Productivity Growth and Efficiency in the T.R.N.C. Banking System

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ABSTRACT

This study aims to examine the productivity growth and the efficiency level of fifteen commercial banks operating in the Turkish Republic of Northern Cyprus (T.R.N.C.) banking industry during 2003-2011. Scale efficiency, technical efficiency and the decomposed productivity growth are measured by the non-parametric data envelopment analysis (DEA) and Malmquist productivity index (MPI). DEA results suggest that 66 % of the commercial banks in T.R.N.C. banking industry are scale inefficient and %73 of those scale inefficient banks are operating under decreasing returns to scale (DRS). Empirical results of DEA also revealed that on average TRNC banking industry is technically inefficient during the study period. Additionally, the decomposed total factor productivity growth shows that T.R.N.C. banking industry has achieved %1 growth in the productivity in the interval 2003-2011 which is mainly due to the technical efficiency change (%2) component rather than the regress in the technological (%1) component. The efficiency gain is attributed to scale efficiency rather than the pure efficiency component. Finally from the policy point of view, the results suggest that bank managers should increase the level of technology used in the commercial banks and imply better manager skills and specialization in the T.R.N.C. banking industry.

Keywords: Productivity growth, data envelopment analysis, efficiency, Malmquist productivity index

ÖZ

Bu çalışmanın amacı, 2003-2011 yılları arasında Kuzey Kıbrıs Türk Cumhuriyeti (K.K.T.C.) bankacılık sektöründe faaliyet gösteren on beş ticari bankanın etkinlik ve verimliliğini incelemektir. Çalışmada ki ölçek etkinliği, teknik etkinlik ve ayrıştırılmış veririmlilik artış oranı parametrik olmayan veri zarflama analizi (VZA) ve Malmquist verimlilik endeksi ile ölçülmüştür. VZA sonuçları, K.K.T.C. bankacılık sektöründeki ticari bankaların %66'sının ölçek etkinsiz olduğunu ve bu ölçek etkinsiz bankalarında %73'unun ölçeğe göre azalan getiri ile faaliyet gösterdiği ortaya çıkmıştır. VZA ile elde edilen diğer ampirik sonuçlarda ise, K.K.T.C. bankacılık sektörünün ortalama olarak, 2003-2011 yılları arasında teknik etkinsiz olarak faaliyet gösterdiği ortaya çıkmıştır. Bu sonuçlara ek olarak, Malmquist toplam faktör verimlilik endeksinden elde edilen bulgulara göre, K.K.T.C. bankacılık sektöründe bahsi geçen dönemler içerisinde %1'lik bir büyüme meydana gelmiştir ve bu büyüme teknolojik olarak bankaların küçülmesine rağmen (%1) teknik etkinlikteki artıştan (%2) meydana gelmiştir. Teknik etkinlikteki artış ise banka personellerinin uzmanlaşması ve banka yöneticelerinin stratejik uygulmalarından değil, daha çok ölçek etkinliğinden meydana gelmiştir. Elde edilen bulgular, K.K.T.C. bankacılık sektöründeki yöneticilerin bankaların teknoloji düzeyini arttırması ve daha üst düzey yöneticilik becerileri göstermeleri geretiğini ortaya çıkarmıştır.

Anahtar Kelimeler: Verimililik büyümesi, veri zarflama analizi, etkinlik, Malmquist verimlilik endeksi.

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LIST OF ABBREVIATIONS

BCC	Banker, Charnes and Cooper
CCR	Charnes, Cooper and Rhodes
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Program
DFA	Distribution Free Approach
DMU	Decision Making Units
DRS	Decreasing Returns to Scale
EFCH	Technical Efficiency Change
IRS	Increasing Returns to Scale
MPI	Malmquist Productivity Index
OECD	Organization for Economic Co-operation and Development
PCH	Pure Efficiency Change
S.D.F.I	Savings Deposit Insurance Fund
SE	Scale Efficiency
SCH	Scale Efficiency Change
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
TECH	Technical Change
TFA	Thick Frontier Approach
TFP	Total Factor Productivity
TFPCH	Total Factor Productivity Change
T.R.N.C.	Turkish Repulic of Northern Cyprus

VRS	Variable Returns to Scale

Chapter 1

INTRODUCTION

1.1 Purpose of the Study

In today's world, the globalized economies increase the importance of the financial institutions in the local markets. Especially the banks among all financial institutions; by their intermediation role through collecting deposits and providing loans to the financial markets play a key role in the development of the economies. In another words, financial intermediaries bring borrowers and savers together and by injecting financial resources into the economy, they contribute in the development of the economies. However, together with globalization as the competition among the banks increases day by day, it becomes more difficult to survive in the financial markets. Thus, using the limited resources efficiently and increases the productivity becomes a vital factor for banks to survive and to keep the operations in the financial markets. Therefore, banks should be able to produce maximum level of output with a given level of resources (inputs) or they should be able to produce a given level of output with a minimum amount of inputs.

Recently, estimation of efficiency in the banking industries has been of research interest and there is a substantial amount of existing literature on efficiency and productivity of banking industries. However, as far as I know, there is no study on the efficiency and productivity of banking industry in T.R.N.C.

In the light of information given above, the main purpose of this study is to measure the efficiency and productivity of commercial banks in the Turkish Republic of North Cyprus (T.R.N.C.). This study employs a non-parametric data envelopment analysis (DEA) together with Malmquist productivity index (MPI) for 15 commercial banks operating in T.R.N.C. over the period 2003-2011. The empirical results obtained by DEA includes the technical efficiency score under constant returns to scale (CRS) and variable returns to scale (VRS) technology and the operating scales of the banks in T.R.N.C. market. The MPI results representes the decomposed total factor productivity into the components of technical efficiency and technological components. Technical efficiency is also decomposed into pure technical and scale efficiency components.

1.2 Banking System in T.R.N.C.

Before the establishment of the Central bank of T.R.N.C. in 1984, the operations in North Cyprus banking sector was carried by the Ziraat Bank. But as the numbers of banks in T.R.N.C. financial market increased, Ministry of Finance had difficulties in regulating the financial sector. Therefore, it was mandatory to have Central bank in T.R.N.C. and it was established in 1984 with 43 employees. Following the establishment of Central Bank, the Bank of Association in T.R.N.C. was established in 1987. The operations of Central bank and the banking industry continued till 1999. The economic crisis in 1999 shows the need of some changes in the banking industry so the economic stabilization program was implemented in T.R.N.C. during 2000. The aim of the program was to change the banking and Central bank laws so that the Central bank could have been restructured. The main purpose of restructuring was to have an independent Central Bank and having a centralized control mechanism over the banking industry.

Recently, there are 23 banks in the T.R.N.C. banking industry including one public, one development, fourteen domestic private and seven foreign branch banks in the sector. There are also nine banks under the control of savings deposit insurance fund (S.D.F.I.) and six banks are under liquidation. There are 205 branches and around 2700 employees working in the banking industry in T.R.N.C.

1.3 Framework of the Study

The structure of the study is as follows. Chapter one explains the purpose of the study and gives brief information about the banking system in T.R.N.C. The following chapter summarizes the literature on the productivity and efficiency in banking industry. Chapter three gives the theory of the empirical part that has been applied in this study. The methodology of DEA and MPI are presented in this chapter. Chapter four provides information about the data used in this study and the summary of descriptive statistics are also defined in this chapter. The empirical results of DEA and MPI are also represented in chapter four. Finally in chapter 5, the conclusion and the policy implications are presented.

Chapter 2

LITERATURE REVIEW

There are substantial amount of studies in the literature on estimating the efficiency and productivity in the banking industries. These studies include the evaluation of relative performances of banks within a country or across different countries. Generally, these studies employed two different models; parametric and non-parametric approaches. Parametric approach was first introduced by Aigner, Lovell and Schmidt (1977) and Stochastic Frontier Analysis (SFA) is a widely accepted technique for the application of the parametric approach. In order to work with SFA, a functional form including cost or production function should be defined. SFA works properly with multiple inputs and single output however it does not work properly with multiple inputs and outputs. Another advantage of SFA is it allows for random error.

Data Envelopment Analysis (DEA) is the most popular non-parametric approach in evaluating the relative efficiency and productivity for the decision making units (DMU). Non-parametric approach was originally introduced by Farrell (1957). The main advantage of DEA is it works well even for multiple inputs and outputs and it does not require a functional form as SFA does. There is no consensus on the approach that will be used in estimating the efficiency and productivity however DEA is more popular since it is easier to obtain the data used in this methodology.

DEA is a mathematical linear programming technique in which frontiers for each DMUs are constructed and relative efficiencies are measures with respect to the best frontier. DEA was firstly introduced by Charnes, Cooper and Rhodes (CCR) (1978) and then enhanced by Banker, Charnes and Cooper (BCC) (1984). One of the first studies by DEA on the banking industry was introduced by Berger and Humprey (1992). The authors intended to estimate the efficiency of commercial banks in US banking industry over the period 1980-1988. The authors concluded that the main reason behind the inefficiency was the excess usage of capital and labor in US banking industry.

In a cross country study, Fare (1994) employed non-parametric DEA together with MPI for 17 Organization for Economic Co-operation and Development (OECD) countries during the period 1979-1988. The authors concluded that the productivity growth in USA was attributed to the technological advancements however the growth in Japan was due to the improvements in technical efficiency and technology proportionally.

Favero and Papi (1995) tried to estimate the technical and scale efficiency in Italian banking industry for the period of 1991. The authors employed non-parametric DEA under the assumptions of CRS and VRS and additionally the authors used a regression analysis in order to find out the relation between the efficiency scores and some bank determinants. The authors revealed that there was a small difference between the estimates of the efficiency under CRS and VRS assumptions. The authors also approved that specialization and bank efficiency statistically had the strongest relation followed by the relation between size of the bank and the efficiency.

One of the most detailed studies on the performance of the banking industries was conducted by Berger and Humprey (1997). The authors in their study investigated 130 parametric and non-parametric studies for 21 countries by comparing five different models. The majority of the sample was consisted of US financial institutions and also financial institutions from other developed and developing countries. The authors revealed that the results obtained by non-parametric approaches had lower efficiency levels than the parametric ones.

Pastor, Perez and Queseda (1997) compared the efficiency and the productivity of US banking and some European banking industries. The authors employed non-parametric DEA together with MPI for 427 commercial banks in 1992. The empirical results of MPI were obtained with respect to the Spanish banks and the results showed that US banks were more productive than the Spanish banks. US banks required only 68 % of the input to reach to the same level of output produced by Spanish banks. Austrian banks were the most productive followed by Italian and German banking industries.

Casu, Girardone and Molyneux (2001) also examined the efficiency and productivity change of European banking industry including more than 2000 large banks and the authors compared the results obtained by non-parametric and parametric approaches. The main aim of the study was to measure the consistency of the results obtained by two approaches. The results of MPI revealed that Spanish banks had the highest productivity gain followed by Italian and French banks. Finally, the authors concluded that except French and German banks, the results of parametric approach were consistent with results of MPI.

In most of the non-parametric studies in the literature, the pre and post liberalization periods are compared. Zaim (1995), Jackson, Duygu and Inal (1998), Mukherjee, Ray and Miller (2001), Sathye (2002), Isik and Hassan (2003), Canhoto and Dermine (2003), Rezitis (2006), Arjomandi, Valadkhani and Harvie (2011) compared the effects of financial deregulations on the efficiency of the banking industries. It at was found that the financial liberalization and deregulation of the financial markets effected the average technical efficiency and the productivity positively.

In some other studies in the literature, the relative efficiency and the productivity of banking industries are measured according to the ownership status of the banks. In the studies of Noulas (1997) for Greece, Grifell and Lovell (1997) for Spain, Akhtar (2002) for Pakistan and Sathye (2003) for India, the banks are categorized according to their ownership status as private, foreign and state banks. The authors tried to find out which banking groups are more efficient and productive in their financial markets.

In recent years, in order to deal with the dependency problem and make statistical inferences, a bootstrapped DEA model has been employed in the literature. Quang and De Borger (2008) and Diler (2011) employed bootstrapped method in estimating the efficiency in the Vietnamese and Turkish financial markets respectively. Quang and De Borger (2008) analyzed the efficiency and the productivity for Vietnamese commercial banks during 2003-2006. The authors revealed that only in 2006 the banking industry achieved a productivity gain however it was statistical insignificant.

The productivity regress in 2003 and 2006 was statistically significant. Diler (2011) also investigated the efficiency and productivity in the Turkish banking industry in the interval 2003-2011 by employing a bootstrapped DEA together with MPI. The DEA results suggested that bootstrapped mean efficiency scores were less than the mean efficiency scores.

Finally, there are substantial amount of studies in the literature for estimating the efficiency and productivity by employing DEA and MPI. However, as far as I know, there is no efficiency study in the literature for the banking industry of North Cyprus. This study provides an up to date efficiency measurement and also the operating scales of the banks are presented. Additionally, the total factor productivity and technical efficiency are decomposed into their components.

Chapter 3

METHODOLOGY

3.1 Introduction

All the DMUs like to benefit from producing maximum level of output with a given level of input or using minimum amount of input in order to produce a given amount of output. Thus, it was important to estimate the efficiency of a DMU from a long time ago. However, the ways of measuring the efficiency are changing time to time. The average productivity of labor was one of the oldest method of measuring the performance of DMUs but as stated by Farrell (1957), because it ignored the savings of labor, the method has not been last long.

Ratio analysis was also a widely used methodology in estimating the efficiency of the DMUs. In this method, the data are generally collected from DMU's balance sheet or income statement and those data are converted into ratios. Ratio analysis is easy to apply and it helps the researchers to compare companies with different sizes. However, this analysis has some drawbacks. The first one is, if you do not have the industrial averages, the ratio does not have any meaning itself. Another drawback of this method is, it gives many results or in another words it does not provide a weighted average single efficiency score as it can be computed by DEA. Finally, ratio analysis ignores the external factors that may affect the production process of a DMU.

Another way of measuring the efficiency of a DMU is the parametric approach. There are three approaches for the application of parametric method. These approaches are stochastic frontier analysis (SFA), distribution free approach (DFA) and thick frontier approach (TFA). All these approaches differ from each other with respect to the shape of the frontier in each approach or the treatment of random error in the model. The common drawback of these three approaches is, they may give improper results with small number of observations.

SFA is one of the most popular parametric approaches and it is also known as econometric approach. In SFA, the input and output variables are used to construct a cost, profit or production function. Finally, SFA is stochastic and it allows for random error.

DFA can be used when the data is in time series form and it is very similar to the SFA approach. The main difference between the two approaches is in the treatment of random error and inefficiency.

Finally, TFA does not calculate efficiency scores for a single DMU but it estimates the average efficiency scores for the industry.

Non-parametric approach is another popular way of measuring the performance of a DMU. In non-parametric approach, the distance of input and output vectors is measured relative to the best practice frontier. It does not require functional form and does not allow for random error. It works well with small number of observations. However, there are some limitations of non-parametric DEA approach as well. The very first drawback is, it is not possible to estimate the economic efficiency by DEA because DEA does not account for the prices of inputs and outputs therefore allocative efficiency cannot be estimated.

To sum up, this study employs DEA together with MPI. Thus, this section describes the methodology used in this study and the structure of this section is as follows. The following section 3.2 explains the importance of deciding about the input and output vectors and also the different types of approaches about input and output specification will be discussed. Section 3.3 and 3.4 give a detailed theory on the methodologies used in this study which are DEA and MPI.

3.2 Input-Output Specification

Estimating the efficiency and the productivity of a DMU starts with the specification of the input and output vectors. Input and output specification is very important because different input-output vectors for each DMU may lead to different results. Therefore, the most suitable input and output vector should be chosen for a DMU according to the role of the DMU in the sector.

In the literature, there is no consensus about how to specify the inputs and outputs and there are several approaches used for the specification of inputs and outputs. Generally, the disagreement about the specification of inputs and outputs lie on the treatment of the deposits. Some studies in the literature treated deposits as an input (Favero and Papi, (1995); Casu and Molyneux, 2003; and Rezitis, 2006). Some other studies treat the deposits as an output (Zaim, 1995; Pastor, Perez and Queseda, 1997 and Fethi, Inal and Jackson, 1998).

In the banking theory literature, as stated by Sealey and Lindley (1977), there are two main approaches used in the specification of inputs and outputs: intermediation approach and production approach. Intermediation approach considers the banks as financial intermediaries between the savers and borrowers and treat the deposits as an input. Generally, the input vector is consisted of number of employees, amount of deposits, fixed assets and capital. The output vector includes the total amount of loans and investments. So, the intermediation approach assumes that the banks are collecting deposits by using their labor and capital and produce loans and investments. Since it is less data demanding, intermediation approach is so popular in the literature. Favero and Papi (1995), Isik and Hassan (2003) and Rezitis (2006) used intermediation approaches in their studies.

Production approach assumes that banks use labor and capital in order to produce deposits and loans. So, deposits are treated as output in the production approach. This approach is more eligible when the efficiency and the productivity of the branches of a same bank are estimated.

Addition to these two approaches, Favero and Papi (1995) defined three other approaches in their study. These approaches are known as asset approach, user cost and value added approaches. Asset approach is very similar to the intermediation approach. Berger and Humprey (1992) stated that bank liabilities have the properties of inputs as they are a source for investable funds and bank assets have the characteristics of outputs as they are uses of funds that generate revenues. The main drawback of the approach is it ignores most of the services offered by banks.

In user cost approach, the contribution of financial instruments on the revenue determines whether it is an input or output. In this approach, if the benefit obtained from the instrument is greater than the opportunity cost of funds, then the instrument is said to be an output. If the benefit obtained from the instrument is less than the opportunity cost of funds then the instrument is said to be an input. The main drawback of this approach is the difficulties in obtaining the data.

Finally, as stated by Berger and Humprey (1992), the value added approach considers that all assets and liabilities have some characteristics of the outputs. The main difference of this approach from user cost is the treatment of the operating cost in which value added approach uses it explicitly but user cost uses them implicitly.

In the light of the information given above, this study uses intermediation approach which was firstly introduced by Sealey and Lindley (1977). The input vector includes the interest and non-interest expenses and the output vector includes interest and non-interest incomes. Interest expenses are used as a proxy for the interest paid on the deposits and non-interest expenses as the labor and other operating expenses. Interest income is the proxy for the interest earned from the loans.

3.3 Data Envelopment Analysis (DEA)

DEA is used to evaluate the efficiency of DMUs based on a linear programming technique. Charnes (1978) was firstly introduced the application of a CRS technology under an input oriented measure. In order to avoid the problems of scale efficiency which raised from the DMUs that are not operating at their optimal scales, Barnes et al. (1984) introduced a model working on VRS technology. BCC model is appropriate when the DMUs are not operating at their optimal scale which is due to the increasing competition in the markets. Under CCR model, the change in the technical efficiency is attributed to pure efficiency change wholly and the scale efficiency change is ignored. However, under BCC model, the change in the technical efficiency is attributed to both pure efficiency change and scale efficiency change.

Efficiency measure used in DEA is simply the division of total outputs to total inputs. DEA is based on the construction of a best practice frontier and the performance of the rest of the DMUs is estimated relative to that best practice frontier. DMUs which are lying on the frontier are known as the efficient firms and they have efficiency score of unit. The scores of the rest of the DMUs vary between 0 and 1 according to their performances relative to the best practice frontier.

3.3.1 Input and Output Oriented Measures

As stated earlier, output oriented DEA technique tries to estimate the maximum output that could be produced by a given level of input and the input oriented measure tries to estimate the minimum level of input that could be used to produce a given level of output. Input and output oriented measures can be applied under both CRS and VRS technologies. But under CRS assumption, input and output oriented measures will provide the same results however under VRS assumption; the results will be different due to the scale efficiency.

Output oriented DEA models are very similar to input oriented measures in terms of the formulation and can be expressed as:

$\max_{\square,\square} \square$,

st $\quad -\square y_i + Y\square \geq 0$,

$x_i - X\square \geq 0$,

$K1'\square = 1$

$\square \geq 0$,

where $1\leq\square<\infty$ and $1-\square$ indicates the proportional increase in outputs when the input level is held constant. Moreover, $0\leq 1/\square \leq 1$ and $1/\square$ shows the technical efficiency scores.

3.3.2 Constant Returns to Scale (CRS) Model

If the firms are operating at their optimal scales, employing CRS assumption is appropriate. This model is firstly introduced by Charnes, Cooper and Rhodes (1978) and they used an input oriented model under the assumption of CRS. The efficiency of a DMU in an input oriented CRS model can be calculated as:

Efficiency: $\dfrac{\text{All weighted outputs}}{\text{All weighted inputs}} = u'y_i \,/\, v'x_i$

In this formulation we assume that there is a data for K inputs and M outputs for each N firm and for the i-th firm, y_i and x_i represents the outputs and inputs respectively. So, K*N indicates the input matrix and M*N indicates the output matrix and represents all the data for N firms. Additionally, u and v represents Mx1 output matrix and Kx1 input matrix respectively. The input oriented CRS model can be solved as:

$\max_{u,v} (u'y_i \,/\, v'x_{i}),$

st $\quad u'y_i \,/\, v'x_i \leq 1, \; j=1, 2, \ldots, N, \qquad (3.2)$

$u,v \geq 0,$

The objective function and the constraint in this problem states the maximization of efficiency score of the i-th firm subject to the constraints that all efficiency scores must be equal to or less than 1 and the aim is to find the values of u and v. The drawback of this formulation is it provides infinite number of solution which can be avoided by imposing the constraint $v'x_i=1$.

$$\max_{\mu,v} (\mu' y_i),$$

$$\text{st} \quad v' x_i = 1,$$

$$\mu' y_j - v' x_j \leq 0, \ j=1, 2, \ldots, N, \qquad (3.3)$$

$$\mu, v \geq 0,$$

This new constraint is the multiplier form of the DEA model and a different linear programming problem has come out by changing the notation from u and v to μ and v. By employing dual linear programming problