,803	2,115	1,524
Aksaray	1,000	1,000	1,000	1,012	1,416	1,000	1,000	1,300	1,000	0,937	1,354	0,692	0,732	1,250	0,608
Amasya	8,859	1,278	1,000	23,581	1,369	1,037	12,871	1,328	1,009	23,545	1,325	1,026	2,076	1,002	0,870
Anadolu	1,448	1,401	1,083	2,093	2,186	1,746	1,874	1,662	1,347	2,067	2,177	1,744	1,876	2,107	1,700
Ankara	1,000	1,000	1,000	1,000	1,000	1,277	1,000	1,000	1,000	0,895	0,875	1,260	0,895	0,875	1,260
Ataturk	1,000	1,000	1,005	1,486	1,397	1,788	1,207	1,075	1,201	1,484	1,394	1,788	1,484	1,393	1,788
Atılım	3,191	1,911	2,065	3,864	2,402	2,284	3,669	2,384	2,208	3,846	2,386	2,284	2,890	2,290	2,249
Bahcesehir	3,616	3,938	1,428	3,787	4,324	1,626	3,671	4,267	1,587	3,638	4,217	1,572	2,440	3,055	1,418
Balıkesir	2,278	1,781	1,713	4,628	3,397	3,195	4,134	3,196	2,136	4,575	3,397	3,179	2,428	2,169	2,062
Başkent	1,000	1,000	1,000	1,629	1,281	1,447	1,000	1,000	1,000	1,576	1,258	1,408	1,566	1,258	1,408
Beykent	7,924	12,345	6,601	8,888	14,046	8,204	8,633	14,018	7,879	8,824	14,046	8,188	3,243	3,752	1,923
Bilkent	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,000	0,000	0,141	0,000	0,000	0,141
Boğaziçi	1,061	1,241	1,038	1,123	1,385	1,171	1,086	1,251	1,054	1,101	1,359	1,156	1,101	1,359	1,156
Bozok	1,807	3,048	1,237	6,668	5,643	3,099	5,795	5,405	2,814	6,431	5,418	2,959	2,953	3,836	2,385
CBÜ	1,363	2,054	1,723	2,984	2,933	2,676	1,409	2,307	1,966	2,880	2,905	2,606	2,281	2,709	2,254

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 6			Model 7			Model 8			Model 9			Model 10		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
Cumhuriyet	2,434	2,681	2,292	3,739	3,646	3,282	3,371	2,890	2,672	3,589	3,569	3,247	2,611	3,216	2,505
Çağ	3,556	2,892	1,000	8,424	3,589	1,000	3,556	2,892	1,000	8,385	3,589	0,913	3,335	2,853	0,911
ÇOMÜ	2,026	1,911	1,516	3,680	3,680	2,978	2,637	2,454	2,176	3,639	3,680	2,978	2,690	3,273	2,608
Çankaya	1,929	2,230	1,001	2,057	2,371	1,189	1,908	2,228	1,022	2,004	2,354	1,181	1,663	2,240	1,144
Çukurova	1,401	1,363	1,382	1,519	1,608	1,533	1,439	1,357	1,403	1,490	1,587	1,528	1,420	1,556	1,500
Dicle	1,850	1,493	2,109	3,394	2,215	3,848	1,997	1,636	2,616	3,303	2,180	3,848	2,981	2,163	3,730
Doğuş	2,410	3,183	1,416	2,623	3,198	1,599	2,359	3,157	1,388	2,564	3,146	1,553	2,155	2,989	1,460
DEÜ	1,293	1,186	1,308	1,553	1,759	1,984	1,491	1,246	1,614	1,514	1,744	1,951	1,456	1,721	1,854
Dumlupınar	1,470	1,304	1,322	3,623	2,726	2,819	3,438	2,579	2,517	3,585	2,702	2,819	1,963	1,848	1,826
Düzce	2,148	1,965	1,158	3,293	2,728	1,452	3,274	2,590	1,387	3,113	2,649	1,364	2,537	2,567	1,256
Ege	1,031	1,000	1,057	1,500	1,727	1,606	1,035	1,010	1,127	1,483	1,712	1,584	1,476	1,689	1,577
Erciyes	1,513	1,063	1,000	1,995	1,514	1,233	1,597	1,066	1,041	1,916	1,468	1,211	1,668	1,416	1,208
Erzincan	4,738	5,097	1,154	13,742	12,819	4,232	12,460	12,484	4,035	13,434	12,757	4,074	4,362	4,618	2,911
ESOGÜ	1,086	1,031	1,105	1,720	1,703	2,234	1,274	1,031	1,105	1,687	1,671	2,175	1,657	1,671	2,082
Fatih	1,592	2,070	1,197	2,129	2,980	1,694	1,829	2,402	1,480	2,034	2,921	1,658	1,765	2,786	1,658
Fırat	1,033	1,012	1,000	1,458	1,744	1,303	1,218	1,074	1,000	1,440	1,719	1,268	1,422	1,719	1,261
Galatasaray	2,551	2,140	2,422	2,630	2,097	2,356	2,548	2,094	2,341	2,552	2,051	2,286	2,393	1,955	2,203
Gazi	1,052	1,000	1,023	1,445	1,441	1,589	1,087	1,000	1,066	1,425	1,439	1,589	1,409	1,435	1,589
Gaziantep	1,591	1,541	1,461	2,045	2,050	2,281	1,850	1,721	1,675	1,951	1,991	2,259	1,749	1,906	2,118
G.osmanpasa	1,459	1,579	1,311	2,998	2,984	2,349	2,183	2,184	2,074	2,914	2,912	2,333	2,213	2,646	2,060

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 6			Model 7			Model 8			Model 9			Model 10		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
GYTE	1,120	1,325	1,218	1,721	1,567	1,215	1,645	1,556	1,201	1,706	1,498	1,188	1,706	1,498	1,188
Giresun	1,000	1,000	1,000	3,201	1,000	1,609	1,636	1,000	1,000	3,121	0,882	1,589	0,750	0,571	0,389
Hacettepe	1,000	1,000	1,000	1,037	1,239	1,154	1,000	1,000	1,000	1,001	1,209	1,130	1,001	1,209	1,130
Halic	5,627	15,639	4,541	6,369	16,212	5,227	5,812	16,174	4,671	6,254	16,212	5,173	3,966	8,041	3,825
Harran	2,062	1,922	1,517	3,756	3,425	2,622	2,761	2,501	1,947	3,671	3,411	2,591	3,162	3,251	2,274
Hitit	1,104	4,338	4,406	1,552	6,849	6,371	1,492	6,428	5,843	1,548	6,849	6,260	1,147	2,668	4,046
Işık	1,000	1,000	1,183	1,000	1,000	1,893	1,000	1,000	1,164	0,492	0,798	1,860	0,492	0,785	1,602
İnönü	1,188	2,417	1,683	2,128	3,571	3,122	1,573	2,867	1,971	2,081	3,565	3,122	1,897	3,387	3,004
İst. Aydin	10,808	18,190	18,782	54,678	23,962	20,982	10,808	18,190	19,385	32,950	23,756	17,418	0,094	0,493	0,691
İst. Bilgi	2,695	2,696	3,163	2,651	2,965	3,600	2,592	2,833	3,599	2,556	2,894	3,508	1,883	2,219	2,767
İst. Bilim	2,756	2,257	2,117	3,617	2,402	2,407	2,673	2,238	2,092	3,497	2,388	2,374	3,161	2,386	2,314
İst. Kültür	3,858	3,514	3,495	5,920	3,852	4,392	3,824	3,467	3,601	5,803	3,814	4,326	3,871	3,569	3,708
İTÜ	1,525	1,472	1,571	2,343	1,873	1,958	1,585	1,472	1,571	2,343	1,840	1,958	2,174	1,835	1,931
İst. Ticaret	7,023	12,138	5,656	8,280	12,560	6,502	6,935	12,138	5,640	8,136	12,560	6,459	3,401	4,759	3,684
İstanbul	1,000	1,000	1,000	1,426	1,422	1,730	1,000	1,000	1,000	1,401	1,399	1,700	1,401	1,399	1,700
İzmir Ekonomi	1,290	1,000	1,000	1,930	1,000	1,080	1,758	1,000	1,022	1,872	0,914	1,052	1,558	0,909	1,016
İYTE	1,808	1,579	1,396	2,574	1,946	1,708	2,449	1,913	1,578	2,401	1,837	1,599	2,278	1,836	1,599
Kadir Has	1,639	1,065	1,000	1,973	1,177	1,000	1,742	1,174	1,000	1,972	1,087	0,148	1,651	1,054	0,148
Kafkas	1,000	1,000	1,436	1,485	1,512	1,753	1,447	1,510	1,675	1,448	1,507	1,741	1,266	1,451	1,664
KSÜ	2,397	1,455	1,711	4,247	2,482	2,779	3,456	2,167	2,162	4,073	2,433	2,779	2,716	2,295	2,490

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 6			Model 7			Model 8			Model 9			Model 10		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
KTÜ	1,167	1,000	1,000	1,929	1,506	1,777	1,242	1,000	1,000	1,885	1,474	1,722	1,727	1,469	1,585
Kastamonu	2,241	2,298	1,840	5,431	3,431	3,161	4,083	3,207	2,265	5,416	3,431	3,049	1,787	2,209	2,033
Kırıkkale	1,654	1,707	1,502	2,853	3,015	2,480	2,016	2,263	1,868	2,759	3,003	2,459	2,300	2,880	2,336
Kocaeli	1,968	1,559	1,224	3,476	2,807	2,225	2,757	1,795	1,347	3,371	2,740	2,143	2,208	1,997	1,687
Koç	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,556	0,449	0,607	0,556	0,449	0,607
Maltepe	3,468	6,112	4,277	4,991	8,419	5,959	3,750	7,342	5,535	4,963	8,419	5,831	3,458	7,227	4,888
Marmara	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,668	0,617	0,582	0,668	0,613	0,582
Mehmet Akif	1,242	1,428	1,344	2,759	2,801	2,352	2,433	2,737	2,279	2,714	2,801	2,321	1,428	2,283	1,856
Mersin	1,880	2,302	1,070	3,903	3,860	2,004	2,010	2,523	1,070	3,788	3,813	1,948	2,771	3,211	1,612
MSGSÜ	1,000	1,000	1,000	1,599	1,000	1,159	1,000	1,000	1,000	1,592	0,910	1,138	1,592	0,910	1,138
Muğla	2,134	1,702	1,642	3,834	2,826	2,570	2,262	1,897	2,009	3,783	2,803	2,570	2,112	2,582	2,142
MKÜ	1,714	1,298	1,091	3,380	2,769	2,351	2,424	1,867	1,676	3,326	2,769	2,351	2,530	2,612	2,124
NKÜ	1,035	1,596	1,675	1,709	1,940	2,816	1,112	1,841	1,984	1,709	1,925	2,778	1,290	1,491	2,327
Nigde	1,464	1,246	1,054	3,324	2,456	2,277	3,115	2,384	2,103	3,264	2,454	2,269	2,462	2,289	2,066
Okan	1,664	2,711	3,447	2,905	3,675	4,026	1,664	2,711	3,904	2,871	3,606	3,980	1,732	1,559	3,391
OMÜ	1,244	1,195	1,000	2,063	1,681	1,703	1,444	1,249	1,083	2,017	1,653	1,674	1,946	1,651	1,651
Ordu	2,682	2,622	2,080	5,093	3,788	4,050	3,910	3,704	3,504	5,072	3,788	3,935	1,874	2,880	2,732
ODTÜ	1,000	1,000	1,000	1,000	1,046	1,000	1,000	1,000	1,000	0,894	0,971	0,927	0,894	0,971	0,927
Pamukkale	1,351	1,483	1,252	2,944	2,776	2,242	1,704	1,804	1,520	2,845	2,744	2,207	2,223	2,551	1,726
Rize	1,333	2,562	1,072	4,452	2,922	1,332	3,252	2,777	1,119	4,309	2,873	1,294	1,792	2,359	1,110

Appendix A (cont'd): Efficiency Scores Of DEA Models

University	Model 6			Model 7			Model 8			Model 9			Model 10		
	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES	2008 ES	2009 ES	2010 ES
Sakarya	1,829	1,834	1,670	3,254	3,149	2,805	2,996	2,602	2,585	2,852	2,906	2,728	1,949	2,121	1,940
Selçuk	1,390	1,021	1,000	1,988	1,706	1,816	1,778	1,172	1,005	1,956	1,682	1,787	1,621	1,608	1,650
SDÜ	1,150	1,261	1,197	1,983	2,116	2,044	1,822	1,755	1,632	1,963	2,114	2,044	1,708	1,910	1,795
TOBB-ETÜ	1,000	1,000	1,000	1,000	1,055	1,154	1,000	1,000	1,000	0,000	0,127	0,489	0,000	0,124	0,470
Trakya	1,378	1,812	1,356	2,742	2,650	3,071	1,853	2,273	1,356	2,652	2,577	2,921	2,306	2,475	2,247
Ufuk	6,431	6,250	3,868	6,675	6,188	4,036	6,208	6,144	3,693	6,452	6,084	3,868	5,576	5,930	3,701
Uludağ	1,424	1,296	1,202	1,767	1,919	1,985	1,434	1,291	1,199	1,716	1,885	1,944	1,561	1,842	1,864
Uşak	4,221	2,171	1,000	7,504	3,769	2,515	7,476	3,636	1,957	7,465	3,769	2,398	1,925	2,375	1,447
Yasar	4,905	3,203	1,540	5,782	3,259	1,769	4,806	3,166	1,687	5,646	3,234	1,743	3,622	3,234	1,724
Yeditepe	1,178	1,000	1,618	1,869	1,470	2,425	1,279	1,000	1,640	1,335	0,761	2,042	1,335	0,758	1,715
YTÜ	1,865	1,422	1,658	2,366	1,719	2,483	2,260	1,629	2,117	2,315	1,694	2,470	2,031	1,644	2,397
Yuzuncuyıl	1,446	1,630	1,249	2,669	2,336	2,136	2,411	1,976	1,643	2,554	2,277	2,054	2,352	2,252	2,021
ZKÜ	1,453	1,799	1,081	3,052	3,667	2,040	2,455	2,838	1,478	2,925	3,623	1,988	2,270	3,335	1,855

Appendix B: Field Based DEA

In Chapter 6, we propose that Model 6, which has variable returns to scale assumption, includes faculty members from different academic ranks as separate input variables, and imposes weight restrictions on human resources inputs is the most preferable model among the ten DEA models that we run in this study.

We also detect that not only citations, but also other research outputs have significantly differed by scientific fields. Thus, we suggest either making evaluations separately for scientific fields or making field- based normalizations with the outputs before constructing the models.

In Model 6, we have utilized field based normalized outputs, whereas in this section we perform DEAs separately for three scientific fields which are (i) health sciences, (ii) social sciences and (iii) basic and applied sciences.

After calculating DEA scores separately for each field, we calculate an overall efficiency score for each university using the weighted average of efficiency scores obtained for separate fields. The weights will be determined by the ratio of the total faculty members working in that scientific field to the total faculty members working in that university.

The overall efficiency score of universities are calculated by Equation A1.

$$\mathrm{OES}_{\mathrm{it}} = \sum_{\mathrm{j=1}}^{3} \mathrm{w}_{\mathrm{jit}} * \mathrm{ES}_{\mathrm{jit}} \qquad \text{(A1)}$$

In Equation A1, OES denotes weighted average efficiency scores, ES denotes efficiency scores obtained for individual scientific fields, t denotes time, i denotes universities, and j denotes scientific field. Consequently, $\mathrm{OES}_{\mathrm{it}}$ is the weighted average efficiency score of i^{th} university in year t, w_{jit} is the ratio of faculty members employed in j^{th} scientific field in i^{th} university in year t, and $\mathrm{ES}_{\mathrm{jit}}$ is the efficiency score of i^{th} university obtained for j^{th} scientific field in year t.

For example, in 2008 efficiency score of AİBÜ is 1.90 for basic and applied sciences, 1.45 for health sciences, and 4.05 for social sciences. Meanwhile, ratio of faculty members is 0.21 for basic and applied sciences, 0.29 for health sciences, and 0.50 for social sciences. We calculate weighted average efficiency score of AİBÜ for year 2008 as:

$$(1.90*0.21) + (1.45*0.29) + (4.05*0.50) = 2.84$$

Apart from DEA Model 6, implemented in Chapter 6, we didn't include funds allocated for research infrastructures as input variable, in the field based DEA evaluations, because we were unable to calculate the amount of funds allocated for each scientific discipline.

If a university doesn't have any faculty members in a scientific field, then we do not include that university in the DEA model that is performed for that scientific field. Field based efficiency scores, and overall efficiency scores are provided in Table 63.

We calculate the Spearman correlation coefficients to compare efficiency scores calculated by DEA Model 6 with the overall efficiency scores given in Table 63. We observe moderate to high positive rank order correlations between efficiency scores that are all significant at the 5% level. The Spearman correlation coefficient is 0.63 in 2008, 0.79 in 2009 and 0.74 in 2010.

Table 63: Field based and overall efficiency scores

University	Basic and applied sciences			Health sciences			Social sciences			Overall		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
AİBÜ	1.90	1.68	1.30	1.45	1.17	1.31	4.05	1.53	2.31	2.84	1.43	1.61
Adıyaman	-	-	2.49	-	-	2.79	3.09	1.06	1.80	3.35	1.13	1.84
A.Menderes	1.69	1.54	1.56	2.49	2.10	2.49	2.26	1.00	1.00	2.17	1.55	1.65
Afyon	1.04	1.00	1.25	1.00	1.44	1.46	2.03	1.60	1.36	1.24	1.37	1.38
Ahi Evran	1.97	1.50	1.41	-	-	-	2.65	2.23	3.14	2.40	1.94	2.27
Akdeniz	2.18	1.34	1.63	1.98	1.00	1.00	2.05	2.73	1.56	2.05	1.32	1.25
Aksaray	1.92	1.41	1.01	-	-	-	2.80	1.00	1.00	2.17	1.23	1.00
Amasya	-	-	1.00	-	-	-	1.41	1.50	1.00	1.45	1.54	1.00
Anadolu	1.00	1.67	1.16	1.70	1.00	1.25	1.95	1.47	1.30	1.47	1.48	1.25
Ankara	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00
Ataturk	1.00	1.00	1.12	1.05	1.11	1.00	2.40	2.05	2.05	1.27	1.26	1.28
Atılım	3.55	2.61	2.72	-	-	-	6.08	1.35	2.30	4.17	1.96	2.56
Bahcesehir	5.49	5.69	3.14	-	-	-	4.81	4.47	2.04	5.09	4.93	2.41
Balıkesir	1.79	1.00	1.00	-	1.04	2.18	4.10	3.79	5.15	2.56	1.62	1.73
Başkent	4.60	3.50	5.19	1.00	1.00	1.00	1.93	1.17	1.12	1.22	1.11	1.12
Beykent	8.66	7.67	9.50	-	-	-	12.76	25.00	12.26	10.23	11.49	10.64
Bilkent	1.00	1.00	1.00	-	-	-	1.00	1.00	1.00	1.00	1.00	1.00
Boğaziçi	1.16	1.35	1.11	-	-	-	1.41	1.52	1.17	1.29	1.46	1.17
Bozok	1.00	2.01	1.13	-	1.00	2.40	-	9.47	2.15	1.70	2.65	1.40
C.Bayar	2.41	2.04	2.28	1.02	1.42	1.33	2.63	1.71	2.50	1.45	1.60	1.70
Cumhuriyet	3.11	3.47	3.04	1.84	2.14	1.81	16.86	3.66	3.81	2.79	2.71	2.40
Çağ	-	1.00	1.00	-	-	-	9.36	3.54	1.49	10.82	2.61	1.39
ÇOMÜ	1.29	1.44	1.51	1.43	1.20	1.46	4.03	7.06	6.73	1.91	2.22	2.35
Çankaya	2.82	3.01	2.91	-	-	-	3.39	3.07	1.77	3.13	3.04	2.11
Çukurova	1.05	1.08	1.06	1.45	1.50	1.37	2.18	1.73	1.84	1.33	1.32	1.28
Dicle	1.67	1.69	1.65	2.19	1.84	2.03	5.10	8.78	8.80	2.37	2.26	2.37

Table 63 (cont'd): Field based and overall efficiency scores

University	Basic and applied sciences			Health sciences			Social sciences			Overall		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Doğuş	2.70	4.42	2.10	-	-	-	3.54	3.53	3.07	3.04	3.95	2.47
DEÜ	1.40	1.47	1.27	1.36	1.16	1.35	1.41	1.91	1.63	1.39	1.46	1.41
Dumlupınar	2.24	1.90	2.15	-	-	1.00	1.39	1.00	1.69	1.71	1.30	1.89
Düzce	1.84	1.76	1.00	1.64	1.18	1.00	1.00	1.00	1.00	1.55	1.22	1.00
Ege	1.32	1.10	1.00	1.05	1.00	1.00	1.65	1.65	1.54	1.23	1.12	1.06
Erciyes	1.00	1.00	1.00	1.57	1.54	1.07	3.64	1.51	1.51	1.54	1.34	1.13
Erzincan	-	1.00	1.72	-	-	-	5.00	20.28	3.41	5.15	16.47	3.45
E.Osmangazi	1.00	1.53	2.02	2.28	1.98	1.74	1.79	3.70	3.53	1.46	1.94	2.08
Fatih	1.87	2.45	2.12	1.23	1.14	1.00	1.77	2.26	1.48	1.57	1.74	1.41
Fırat	1.00	1.15	1.00	1.70	1.92	1.47	1.42	1.15	1.80	1.31	1.36	1.32
Galatasaray	6.90	1.44	2.68	-	-	-	4.09	3.92	4.85	4.54	2.76	4.05
Gazi	1.00	1.00	1.00	1.06	1.23	1.40	1.34	1.00	1.00	1.16	1.07	1.11
Gaziantep	1.40	1.75	1.91	1.34	1.32	1.16	1.00	1.00	1.47	1.30	1.37	1.38
G.osmanpasa	1.00	1.15	1.58	1.00	1.00	1.00	2.15	2.39	2.24	1.17	1.27	1.43
GYTE	1.16	1.54	1.27	-	-	-	1.00	1.00	1.00	1.14	1.44	1.22
Giresun	1.00	1.00	1.00	-	-	2.65	-	1.00	2.85	4.00	1.08	1.93
Hacettepe	1.28	1.27	1.37	1.00	1.00	1.00	1.03	1.00	1.00	1.06	1.05	1.06
Halic	25.00	15.91	25.00	-	-	-	4.90	25.00	7.97	10.44	18.43	14.46
Harran	1.00	1.64	1.95	1.73	1.72	1.41	8.13	6.79	1.00	1.59	2.12	1.41
Hitit	1.00	2.16	7.28	-	-	-	1.47	15.28	25.00	1.32	5.93	15.45
Işık	2.40	3.53	4.04	-	-	-	1.00	1.00	1.05	1.52	1.71	1.88
İnönü	1.24	2.21	2.60	1.56	1.76	1.23	1.83	4.92	5.32	1.57	2.43	2.00
İstanbul Aydin	21.74	4.13	25.00	-	-	-	20.00	25.00	20.00	20.89	6.81	22.41
İstanbul Bilgi	36.62	35.73	25.00	-	-	-	3.54	3.63	5.50	4.29	4.40	6.49
İstanbul Bilim	-	-	1.00	1.52	1.00	1.31	-	-	-	1.52	1.00	1.31
İstanbul Kültür	9.76	6.33	6.95	-	-	-	10.03	6.96	8.80	9.87	6.58	7.61

Table 63 (cont'd): Field based and overall efficiency scores

University	Basic and applied sciences			Health sciences			Social sciences			Overall		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
İTÜ	1.04	1.03	1.00	-	-	-	1.82	1.02	1.32	1.09	1.03	1.03
İstanbul Ticaret	7.96	10.78	14.41	-	-	-	25.00	25.00	14.99	15.05	17.78	14.80
İstanbul	1.54	1.44	1.18	1.00	1.00	1.00	1.42	1.52	1.50	1.16	1.17	1.13
İzmir Ekonomi	4.28	1.68	2.30	-	-	-	2.34	1.00	1.56	2.77	1.16	1.75
İYTE	1.34	1.53	1.16	-	-	-	-	-	-	1.34	1.53	1.16
Kadir Has	2.77	1.45	2.29	-	-	-	2.68	2.47	1.00	2.71	2.00	1.23
Kafkas	1.00	1.00	1.00	1.90	1.36	1.31	2.46	5.05	5.79	1.77	1.59	1.56
KSÜ	1.88	1.84	1.60	1.47	1.00	1.32	2.36	1.85	6.47	1.83	1.52	1.78
KTÜ	1.34	1.33	1.54	1.49	1.50	1.57	5.16	1.03	1.02	1.70	1.28	1.37
Kastamonu	1.73	1.80	5.06	-	-	-	25.00	4.53	4.96	4.78	3.09	4.99
Kırıkkale	1.22	1.62	1.41	1.11	1.62	2.21	7.54	4.23	4.13	1.55	2.00	2.23
Kocaeli	1.10	1.33	1.21	1.04	1.00	1.00	4.03	1.83	1.69	1.43	1.33	1.26
Koç	1.31	1.28	1.00	-	-	1.00	1.00	1.00	1.00	1.12	1.10	1.00
Maltepe	24.00	23.00	12.74	3.20	2.28	3.16	5.68	13.48	9.59	5.47	5.45	6.02
Marmara	1.00	1.05	1.25	1.00	1.00	1.00	1.03	1.06	1.00	1.02	1.04	1.02
M.Akif	-	1.00	1.00	1.00	5.21	7.14	2.80	2.23	6.49	1.59	2.81	5.45
Mersin	1.86	2.25	1.77	1.58	1.11	1.35	3.04	3.50	1.73	1.85	1.59	1.54
MSGSÜ	1.00	1.29	2.78	-	-	-	7.07	2.49	1.00	1.20	1.43	2.06
Muğla	1.76	1.81	2.32	-	-	-	4.01	1.69	1.88	2.82	1.72	2.01
MKÜ	1.22	1.26	1.31	1.69	1.23	1.16	1.48	1.60	1.12	1.40	1.29	1.22
NKÜ	4.69	2.36	2.04	-	-	2.63	-	-	2.43	4.77	2.40	2.05
Nigde	1.09	1.27	1.46	-	-	-	3.43	1.47	1.44	1.71	1.37	1.45
Okan	5.99	2.64	14.26	-	-	-	2.64	4.26	4.24	3.20	3.55	5.44
OMÜ	1.01	1.00	1.00	1.71	1.55	1.36	6.17	3.80	2.57	1.70	1.55	1.39
Ordu	7.61	3.32	5.44	-	-	1.00	1.00	1.00	1.00	3.47	2.32	3.03

Table 63 (cont'd): Field based and overall efficiency scores

University	Basic and applied sciences			Health sciences			Social sciences			Overall		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
ODTÜ	1.00	1.00	1.00	-	-	-	1.00	1.00	1.00	1.00	1.00	1.00
Pamukkale	1.43	1.92	1.68	1.00	1.69	1.65	2.10	1.37	1.10	1.36	1.63	1.43
Rize	1.10	1.57	1.01	-	1.00	1.00	3.56	25.00	3.77	2.00	4.06	1.93
Sabancı	1.00	1.00	1.00	-	-	-	1.00	1.02	1.03	1.00	1.01	1.02
Sakarya	1.18	1.84	1.05	-	1.00	2.35	3.45	2.47	2.00	1.81	2.13	1.40
Selçuk	1.21	1.00	1.00	1.69	1.68	1.83	1.50	1.28	1.00	1.46	1.29	1.21
SDÜ	1.15	1.18	1.17	1.16	1.44	1.57	1.58	1.00	1.00	1.24	1.18	1.20
TOBB-ETÜ	1.00	1.00	1.00	-	-	-	1.08	1.00	1.39	1.03	1.00	1.10
Trakya	1.47	1.39	1.20	1.73	1.62	1.48	2.31	2.25	2.14	1.78	1.69	1.53
Ufuk	-	-	1.00	2.70	2.42	2.19	25.00	25.00	25.00	3.59	3.26	2.86
Uludağ	1.26	1.26	1.19	2.05	1.81	2.12	2.59	2.63	3.18	1.84	1.75	1.90
Uşak	1.23	2.11	1.08	-	-	-	25.00	3.55	1.00	3.63	2.95	1.02
Yasar	18.59	20.54	5.77	-	-	-	6.99	2.56	1.42	9.64	4.18	2.12
Yeditepe	1.78	3.67	2.44	1.06	1.00	1.00	6.41	3.22	5.60	1.74	1.69	1.74
YTÜ	1.55	1.18	1.69	-	-	-	3.55	1.92	2.12	1.74	1.28	1.76
YYÜ	1.11	1.32	1.51	1.96	2.19	1.36	3.56	5.61	2.57	1.75	2.12	1.64
ZKÜ	1.76	2.99	1.00	1.14	1.38	1.34	2.64	2.00	1.00	1.49	1.80	1.13

Appendix C: Diversity Indices

Some studies argue that variation in terms of scientific disciplines facilitates research. The assumption behind this argument is that research studies become more and more interdisciplinary and availability of researchers from different scientific fields might result in more and better research environment. In other words, universities with a diversified science disciplines portfolio are likely to have a diversified R&D portfolio and hence are able to make multiple use of R&D activities

In order to capture the scientific heterogeneity of universities, two different indices (denoted by DIVERS1 and DIVERS2) were constructed using the Herfindahl-Hirschman index (HHI), which is a statistical measure of concentration.

HHI can be used to measure concentration in a variety of contexts from concentration of income or wealth to competition levels in the markets. It is calculated through Equation A2 where s_i is the market share of i^{th} unit in the market, and N is the number of units (Rhoades, 1993):

$$H = \sum_{i=1}^{N} s_i^2 \qquad \text{(A2)}$$

Small HHI values indicate competitive environments with no dominant players, whereas high HHI values indicate high concentration with one or few dominant players.

While calculating DIVERS1 and DIVERS2 for each university, we used shares of academic staff by the following departmental groups:

(1) health sciences,
(2) basic and applied sciences,
(3) social sciences,
(4) vocational training schools.

$$\text{DIVERS1} = \sum_{i=1}^{N} s_i^2 \qquad \text{where } i = 1, 2, 3, \text{ and } 4 \qquad \text{(A3)}$$

$$\text{DIVERS2} = \sum_{i=1}^{N} s_i^2 \qquad \text{where } i = 1, 2, \text{ and } 3 \qquad \text{(A4)}$$

In Equation A3 and A4**,** s_i denotes the share of faculty members in i^{th} scientific discipline. DIVERS1 is calculated by using four of the departmental groups, whereas DIVERS2 is calculated by excluding faculty members working in the vocational training schools.

Panel data analyses performed in Chapter 7 showed that neither DIVERS1, nor DIVERS2 had a significant impact on the research efficiency and productivity. Thus, we do not include these indices in the panel data models as explanatory variables.

Meanwhile, we thought that it would be interesting to see the disciplinary heterogeneity of universities. Thus, in Table 64 we provide the diversity indices of universities. Smaller values indicate faculty members are distributed evenly across scientific fields, whereas higher values indicate faculty members are concentrated in a few disciplines. We see that DIVERS1varies between 0.28 and 1.00, and DIVERS 2 varies between 0.33 and 1.00 during the analysis period . Moreover, we observe that for all universities, both diversity indices do not change significantly between 2008 – 2010 period.

Table 64: Diversity indices of universities

University	DIVERS1			DIVERS2		
	2008	2009	2010	2008	2009	2010
AİBÜ	0.313	0.311	0.302	0.380	0.387	0.362
Adıyaman	0.797	0.785	0.791	0.858	0.883	0.854
A.Menderes	0.321	0.321	0.321	0.377	0.377	0.376
Afyon	0.329	0.330	0.329	0.366	0.366	0.366
Ahi Evran	0.430	0.427	0.426	0.572	0.569	0.569
Akdeniz	0.316	0.316	0.316	0.357	0.357	0.356
Aksaray	0.410	0.412	0.402	0.533	0.541	0.527
Amasya	0.726	0.715	0.734	0.949	0.946	0.957
Anadolu	0.388	0.388	0.388	0.465	0.466	0.465
Ankara	0.342	0.342	0.343	0.355	0.355	0.355
Ataturk	0.296	0.296	0.296	0.339	0.339	0.339
Atılım	0.540	0.542	0.541	0.540	0.542	0.541
Bahcesehir	0.493	0.495	0.489	0.508	0.509	0.507
Balıkesir	0.356	0.356	0.355	0.493	0.493	0.492
Başkent	0.519	0.520	0.520	0.527	0.528	0.527
Beykent	0.375	0.374	0.373	0.501	0.501	0.501
Bilkent	0.453	0.454	0.452	0.503	0.503	0.503
Boğaziçi	0.419	0.420	0.420	0.488	0.489	0.489
Bozok	0.429	0.423	0.432	0.485	0.483	0.488
C.Bayar	0.280	0.280	0.280	0.380	0.380	0.379
Cumhuriyet	0.341	0.341	0.341	0.363	0.362	0.362
Çağ	0.766	0.760	0.755	0.766	0.760	0.755
ÇOMÜ	0.343	0.344	0.343	0.420	0.420	0.420
Çankaya	0.501	0.502	0.506	0.517	0.515	0.517
Çukurova	0.337	0.337	0.338	0.354	0.354	0.354
Dicle	0.359	0.359	0.359	0.373	0.373	0.373
Doğuş	0.488	0.491	0.489	0.502	0.501	0.502
DEÜ	0.301	0.301	0.301	0.336	0.336	0.336
Dumlupınar	0.350	0.350	0.350	0.500	0.500	0.500
Düzce	0.460	0.461	0.463	0.576	0.574	0.577
Ege	0.335	0.334	0.335	0.372	0.372	0.372
Erciyes	0.340	0.339	0.340	0.371	0.370	0.371
Erzincan	0.586	0.587	0.585	0.943	0.950	0.943
E.Osmangazi	0.342	0.342	0.342	0.356	0.355	0.355
Fatih	0.321	0.319	0.321	0.336	0.336	0.336
Fırat	0.305	0.304	0.305	0.339	0.339	0.339
Galatasaray	0.623	0.623	0.619	0.633	0.633	0.629
Gazi	0.313	0.313	0.313	0.371	0.371	0.371
Gaziantep	0.369	0.370	0.370	0.407	0.409	0.407
Gaziosmanpasa	0.291	0.292	0.291	0.344	0.344	0.344
GYTE	0.776	0.779	0.774	0.776	0.779	0.774
Giresun	0.473	0.471	0.469	0.502	0.506	0.507
Hacettepe	0.371	0.371	0.371	0.388	0.388	0.388
Halic	0.388	0.391	0.388	0.529	0.533	0.528
Harran	0.313	0.313	0.313	0.346	0.346	0.346
Hitit	0.584	0.570	0.580	0.621	0.615	0.621
Işık	0.515	0.512	0.518	0.515	0.512	0.518
İnönü	0.351	0.351	0.350	0.363	0.363	0.363

Table 64 (cont'd): Diversity indices of universities

University	DIVERS1			DIVERS2		
	2008	2009	2010	2008	2009	2010
İstanbul Aydin	0.427	0.437	0.426	0.502	0.502	0.503
İstanbul Bilgi	0.667	0.668	0.663	0.687	0.684	0.686
İstanbul Bilim	0.926	0.920	0.921	1.000	1.000	1.000
İstanbul Kültür	0.427	0.427	0.429	0.514	0.515	0.515
İTÜ	0.797	0.797	0.797	0.801	0.800	0.800
İstanbul Ticaret	0.527	0.522	0.526	0.573	0.574	0.571
İstanbul	0.382	0.382	0.382	0.409	0.409	0.409
İzmir Ekonomi	0.509	0.508	0.512	0.550	0.553	0.550
İYTE	1.000	1.000	1.000	1.000	1.000	1.000
Kadir Has	0.536	0.539	0.539	0.552	0.553	0.553
Kafkas	0.416	0.412	0.416	0.433	0.431	0.434
KSÜ	0.383	0.383	0.382	0.395	0.395	0.396
KTÜ	0.327	0.327	0.326	0.355	0.355	0.355
Kastamonu	0.455	0.456	0.454	0.569	0.575	0.564
Kırıkkale	0.341	0.341	0.340	0.359	0.359	0.359
Kocaeli	0.291	0.290	0.291	0.339	0.339	0.339
Koç	0.473	0.475	0.474	0.508	0.508	0.508
Maltepe	0.324	0.325	0.325	0.341	0.341	0.341
Marmara	0.375	0.376	0.375	0.434	0.435	0.434
M.Akif	0.399	0.402	0.397	0.466	0.469	0.464
Mersin	0.320	0.320	0.320	0.371	0.371	0.371
MSGSÜ	0.662	0.663	0.661	0.686	0.686	0.684
Muğla	0.409	0.409	0.409	0.558	0.559	0.558
MKÜ	0.353	0.353	0.353	0.385	0.385	0.384
NKÜ	0.797	0.794	0.797	0.969	0.967	0.965
Nigde	0.421	0.420	0.421	0.502	0.502	0.502
Okan	0.457	0.456	0.461	0.568	0.561	0.570
OMÜ	0.343	0.343	0.342	0.361	0.361	0.361
Ordu	0.517	0.513	0.515	0.705	0.699	0.705
ODTÜ	0.597	0.596	0.597	0.603	0.603	0.604
Pamukkale	0.305	0.305	0.305	0.334	0.334	0.334
Rize	0.545	0.549	0.546	0.545	0.549	0.546
Sabancı	0.500	0.500	0.500	0.500	0.500	0.500
Sakarya	0.397	0.397	0.397	0.502	0.502	0.502
Selçuk	0.288	0.288	0.288	0.337	0.337	0.337
SDÜ	0.334	0.334	0.333	0.357	0.357	0.357
TOBB-ETÜ	0.556	0.556	0.554	0.556	0.556	0.554
Trakya	0.325	0.324	0.325	0.358	0.358	0.358
Ufuk	0.571	0.564	0.574	0.594	0.589	0.595
Uludağ	0.322	0.322	0.322	0.349	0.349	0.349
Uşak	0.496	0.498	0.493	0.576	0.581	0.573
Yasar	0.449	0.449	0.449	0.507	0.506	0.508
Yeditepe	0.355	0.355	0.356	0.355	0.355	0.356
YTÜ	0.656	0.656	0.655	0.680	0.680	0.680
YYÜ	0.311	0.310	0.310	0.337	0.337	0.337
ZKÜ	0.325	0.325	0.325	0.362	0.363	0.362
Average	**0.446**	**0.446**	**0.446**	**0.499**	**0.500**	**0.499**

Appendix D: Curriculum Vitae

PERSONAL INFORMATION

Surname, Name: Tekneci, Pelin Deniz
Nationality: Turkish (TC)
Date and Place of Birth: 1 December 1975, Erzurum
Marital Status: Married
E-mail: ptekneci@dpt.gov.tr

EDUCATION

Degree	Institution	Year of Graduation
MBA	Rice University (USA)	2006
BS	METU Industrial Engineering	1997

WORK EXPERIENCE

Year	Place	Enrollment
2011- present	Ministry of Development	Planning Expert
2003- 2011	State Planning Organization	Planning Expert
1998-2003	State Planning Organization	Assistant Planning Expert

FOREIGN LANGUAGES

English (Advanced)

PUBLICATIONS

Tekneci P.D. "Türkiye Adresli Spor Alanındaki Bilimsel Yayınların Bibliyometrik Analizi", Pamukkale Journal of Sports Science, 4(13), 76-91 (2013)

OTHER RELEVANT INFORMATION:

- Planning Expertise Thesis, "Reducing Health Inequalities In Turkey" (2004),
- Certified as IPA Trainer (2008),
- Received Certificate on "Training on Sustainable Development" by Lund University, Sweden (2008),
- Received Certificate on Seminar for Staff Training on Evaluation Management of National Research and Development Projects given by JICA, Japan (2007),

Appendix E: Turkish Summary

Bu tez, Türk üniversitelerinin araştırma alanındaki üretkenlik ve verimlilik düzeylerini derinlemesine incelemeyi amaçlamaktadır. Bu kapsamda, 2008-2010 yılları arasında 94 adet devlet ve vakıf üniversitesinin araştırma alanındaki etkinlikleri hem Veri Zarflama Analizi (VZA), hem de Stokastik Sınır Analizi (SSA) yöntemleri kullanılarak hesaplanmıştır. Ayrıca seçilen bazı faktörlerin araştırma verimliliği, öğretim üyesi başına düşen makale sayısı ve öğretim üyesi başına düşen atıf sayısı üzerindeki etkileri Panel Veri Analizi yöntemi kullanılarak incelenmiştir. Bu çalışmayı literatürdeki benzer çalışmalardan ayıran iki temel nokta bulunmaktadır. Bunların ilki gerek VZA gerekse SSA'da kullanılan çıktıların bilimsel disiplinler bazında normalize edilerek modellere dahil edilmesidir. İkincisi ise çalışmada hem devlet, hem de vakıf üniversiteleri birarada incelenmiş, analizler üniversite bazında ve üç yıllık süreç için gerçekleşetirilmiş ve sadece araştırma performansı konusu ele alınmıştır. Çalışma bu haliyle Türkiye'deki yüksek öğretim sektörünün araştırma performansına yönelik özgün ve derinlemesine bilgiler sunmaktadır.

Son yıllarda gerek üniversitelere, gerekse bu kurumların sundukları hizmetlere olan talep pek çok ülkede fark edilir derecede artmıştır. Bundan 20-30 yıl öncesine kadar elitist yaklaşımla kurulmuş olan sınırlı sayıda üniversite sınırlı sayıda kişiye eğitim imkânı sağlamaktayken, bu yaklaşım yerini dünya genelinde kitlesel yükseköğretim sistemine bırakmıştır. Yükseköğretim sisteminde yaşanan bu paradigma değişimi neticesinde dünya genelindeki toplam üniversite sayısıyla birlikte bu kurumlarda eğitim gören öğrenci sayısı da önemli ölçüde artmıştır. Öyle ki tüm dünyada 1984 yılında 20 milyon olan öğrenci sayısı, 2007 yılında 150 milyona ulaşmıştır (UNESCO, 2009; İlyas, 2012).

Yükseköğretim sisteminde küresel bazda yaşanan bu genişlemeye etki eden iki önemli faktör bulunmaktadır. Bunların ilki vatandaşların yükseköğretim kurumlarından mezun oldukları takdirde daha fazla ücretle iş bulacaklarına ve toplum içindeki sosyal statülerinin daha iyi olacağına inanmalarına bağlı olarak yükseköğretim kurumlarına olan taleplerinin artmasıdır. İkincisi ise küresel düzeyde yaşanan tekno-ekonomik rekabetin, üniversitelerin sundukları hizmetleri (nitelikli insan gücü yetiştirme, araştırma-geliştirme faaliyetleri yapma, araştırma altyapısı desteği sunma, danışmanlık hizmeti verme, vb.) daha fazla talep edilir hale getirmesidir (Altbach, 2011).

Üniversite ve üniversiteye devam eden öğrenci sayılarının artmasıyla birlikte pek çok ülkenin milli gelirlerinden bu alana aktardığı kaynak miktarı artmış ve sınırlı olan bu kaynaklar için üniversiteler giderek birbirleriyle daha fazla rekabet içine girmiştir. Oluşan rekabet ortamında hangi üniversitenin ne ölçüde başarılı olduğu merak edilen konular haline gelmiştir. Bu bilgi talebi ulusal bazda üniversite değerlendirme sistemlerinin hayata geçirilmesine, uluslararası üniversite derecelendirme sistemlerinin ve üniversite sınıflandırma çalışmalarının yaygınlaşmasına ve bu alanda yapılan akademik çalışmaların artmasına vesile olmuştur. Dolayısıyla yaptığımız literatür çalışmasından da anlaşılacağı üzere üniversitelerin performansları çok farklı şekilde ve farklı veri setleri kullanılarak inceleme konusu olmuştur.

Özellikle araştırma-geliştirme (ar-ge) alanına önemli ölçüde kyank ayıran ve bu alanda kendini geliştirmiş olan çok sayıda ülkede hükümetler üniversitelerin eğitim ve araştırma alanındaki performanslarını değerlendirmeye yönelik ulusal değerlendirme sistemlerini oluşturmuşlardır. Bu değerlendirme sistemleriyle hem üniversitelere aktarılan kaynakların etkinliğini ölçmek hem de gelecekte bu kurumlara tahsis edilecek ödenek miktarını belirlemek amaçlanmaktadır.

Türkiye'de üniversitelerin bilim, teknoloji ve yenilik (BTY) sistemi üzerindeki etkisinin dikkatli biçimde incelenmesi gerekmektedir, çünkü bu kurumlar ar-ge kapasiteleri açısından ulusal BTY sisteminin en önemli aktörleri konumundadır. Şöyle ki 2012 yılı itibarıyla ar-ge harcamalarının % 43,9'u üniversitelerce gerçekleştirilmekte, tam zaman eşdeğeri araştırmacıların ise %38,2'si bu kurumlarda istihdam edilmektedir (TÜİK, 2013).

Bir yandan Kalkınma Bakanlığı, TÜBİTAK ve Bilim, Sanayi ve Teknoloji Bakanlığı tarafından üniversitelere ar-ge faaliyetlerini desteklemek için çeşitli programlar açılmış olup, diğer yandan TÜBİTAK, MEB ve YÖK nezdinde araştırmacı insan gücünün yetiştirilmesi için burslar verilmektedir. Ancak bu kurumların hiçbirisi verilen destekler neticesinde üniversitelerin eğitim ve araştırma çıktılarının etkilerine dair bir değerlendirme sistemi oluşturmamışlardır. Sadece TÜBİTAK tarafından 2012 yılından itibaren "Yenilikçi ve Girişimci Üniversite Endeksi" hesaplanmaktadır. Ancak bu endekste sadece ilk 50'ye giren üniversiteler ilan edilmektedir. İlk 50'ye giren üniversitelere doğrudan bir destek sağlanmamakta, sadece bu üniversiteler yine TÜBİTAK tarafından açılmış olan teknoloji transfer ofisi programına başvuru hakkı elde etmektedir.

Türkiye'de üniversitelerin gerçekleştirdikleri araştırma faaliyetlerine ilişkin bir veri tabanı olmadığından bu konuda yapılan akademik çalışmalar da sınırlı düzeydedir. Ayrıca ulaşabildiğimiz bütün akademik çalışmalarda salt vakıf ya da salt devlet üniversitelerinin analizlere dâhil edildiği, bütün üniversitelerin ise bir arada incelenmediği görülmektedir.

Bu çalışmada üniversitelerin araştırma faaliyetleriyle ilgili çok sayıda veri farklı kaynaklardan derlenerek bir araya getirilmiş, beş farklı disiplin bazında analizler yapılmış, farklı üniversite grupları ve disiplinler karşılaştırılmıştır. Böylelikle bu konuda eksikliği hissedilen bazı hususları daha yakından inceleme fırsatı yaratılmıştır.

Çalışmada 2006 yılı ve öncesinde kurulan 94 adet üniversite ele alınmıştır. Bunların 53 tanesi 1992 ve öncesinde kurulmuş devlet üniversitesi (bu üniversiteler eski devlet üniversiteleri olarak adlandırılmıştır), 15 tanesi 2006 yılında kurulmuş devlet üniversitesi (bu üniversiteler eski devlet üniversiteleri olarak adlandırılmıştır) ve 26 tanesi ise vakıf üniversitesidir. Analizler 2008- 2010 yılları arasındaki 3 yıllık süreyi kapsamaktadır.

Araştırma çıktısı olarak kullanılan yayın ve atıf sayıları Thomson Reuters'in Web of Science (WoS) veri tabanından indirilmiştir. Ancak bu veri tabanı kullanılırken üniversitelerin isim kodlamasında ciddi sıkıntılar olduğu tespit edilmiştir. Dolayısıyla veriler indirilirken sadece üniversitenin tam adı değil, o üniversitenin bulunduğu il ve üniversite isminde yer alan kelimeler de anahtar kelime olarak girilmiştir. Örneğin Adnan Menderes Üniversitesi'nde görev yapan araştırmacılar tarafından 2008-2010 yılları arasından toplam 788 yayın yapılmış olmakla birlikte bunların 93 tanesi yanlış isimle kodlanmıştır.

Yine araştırma çıktısı olarak kullanılan doktora mezunu sayısı ÖSYM tarafından yıllık olarak yayınlanan Yükseköğretim İstatistiklerinden derlenmiştir. Öğretim üyesi, öğrenci, bölüm sayıları da bu yolla elde edilmiştir.

Bir diğer araştırma çıktısı olarak seçilen TÜBİTAK tarafından üniversitelerde desteklenen akademik ar-ge proje sayıları ve bu kapsamda üniversitelere tahsis edilen ödenek miktarı TÜBİTAK'in Araştırma Destek Programları Başkanlığından elde edilmiştir.

Araştırma girdisi olarak kullanılan ve üniversitelere tahsis edilen araştırma altyapı desteğine ilişkin bilgiler Kalkınma Bakanlığından alınmıştır. Bunun dışında araştırma performansına etki eden faktörleri incelediğimiz modellerde kullanılan illerin soyo-ekonomik gelişmişlik göstergeleri de yine Kalkınma Bakanlığı tarafından 2013 yılında yayınlanan İllerin ve Bölgelerin Sosyo-Ekonomik Gelişmişlik Sıralaması Araştırmasından alınmıştır.

94 üniversitenin araştırma alanında gösterdikleri performans, elde edilebilen veriler çerçevesinde hem Veri Zarflama Analizi (VZA) hem de Stokastik Sınır Analizi (SSA) yöntemleri kullanılarak analiz edilmiştir. Ayrıca Panel Veri Analizi yöntemi kullanılarak seçilen bazı faktörlerin öğretim üyesi başına düşen yayın sayısı, öğretim üyesi başına düşen atıf sayısı ve VZA sonucunda elde edilen etkinlik değerlerine olan etkisi incelenmiştir. Dolayısıyla bu çalışmanın üç bölümü, üç farklı sayısal çalışmaya ayrılmıştır.

İkinci Bölümde yapılan literatür taraması kısmında İngiltere, İtalya Yeni Zelanda ve Hollanda'da uygulanan ulusal değerlendirme sistemlerine, popüler üniversite sıralamalarına, üniversiteler için yapılan sınıflandırmalara ve üniversitelerin gerek eğitim gerekse araştırma alanındaki performanslarını ölçen akademik çalışmalara yer verilmiştir. Bu çalışmaların tümünde bibliyometrik verilerin ve panel/hakem değerlendirmelerinin en sık kullanılan yöntemler arasında olduğu görülmektedir. Yine bu çalışmaların tümünde üniversitelerin araştırma alanındaki performanslarının genel performansları üzerinde önemli ölçüde belirleyici olduğu görülmektedir.

Araştırma alanında performans değerlendirmesi yapılırken en sık kullanılan çıktı göstergelerinin akademik yayın sayısı, alınan atıf sayısı, gerçekleştirilen ar-ge projesi sayısı, yüksek lisans ve doktora programlarından mezun olan öğrenci sayısı olduğu görülmektedir. Bu çalışmada araştırma çıktısı olarak Web of Science veri tabanı kapsamındaki yayın sayıları, bu yayınların aldıkları atıf sayıları, TÜBİTAK'tan alınan proje sayıları ve mezun edilen doktora öğrencisi sayıları kullanılmıştır.

Çalışmanın Üçüncü Bölümünde Türkiye'nin bilim, teknoloji ve yenilik (BTY) istatistikleri ve Türk yükseköğretim sektöründeki gelişmeler özetlenmiş, seçilen araştırma çıktıları başta olmak üzere üniversitelerin araştırma performansını gösteren çeşitli çıktılar açısından üniversitelerin son 10 yılda gösterdiği performans incelenmiştir.

Bu bölümde yapılan analizlerin de gösterdiği üzere 2002 yılında 74 olan üniversite sayısı 2013 yılında 178'e çıkmış, öğrenci sayısında %161'lik öğretim elemanı sayısında ise % 72'lik artış yaşanmıştır. Bu artışa paralel olarak WoS'da endekslenen makale ve alınan atıf sayısı, TÜBİTAK tarafından desteklenen proje sayısı ve doktora mezunu sayısı artmıştır.

Dördüncü bölümde 2008-2010 dönemi için öğretim üyesi başına düşen yayın, atıf, ve ar-ge projesi oranları beş farklı disiplin bazında, öğretim üyesi başına düşen doktora mezunu oranı ise üç farklı disiplin bazında incelenmiştir. Her dört araştırma çıktısı için bu oranların disiplinler arası önemli farklılık gösterdiği tespit edilmiştir.

Öğretim üyesi başına düşen akademik yayın sayısını incelediğimizde bu oranın temel bilimlerde 1,44, sağlık bilimlerinde 0,84, mühendislik bilimlerinde 0,73, tarım-orman-veterinerlik (TOV) bilimlerinde 0,41, sosyal bilimlerde ise 0,15 olduğu görülmektedir.

Öğretim üyesi başına düşen atıf sayısını incelediğimizde karşımıza yayınlardaki duruma benzer bir tablo çıkmaktadır. Öyle ki bu oran, temel bilimlerde 1,81, sağlık bilimlerinde 0,62, mühendislik bilimlerinde 0,75, TOV bilimlerinde 0,20, sosyal bilimlerde ise 0,09 olarak hesaplanmıştır.

Öğretim üyesi başına düşen TÜBİTAK projesinde en yüksek oran 0,051 ile yine temel bilimler alanında gerçekleşmiştir. Temel bilimleri sırasıyla TOV bilimleri (0,026), mühendislik bilimleri (0,025), sosyal bilimler (0,006) ve sağlık bilimleri (0,005) takip etmektedir.

Öğretim üyesi başına düşen doktora mezunu sayısı (bu başlık altındaki veriler beş farklı disiplin bazında ayrıştırılamadığından) üç farklı disiplin bazında incelenmiştir. Bunun nedeni verilerin kaynağı olan ve ÖSYM tarafından yayınlanan Yükseköğretim İstatistiklerinde doktora mezunlarının bölümler bazında değil, enstitüler bazında veriliyor olmasıdır. Temel bilimler, mühendislik bilimleri ve TOV bilimleri Fen Bilimleri Enstitüsü altında ve ayrıştırılmadan verilmektedir. Analizlerimizin sonucunda öğretim üyesi başına düşen doktora mezunu oranının temel ve uygulamalı bilimlerde 0,14, sosyal bilimlerde 0,13 ve sağlık bilimlerinde 0,06 olduğu görülmektedir.

Öğretim üyesi başına düşen araştırma çıktılarının disiplinler arasında önemli ölçüde farklılık gösterdiğinden farklı alanlardaki çıktıların birbiriyle toplanmasının yerinde bir yöntem olmayacağı düşünülmüştür.

Disiplinler arasındaki farklılıkları göz önüne alabilmek için çıktılar normalize edilmiş ve hem VZA'nın hem de SSA'nın normalize edilmiş çıktılar kullanılarak yapılmasına karar verilmiştir. Çalışmamızı literatürdeki diğer çalışmalardan ayıran en önemli özelliklerden bir tanesi de budur. Diğer çalışmalarda atıfların ve yayınların alan bazlı normalize edildiğine rastlanmış, ancak doktora mezunu ve proje sayısı açısından farklılıkların dikkate alınmadığı görülmüştür.

Beşinci bölümün temel iki temel amacı bulunmaktadır. İlk olarak Veri Zarflama Analizinin üniversitelerin araştırma etkinliğini tespit etmek için uygun bir yöntem olup olmadığını tespit etmek, ikincisi ise en uygun VZA modelini kullanarak üniversitelerin araştırma etkinliği ölçmektir. Bu kapsamda 10 farklı VZA modeli uygulanmıştır. Bunların iki tanesi Ölçeğe Göre Sabit Getiri (ÖSG) Modeli, iki tanesi Ölçeğe Göre Değişen Getiri (ÖDG) Modeli, dört tanesi güvenlik bölgesi modeli, iki tanesi de süper etkinlik modelidir.

Bu modellerin yarısında öğretim üyelerinin sayısı toplanarak tek bir girdi değişkeni halinde modele entegre edilmiş, diğer yarısında ise profesör, doçent ve yardımcı doçent kadrosundaki öğretim üyeleri farklı girdi değişkeni olarak kullanılmıştır.

Modellerin tamamında öğretim üyesi değişkenine ilaveten araştırma görevlisi sayısı ve DPT tarafından son üç yılda tahsis edilen araştırma altyapı ödeneği toplamı da girdi değişkeni olarak seçilmiştir.

Özetlemek gerekirse uygulanan on adet modelin tamamında dört adet çıktı yer almaktadır. Bunlar önceden de ifade edildiği gibi yayın sayısı, atıf sayısı, TÜBİTAK projesi sayısı ve doktora mezunu sayısıdır. Çıktı değişkenlerinin tamamı alan bazında normalize edildikten sonra toplanmış ve modele normalize edilmiş toplamlar girilmiştir. VZA modelleri her yıl için ayrı ayrı uygulanmıştır.

Bauer ve diğerlerinin (1998) geliştirdiği bir kıyaslama yöntemi kullanılarak uygulanan 10 VZA modelinin çıktıları dört farklı tutarlılık kriterine göre değerlendirilmiştir. Bu kriterler şunlardır: etkinlik puanlarının istatistiksel dağılımlarının benzer olması, üniversitelerin etkinlik değerine göre Spearman sıralama korelasyon katsayılarının yüksek olması, en iyi ve en kötü yüzde 25'lik dilimde yer alan üniversitelerin ortak olması ve her model için farklı yıllarda elde edilen etkinlik puanlarının Spearman sıralama korelasyon katsayılarının yüksek olması.

Bu kriterler bazında yapılan analizlerde, etkinlik puanlarının dağılımlarının modeller bazında farklılık gösterdiği görülmüştür. Diğer yandan etkinlik değerine göre sıralama korelasyon katsayıları ile her model için farklı yıllarda elde edilen etkinlik puanlarının sıralama korelasyon katsayıları yüksek çıkmış; en iyi ve en kötü yüzde 25'lik dilimde yer alan üniversitelerin büyük oranda örtüştüğü görülmüştür. Bu sonuçlar, VZA yönteminin üniversitelerin araştırma alanındaki etkinliğini ölçmek için kullanılmasının uygun olduğunu göstermektedir.

ÖGS modellerinde hesaplanan artık değerler incelendiğinde, çıktılar bazında en etkin üretilenlerin yayın sayısı ve doktora mezunu sayısı olduğu görülmektedir. Diğer yandan TÜBİTAK projesi ve atıf sayıları açısından çok sayıda üniversitenin etkin üretim yapamadığı tespit edilmiştir. Üniversitelerin yaklaşık üçte ikisi bu araştırma çıktılarını yeterince üretememekte ve bu durum üç yıllık analiz dönemi boyunca devam etmektedir. Başka bir ifadeyle TÜBİTAK projesi ve atıf sayısında yeterli çıktı üretemeyen üniversiteler çoğunlukta olup, bu durum kronik hale gelmiştir.

Girdiler açısından baktığımızda ise en etkin kullanılan girdinin araştırma altyapıları için sağlanan yatırım ödeneği, en az etkin kullanılan girdinin ise araştırma görevlileri olduğu görülmektedir.

Her iki ÖGS modelinde üniversitelerin yaklaşık üçte ikisinin analiz dönemi boyunca ölçeğe göre azalan getiride oldukları görülmektedir. Bu üniversiteler arasında, eski devlet üniversiteleri çoğunluktadır. Yani VZA sonuçları eski devlet üniversitelerinin çoğunluğunun etkin çalışabilecekleri kapasitenin üstünde bir büyüklüğe ulaşmış durumda olduğuna işaret etmektedir. Diğer yandan, ölçeğe göre artan ya da sabit getiriye sahip üniversitelerin de ekseriyetle yeni devlet üniversiteleri ya da vakıf üniversiteleri olduğu görülmektedir.

Aynı girdi ve çıktıları kullanan ÖSG ve ÖDG modellerinin etkinlik puanları arasındaki korelasyon 2008 yılında düşük çıkmıştır. Avkıran (2001) bu durumda ÖDG modelinin kullanılmasını tavsiye etmektedir.

Öğretim üyelerini tek bir girdi değişkeni olarak kullanan modellerle, onları üç girdi değişkeni şeklinde kullanan modelleri incelediğimizde ÖSG modellerinin birbirleriyle benzer sonuçlar verdiği görülmektedir. Diğer yandan ÖDG modellerinde, özellikle de 2008 yılında, etkinlik puanlarında farklılıklar görülmüştür. Öğretim üyeleri hem aldıkları maaş hem de akademik deneyimleri açısından farklı olduklarından onları üç ayrı girdi değişkeni olarak dahil eden modellerin kullanılmasının daha anlamlı olacağı kararına varılmıştır.

Bütün modellerde en iyi ortalama etkinlik puanı 2010 yılında elde edilmiştir. Bu durumun iki farklı açıklaması olabileceği düşünülmektedir. İlk olarak, üniversitelerin araştırma etkinliği 2010 yılında birbirine yakınsamış olabilir. İkinci olarak, yüksek atıf alan yayınların diğer yayınlardan farkının ortaya çıkarabilmesi için zamana ihtiyaç duyulmaktadır. Yayın ve atıflar WoS'dan 12-15 Ocak 2013 tarihleri arasında derlenmiştir. Bu durumda, 2010 yılında yazılan makalelerin aldıkları atıf açısından ayrışmaları için yeterli süre geçmemiş olabilir. Bu sonuçlara dayanarak atıfları araştırma çıktısı olarak kullanacak performans çalışmalarının en az 3 yıllık yayınları kullanmasını önermekteyiz.

Güvenlik Bölgesi modelleri uygulanırken değişkenlerin katsayılarına dair konulan kısıtların herhangi bir grup üniversiteyi ödüllendirmemesi ya da cezalandırmaması hususuna dikkat edilmelidir. Böyle bir durum olup olmadığını tespit edebilmek amacıyla Güvenlik Bölgesi modelleri, kısıt bulundurmayan ÖSG ve ÖDG modelleriyle karşılaştırılmıştır. Sonuçlar konulan kısıtların belli bir grup üniversiteyi ödüllendirmediğini ya da cezalandırmadığını göstermektedir.

Bu çalışmada uygulanan Güvenlik Bölgesi modellerinde girdi değişkenlerinin ağırlıkları (maliyetleri) üzerine kısıt konulmuştur. Bu kısıtlara göre profesörlerin ağırlığı doçentlerden, doçentlerinki yardımcı doçentlerden, yardımcı doçentlerinki ise araştırma görevlilerinden yüksek olmalıdır. Söz konusu kısıtlar makul olduğundan ve belirli bir tip üniversiteyi daha fazla etkilemediğinden Güvenlik Bölgesi modellerinin ÖSG ve ÖDG modellerine kıyasla tercih edilmesi gerektiği değerlendirilmiştir.

Bu değerlendirmeler neticesinde 6. VZA Modeli en uygun model olarak kabul edilmiştir. Özet olarak 6. Model ÖDG varsayımına dayanmakta, profesör, doçent ve yardımcı doçentleri ayrı girdi değişkenleri olarak kullanmakta ve öğretim elemanlarının maliyetlerine (ağırlıkları) ilişkin kısıtlar getirmektedir.

Altıncı bölümde çeşitli faktörlerin araştırma performansına olan etkileri panel veri analizi yöntemi kullanılarak incelenmiştir. Aynı bağımsız değişkenler kullanılarak 5 farklı model oluşturulmuştur. Bu modeller sadece kullandıkları bağımlı değişkenler açısından farklılık göstermektedir. Seçilen bağımlı değişkenler şunlardır: (i) 6.modelde elde edilen etkinlik puanları (ii) öğretim üyesi başına düşen yayın sayısı, (iii) öğretim üyesi başına düşen atıf sayısı, (iv) öğretim üyesi başına düşen normalize edilmiş yayın sayısı, (iv) öğretim üyesi başına düşen normalize edilmiş atıf sayısı.

Bu bölümde tek bir model yerine beş farklı model oluşturmamamızın sebebi, bazı faktörlerin bütün araştırma çıktılarını aynı yönde ve büyüklükte etkilemeyeceği ihtimalini göz önünde bulundurmamızdır. Diğer yandan literatürde bulabildiğimiz kaynakların, tek bir bağımlı değişken kullanarak etki analizlerini yaptıkları görülmektedir.

Bu modellerde seçilen bağımsız değişkenler şunlardır:

- Üniversitelerin vakıf ya da yeni kurulmuş devlet üniversitesi olması,
- toplam öğretim üyesi sayısı,
- Doçent ve yardımcı doçentlerin öğretim üyesi içindeki oranı,
- öğretim üyesi başına düşen TÜBİTAK destek miktarı,
- öğretim üyesi başına düşen doktora öğrenci sayısı,
- öğretim üyesi başına düşen öğrenci sayısı,
- öğretim üyesi başına düşen akademik destek personel sayısı,
- meslek yüksekokullarında görevlendirilmiş öğretim üyelerinin oranı,
- sağlık bilimlerinde ve fen bilimlerinde görevlendirilmiş öğretim üyesi oranı,
- üniversitelerin bulundukları ilin sosyo-ekonomik gelişmişlik düzeyi

Yaptığımız öncül analizler, sabit etkili modeller (fixed effects models) ve havuzlanmış en düşük kareler modelleri (pooled OLS models) yerine tesadüf etkili modellerin (random effects models) kullanılmasının daha uyun olacağını göstermiştir.

Tesadüf etkili modellerin sonuçlarına göre bütün modellerde vakıf üniversitelerinin devlet üniversitelerine kıyasla daha başarılı olduğu anlaşılmıştır.

Üniversitelerde çalışan toplam öğretim üyesi sayısının, öğretim üyesi başına düşen yayın ve atıf sayısına anlamlı düzeyde bir etkisi olmadığı, ancak araştırma etkinliğine anlamlı düzeyde pozitif etkisi olduğu görülmüştür.

Öğretim üyesi kompozisyonu içerisinde profesörlerin oranının azalıp, doçentlerin oranının yükselmesi hem öğretim üyesi başına düşen yayın ve atıf oranını hem de araştırma etkinliğini anlamlı düzeyde olumlu yönde etkilemektedir. Benzer şekilde öğretim üyesi kompozisyonu içerisinde profesörlerin oranının azalıp, yardımcı doçentlerin oranının yükselmesi öğretim üyesi başına düşen atıf oranı ile araştırma etkinliğini anlamlı düzeyde ve olumlu yönde etkilemektedir. Dolayısıyla incelediğimiz araştırma çıktıları bazında en büyük katkıyı doçentlerin sağladığı görülmektedir.

Literadürdeki diğer çalışmalara paralel olarak öğretim üyesi başına düşen doktora öğrencisi, destek personel ve TÜBİTAK destek miktarı öğretim üyesi başına düşen yayın ve atıf oranı ile araştırma etkinliği üzerinde anlamlı düzeyde olumlu etki yaratmaktadır. Yine beklediğimiz üzere meslek yüksekokullarında görevlendirilen öğretim üyelerinin oranı bütün performans kriterlerini negatif yönde ve anlamlı düzeyde etkilemektedir.

Diğer yandan literatürdeki diğer çalışmaların aksine öğretim üyesi başına düşen öğrenci sayısının katsayıları pozitif, üniversitenin bulunduğu ilin sosyo-ekonomik gelişmişlik düzeyi ise negatif katsayılara sahip çıkmıştır. Bu durum üzerine getirebileceğimiz bazı yorumlar olmakla birlikte derinlemesine bir analiz yapılmadan bu yorumların doğruluğu tartışılmaya devam edilmelidir. Birinci durum için getirdiğimiz açıklama şu şekildedir. Araştırma alanında iyi olan üniversiteler öğrenciler tarafından da talep görmekte bu yüzden öğretim üyesi başına düşen öğrenci sayısı ile araştırma çıktıları arasında pozitif ilişki ortaya çıkmaktadır. Diğer yandan sosyo-ekonomik indeksin düşük olduğu illerde bulunan üniversitelerin çoğunluğunun yeni devlet üniversitesi olduğu görülmektedir. Bu üniversitelerde akademik kadro temini daha kolay olduğu için bu üniversitelerde görev yapan öğretim üyelerinin yayın yaparak bir an önce akademik terfi elde etme motivasyonları diğer üniversitelerdeki öğretim üyelerine kıyasla daha yüksek olabilir.

Üniversitelerin hangi disiplinde daha fazla yoğunlaştığı araştırma etkinliğine ve öğretim üyesi başına düşen normalize edilmiş yayın ve atıf sayısına anlamlı düzeyde etkide bulunmamaktadır. Diğer yandan normalize edilmemiş yayın ve atıf sayılarını kullanan modellerde sosyal bilimlerde yoğunlaşan üniversitelerin yayın ve atıf performanslarının, sağlık bilimleri ile fen bilimlerde yoğunlaşan üniversitelere kıyasla anlamı düzeyde düşük olduğu görülmektedir. Bu durumda alan-bazlı performans farklılıklarını dikkate almayan modellerin sosyal bilimlerde yoğunlaşan üniversiteleri bir nevi cezalandırdığını söyleyebiliriz.

Yedinci bölümde, önceki bölümlerde incelenen 94 üniversitenin araştırma verimliliği iki farklı SSA modeli kullanılarak ölçülmüş, elde edilen sonuçlar karşılaştırılmıştır. Her iki modelde de Battese ve Coelli (1995)'nin geliştirdiği trans-log üretim fonksiyonu kullanılmıştır. Bu model tek bir çıktı değişkeninin kullanılmasına izin vermektedir. Birinci modeldeki bağımsız değişken üniversitelerin normalize edilmiş toplam yayın sayısı, ikinci modelde kullanılan bağımsız değişken ise üniversitelerin normalize edilmiş toplam atıf sayısıdır.

Öte yandan maliyet fonksiyonlu SSA'larda birden fazla çıktı aynı modele entegre edilebilmektedir. Ama bunun için girdilerin birim maliyetlerinin ve analiz birimlerinin toplam harcamalarının bilinmesi gerekmektedir. Türk üniversitelerinin gerçekleştirdiği ar-ge harcamaları TÜİK tarafından topluca verilmekte, üniversite bazlı kırımlar çekilememektedir. Buna ilaveten öğretim üyesi maaşları devlet ve vakıf üniversitelerinde ciddi düzeyde farklılık göstermektedir. Bu iki nedenden dolayı çalışmada maliyet fonksiyonu yerine üretim fonksiyonu kullanılmıştır.

VZA yönteminden farklı olarak, SSA yöntemi aynı model içerisinde hem etkinlik puanlarını hesaplamakta hem de modele yerleştirilen etkinsizlik değişkenlerinin bu puan üzerindeki istatistiksel etkisini ölçebilmektedir.

Çıktıları normalize ettiğimiz için analizler üç yıllık veri bir arada kullanılarak yapılmış ve süreç içerisinde üretkenlik artışı olup olmadığını tespit edebilmek için yıllar kukla değişken olarak modele ilave edilmiştir. Modeldeki diğer etkinsizlik değişkenleri panel veri analizinde kullanılan bağımsız değişkenlerle aynı seçilmiştir. Böylelikle bu bölümdeki analizlerle bundan önceki iki bölümde yapılan analizlerin kıyaslaması daha net bir şekilde yapılabilecektir.

Birinci modeldeki log-benzerlik değeri 0.94, ikinci modeldeki ise 0.95 çıkmıştır. Log-benzerlik değerlerinin yüksek çıkması, birleşik hata terimi içerisindeki varyasyonun büyük kısmının etkinsizlikten kaynaklandığını göstermekte ve EKK yerine SSA modellerinin kullanılması gerektiğini göstermektedir.

Her iki SSA modeliyle elde edilen etkinlik puanları Spearman Sıralama testiyle karşılaştırılmış ve hesaplanan korelasyonlar her iki modelin benzer sıralamalar verdiğini göstermiştir. Başka bir ifadeyle bir üniversitenin toplam normalize edilmiş yayın üretimindeki etkinliği ile toplam normalize edilmiş atıf üretimindeki etkinliği birbiriyle ilintili çıkmıştır.

Altıncı Bölümde yapılan panel veri analizleriyle SSA sonuçları birbiriyle oldukça tutarlı çıkmıştır. İlk olarak, vakıf üniversiteleri normalize edilmiş toplam yayın sayısı açısından devlet üniversitelerinden daha başarılıdır. Normalize edilmiş toplam atıf sayısında ise anlamlı düzeyde fark çıkmamıştır.

İkinci olarak, öğretim üyesi başına düşen doktora öğrencisi sayısı, TÜBİTAK destek miktarı ve akademik destek personel sayısı toplam yayın ve atıf üretimini pozitif yönde ve anlamlı şekilde etkilemektedir.

Üçüncü olarak, sosyo-ekonomik gelişmişlik düzeyinin toplam yayın ve atıf çıktısını olumsuz yönde etkilediği tespit edilmiştir. Son olarak, doçentlerin çıktı esnekliği profesörlerden ve yardımcı doçentlerden daha yüksektir. Yardımcı doçentler ve profesörlerin karesel etkileşim terimlerine baktığımızda ise bu öğretim üyelerinin ölçeğe göre azalan getiride çalıştıkları görülmektedir.

SSA modelleriyle elde edilen etkinlik sıralamaları ile Beşinci Bölümde uygulanan 6. VZA modeliyle elde edilen etkinlik sıralamaları Spearman sıralama testiyle karşılaştırılmıştır. Ayrıca 6.Model SSA modellerindeki gibi tek çıktı kullanılarak iki kere daha uygulanmış ve bu iki modelin etkinlik puanları da SSA modelleriyle Spearman sıralama testi kullanılarak karşılaştırılmıştır.

Karşılaştırma sonuçları orijinal VZA modeliyle SSA modelleri arasındaki sıralama korelasyon katsayısının 0.46 ile 0.59 arasında değiştiğini göstermektedir. Dolayısıyla tek çıktılı SSA modelleriyle çok çıktılı VZA modeli benzer sıralama vermemektedir.

Diğer yandan tek çıktılı VZA modelleriyle SSA modelleri arasındaki sıralama korelasyonu, yayınlar için 0.61 ile 0.67 arasında, atıflar içinse 0.76 ile 0.85 arasında değişmektedir. Başka bir ifadeyle tek çıktılı VZA ve SSA modelleri üniversiteler için benzer etkinlik sıralaması vermektedir. Aradaki farkın bir kısmı VZA'nın tek yıllık, SSA'nın ise üç yıllık uygulanmış olmasından kaynaklanmaktadır.

Araştırma çıktıları yayından, lisansüstü öğrenciye, ar-ge projelerinden sanayiyle yapılan işbirliklerine, fikri mülkiyet haklarından bilimsel organizasyonlar gerçekleştirmeye kadar oldukça geniş bir yelpazeye dağılmıştır. Dolayısıyla yapılan değerlendirme çalışmalarında tek çıktıya değil çok sayıda çıktıya odaklanılmasının daha uygun olacağı düşünülmektedir. Bu görüş doğrultusunda, üniversitelerin araştırma performansları incelenirken SSA yerine VZA yönteminin kullanılması tarafımızca daha fazla önerilmektedir.

Ayrıca VZA yöntemi kullanıldıktan sonra ede edilen sonuçların bizim bu çalışmada yaptığımız gibi ekonometrik analizlerle incelenmesi ve etkinlik puanına etki eden faktörlerin tespit edilmesi, çalışmanın içeriğini zenginleştirecektir.

Çalışmamızın sonunda hem literatür taramasına hem de yapılan analizlere dayanarak çeşitli politika önerileri ve bu politikalar uygulanırken kullanılabilecek tedbirler geliştirilmiştir.

Çalışma sonucunda ortaya çıkan üç temel politika önerisi şunlardır:

1. Türkiye'deki üniversitelerin hem eğitim hem de araştırma alanındaki performanslarını değerlendirecek bir ulusal değerlendirme sistemi geliştirilmeli ve uygulanmalıdır.
2. Türk üniversitelerinin araştırma alanındaki operasyonel ve yönetim kapasiteleri geliştirilmelidir.
3. Türkiye'de dünya standartlarında araştırma üniversiteleri oluşturulmalıdır.

Türkiye'deki üniversitelerin hem eğitim hem de araştırma alanındaki performanslarını değerlendirecek bir ulusal değerlendirme sistemi geliştirilmesi önerisi altında dört temel tedbir geliştirilmiştir.

İlk olarak, bizim yaptığımız çalışmada da görüleceği üzere üniversitelerin performans değerlendirmesi hassas ve karışık bir konudur. Farklı yöntemler ve kriterler farklı sonuçlar çıkmasına yol açabilecektir. Bu nedenle farklı yöntemlerin bir arada uygulanması, sonuçların karşılaştırılması ve en tutarlı yöntemin belirlenmesi sistemin kabul edilebilirliğini artırmak için gereklidir. Bu kapsamda, değerlendirme sisteminde hem bibliyometrik veriler kullanılmalı hem de panel değerlendirmeleri yapılmalıdır.

İkinci olarak, değerlendirmelerin farklı disiplinler bazında ayrı ayrı yapılması gerekmektedir. Aksi takdirde disiplinler arası üretim farklılıkları dikkate alınmamış ve sonuçlar yanlı hesaplanmış olacaktır.

Üçüncü olarak, kullanılacak olan yöntemlerde mümkün olduğunca çok sayıda araştırma çıktısının ele alınması faydalı olacaktır. Böylelikle hem hükümetler, hem de üniversiteler hangi araştırma çıktılarına daha fazla odaklanmaları gerektiğini daha net bir şekilde tespit edebilecektir.

Dördüncü ve son olarak değerlendirme sistemi kapsamında derlenen meta verilerin ve elde edilen sonuçların ilgili kurumların ve araştırmacıların kullanımına açılması da önem taşımaktadır.

İkinci politika önerimiz üniversitelerin araştırma faaliyetleri açısından hem operasyonel hem de yönetim kapasitelerinin geliştirilmesine yöneliktir. VZA ve SSA sonuçlarına göre pek çok üniversitenin araştırma alanında yeterince etkin bir performans sergilemediği görülmektedir. Diğer yandan panel veri analizleri ve SSA sonuçları bu etkinsizliğin gözlemlenemeyen faktörlere, başka bir ifadeyle kurumların doğal yapısına, kültürüne ve yönetim şekillerine bağlı olduğuna işaret etmektedir. Bu politika önerisi altında 7 farklı tedbir önerisi geliştirilmiştir.

İlk olarak üniversitelere kamu bütçesinden ayrılan araştırma ödeneklerinin bir kısmının, üniversitelerin genel performansına dayanılarak verilmesi gerektiği düşünülmektedir. Mevcut durumda bireysel araştırmacılar TÜBİTAK'a ve Bilim, Sanayi ve Teknoloji Bakanlığına proje hazırlamakta ve başarılı olanlar desteklenmektedir. Ancak bunlar bireysel başarılardır. Üniversitelerin ulusal değerlendirme sistemiyle hesaplanacak genel başarısının da kamudan alacakları fon miktarında etkisi olmasında yarar görülmektedir. Böylelikle araştırma alanında üniversiteler arası rekabetin artacağı ve bu durumun bu alandaki etkinsizliklerin azaltılmasında olumlu katkı sağlayacağı düşünülmektedir.

İkinci olarak üniversitelerin araştırma faaliyetlerinde destek sağlayacak proje koordinasyon ofisleri yahut araştırma destek ofisleri kurmaları önerilmektedir. Bu ofisler araştırmacılara proje önerisi hazırlama, makale yazma, ulusal ve uluslar arası araştırma ağlarına dahil olma, yayınları yüksek etki faktörüne sahip dergilere yönlendirme konularında destek sağlayabilmelidir.

Üçüncü olarak üniversitelerdeki disiplinler arası araştırma faaliyetlerinin özendirilmesi gerektiği düşünülmektedir. Panel veri analizlerinde üniversitelerin öğretim üyesi açısından büyüklüğünün araştırma performansına katkısı olmadığı görülmektedir. VZA analizlerinde ise çok sayıda üniversitenin, özellikle de eski devlet üniversitelerinin ölçeğe göre azalan getiride çalıştıkları tespit edilmiştir. Oysa ki Dündar ve Lewis (1999) ile Wolszczak-Derlacz ve Parteka (2011) yaptıkları çalışmada üniversitelerdeki toplam öğretim üyesi sayısıyla araştırma verimliliği arasında pozitif ve anlamlı bir ilişki bulmuşlardır. Bu durumu büyük üniversitelerin çalışanlarına daha fazla disiplinler arası çalışma yapma imkanı sağlamasıyla açıklamışlardır. Üniversitelerin ölçek büyüklüğünden faydalanabilmeleri için disiplinler arası çalışmaları teşvik etmeleri gerektiği düşünülmektedir. Bu kapsamda, farklı bilim dallarını kapsayan yayınlara ve ortak projelere daha fazla destek sağlanabileceği ve disiplinler arası yüksek lisans ve doktora programlarının desteklenebileceği düşünülmektedir.

Dördüncü olarak öğretim üyelerinin, özellikle de profesörlerin araştırmanın farklı alanlarında daha etkin faaliyet göstermeleri teşvik edilmelidir. Mevcut durumda ülkemizde akademik terfiler yoğun olarak yayın yapma odaklı olup, diğer araştırma faaliyetlerinin terfi ve ücretlere etkisi olmamaktadır. Akademik terfilerde farklı araştırma çıktılarındaki başarılara yer verilmesi ve ücretlendirme sistemlerinin performansa dayalı şekilde yapılmasının üniversitelerin araştırma alanındaki etkinliğini ve üretkenliğini artıracağı düşünülmektedir.

Beşinci olarak araştırma görevlilerinin araştırma faaliyetlerinde daha etkin görev almaları sağlanmalıdır. VZA analizleri en verimsiz kullanılan girdinin araştırma görevlileri olduğunu göstermektedir. Bunun nedenleri konusunda ne yazık ki elimizde sayısal verilere, görüşmelere veya anket uygulamalarına dayanan sonuçlar bulunmamaktadır. Ancak araştırma görevlilerinin araştırma becerilerinin geliştirilmesi mevcut duruma mutlaka katkı sağlayacağı düşünülmektedir. Bu bağlamda, araştırma görevlilerine makale yazma, proje hazırlama, istatistiksel analiz ve araştırma teknikleri gibi konularda hizmet içi eğitimler verilmesi önerilmektedir.

Altıncı olarak meslek yüksekokullarında görev yapan öğretim üyelerinin araştırma faaliyetleri kapsamında desteklenmesi önerilmektedir. Çünkü hem panel veri analizleri hem de SSA sonuçları, meslek yüksekokulunda görev yapan öğretim üyelerinin yayın yapma ve atıf alma hususlarında sıkıntı yaşadığı gözlemlenmektedir. Bu öğretim üyelerinin özel sektör ve sanayiyle iletişim kurmaları, ortak çalışmalarda bulunmaları ve bunları yayın haline çevirmeleri konusunda yönlendirilmeleri faydalı olacaktır.

İkinci politika önerisi altındaki son tedbir olarak üniversitelerde araştırma kültürünün geliştirilmesine yönelik bilimsel organizasyonların daha sık gerçekleştirilmesi önerilmektedir. Bu çerçevede bilimsel kongre ve çalıştayların düzenlenmesinin, alanında söz sahibi bilim insanlarının konuşmacı olarak davet edilmesinin, öğretim üyesi, araştırmacı ve öğrencilere ödül verilmesinin araştırma faaliyetlerine olan ilgiyi artıracağı düşünülmektedir.

Üçüncü ve son politika önerimiz, araştırma üniversitesi kavramının Türk yükseköğretim sistemine entegre edilmesidir. Bu kapsamda, dünya standartlarında araştırma üniversitesi olabilecek üniversitelerin tespit edilmesi ve bunların diğer üniversitelerden farklı şekilde desteklenmesi gerekmektedir.

Araştırma üniversiteleri çok sayıda akademik görevi ve toplumsal rolü yerine getiren karmaşık ve seçkin kurumlardır. Bir yandan teknolojiyi ileri götüren yeni buluşlar ve düşünceler üretirken, diğer yandan insanların, içinde yaşadıkları çevrenin ve toplum olaylarının daha iyi anlanmasını sağlamak adına sosyal bilimler alanında çalışmalar yapar (Altbach, 2011).

Ulusal kurumlar olma niteliğini taşıyan araştırma üniversiteleri, lisans düzeyinde sınırlı sayıda öğrenciye eğitim sağlar, çünkü asıl hedef kitlesi yüksek lisans ve doktora öğrencileridir. Yine bu üniversiteler üst düzeyde araştırma faaliyetleri yapmakla yükümlü oldukları için alanlarında yetkin öğretim üyelerini istihdam ederler. Bu üniversiteler yükseköğretim sisteminin sınırlı kesimini oluşturmaktadır. Örneğin Amerika Birleşik Devletlerindeki 4.800 üniversitenin 150'si, Hindistan'da 18.000 üniversitenin 10 tanesi, Çin'de ise 5.000 üniversitenin sadece 100 tanesi dünya çapında araştırma üniversitesi olarak nitelendirilebilir (Altbach, 2011).

Yaptığımız literatür araştırmasında gördüğümüz üzere, pek çok ülke araştırma üniversitelerini desteklemek üzere kendi sınıflandırma sistemlerini geliştirmişlerdir. Bu çerçevede, Çin 1998 yılında 985 Projesi çerçevesinde araştırma üniversiteleri için özel bir destek programı başlatmıştır (Ma, 2007). Benzer şekilde 1999 yılında Güney Kore "Brain Korea 21" programını (Shin, 2009b), 2002'de ise Japonya Mükemmeliyet Merkezleri programını hayata geçirmiştir (Yonezawa, 2007). Almanya da rekabetçi araştırma üniversiteleri oluşturmak için 2005 yılında yeni bir destek programı oluşturmuştur (Jürgen, 2006).

Araştırma üniversitelerine yönelik destek programları oluşturan bu ülkelerde, araştırma üniversitesi olarak seçilen kurumlarda görev yapan araştırmacıların araştırma alanındaki performanslarında kısa süre zarfında önemli artış gözlemlenmiştir (Balan, 2007; King, 2004; Leydesdorff and Zhou, 2005; Shin, 2009b).

Türkiye'de 2012 yılından başlamak üzere TÜBİTAK tarafından "Yenilikçi ve Girişimci Üniversite Endeksi" isimli bir çalışma yapılmaktadır. Bu endeks hazırlanırken araştırma faaliyetlerinin yanı sıra fikri mülkiyet hakları, girişimcilik, ticarileştirme, sanayiyle ortak projeler yapma gibi faaliyetler bazında değerlendirme yapılmaktadır. Bu çalışmada ilk 50'ye giren üniversitelerin listesi yer almaktadır. Ancak bu listeye giren üniversitelere doğrudan verilen bir destek bulunmamaktadır. Sadece listeye giren üniversitelere teknoloji transfer ofisi desteğine başvuru hakkı verilmektedir.

Üniversitelerde yürütülmekte olan araştırma faaliyetlerinin hem kalitesini hem de miktarını artırmak için Türk yükseköğretim sistemine "araştırma üniversiteleri" kavramının getirilmesinin faydalı olacağı düşünülmekte ve bu politika önerisi altında beş farklı tedbir önerisine yer verilmektedir.

İlk olarak araştırma üniversitelerinin tespitinde kullanılacak kriterlerin yükseköğretim sektöründe yer alan aktörlerce benimsenecek, objektif kriterler olması önem taşımaktadır. Araştırma üniversiteleri kendilerine verilen özellikli araştırma görevlerini yerine getirebilmeleri için farklı mekanizmalarla desteklendiklerinden ve araştırma üniversitesi ünvanını almak o kuruma itibar sağladığından çok sayıda üniversite bu statüyü almayı talep edecektir. Örneğin, Güney Kore "Brain Korea 21" programını başlattıktan kısa bir süre sonra bu sorunla karşılaşmış, sorunu çözemeyince de doktora programı veren bütün üniversitelerin bu program kapsamında desteklenmesine karar vermiştir (Shin, 2009b).

Bundan sonraki dört tedbir önerimizin tamamı bu çalışma kapsamında yapılan analiz sonuçlarını dayanmaktadır. İlk olarak, panel veri analizi ve SSA sonuçlarına göre öğretim üyesi başına düşen doktora öğrencisi sayısının hem yayın sayısını ve kalitesini hem de araştırma etkinliğini olumlu yönde etkilediği ortaya çıkmıştır. Bu sonuçlara dayanarak, araştırma üniversitesi olarak seçilen üniversitelerde doktora programlarının desteklenmesi önerilmektedir. Bu kapsamda üniversiteler arası ortak programlar geliştirilmesinin ve uzaktan verilen doktora derslerinin çeşitlendirilmesinin olumlu etki yaratacağı düşünülmektedir.

İkinci önerimiz de hem panel veri analizi hem de SSA sonuçlarına göre geliştirilmiştir. Her iki analiz sonuçlarına göre öğretim üyesi başına düşen akademik destek personel (öğretim elemanı ve araştırma görevlisi) sayısı, hem yayın sayısını ve kalitesini hem de araştırma etkinliğini olumlu yönde etkilemektedir. Dolayısıyla araştırma üniversitelerinde öğretim üyelerinin ders yüklerini hafifletecek ve araştırmaya daha fazla zaman ayırmalarını sağlayacak oranda destek personel istihdam edilmesi önem taşımaktadır.

Üçüncü olarak, analiz sonuçları araştırma üniversitelerinde görev yapan öğretim üyelerine temel ve uygulama araştırma projelerinde kullanmaları için yeterli miktarda fon tahsis edilmesinin, kurumların yayın ve atıf sayısının yanı sıra araştırma etkinliğini de olumlu yönde katkı sağladığını göstermektedir. Dolayısıyla araştırma üniversitelerinin ar-ge projelerinin bir kısmının özel programları kapsamında desteklenmesinde yarar görülmektedir.

Son olarak, araştırma üniversitelerinin daha otonom yönetimlerinin olması ve araştırma yaparken daha bağımsız hareket edebilmeleri sağlanmalıdır. Literatürdeki pek çok çalışmada olduğu gibi bu çalışmada da yayın ve atıf performansları ile araştırma etkinliği açısından, özel üniversitelerin devlet üniversitelerinden daha başarılı olduğu görülmektedir. Bu durumun en önemli etkenlerinden birinin vakıf üniversitelerinin görece daha bağımsız ve profesyonel yönetilmelerinden kaynaklandığı düşünülmektedir. Ayrıca hem panel veri analizleri hem de SSA sonuçları, gözlemlenemeyen faktörlerin yani kurumsal kültür ve becerilerin araştırma etkinliğine etkisinin büyük olduğunu göstermektedir.

Bu çalışmanın yeterli veri bulunamamasından kaynaklı bazı kısıtları bulunmaktadır. İlk olarak, araştırma çıktısı olarak kullanılan yayınlar sadece WoS veri tabanında yer alan ve uluslararası hakemli dergilerde yer alan yayınlardır. Ulusal dergilerde yapılan yayınlar ya da kitaplar bu konuda veri alabilecek bir kaynak olmadığı için bu çalışmaya dâhil edilememiştir.

İkinci olarak, doktora programlarından mezun olan öğrenci sayıları, programlar bazında değil, enstitüler bazında verildiği için analizler en fazla üç disiplin bazında yapılabilmiştir. Çünkü temel bilimler, mühendislik bilimleri ve ziraat bilimlerinde açılan doktora programlarına ilişkin verilerin tamamı fen bilimleri enstitüsü altında ve toplu olarak verilmektedir.

Üçüncü olarak, çalışmada kullandığımız öğretim üyesi ve öğrenci sayıları akademik eğitim yılı başı itibarıyla verildiğinden ve yıl içerisindeki öğrenci ve öğretim üyesi hareketliliği takip edilemediğinden yıl ortası değerleri kullanılamamıştır.

Araştırma performansına etki eden faktörlerin daha detaylı incelenebilmesi ve beklenmeyen sonuçların yorumlanması açısından bu konuda yapılacak diğer çalışmaların nitel analizler yapmasının faydalı olacağı düşünülmektedir. Örneğin vakıf üniversitelerinde araştırma performansının hangi faktörler nedeniyle daha yüksek çıktığının incelenmesi Türk yükseköğretim sisteminin daha etkin şekilde kurgulanması için önemli çıktılar sağlayacaktır. Ayrıca öğretim üyelerinin ve araştırma görevlilerinin araştırma faaliyetlerinde bulunurken en fazla karşılaştıkları sorunlar ve öncelikli talepleri de bu çeşit nitel çalışmalarla daha net olarak anlaşılabilecektir.

Appendix F: Tez Fotokopisi İzin Formu

ENSTİTÜ

Fen Bilimleri Enstitüsü	
Sosyal Bilimler Enstitüsü	X
Uygulamalı Matematik Enstitüsü	
Enformatik Enstitüsü	
Deniz Bilimleri Enstitüsü	

YAZARIN

Soyadı : Tekneci
Adı : Pelin Deniz
Bölümü : Bilim ve Teknoloji Politikası Çalışmaları

TEZİN ADI (İngilizce) : Evaluating Research Performance of Turkish Universities

TEZİN TÜRÜ : Yüksek Lisans [ ] Doktora [X]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. [ ]

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: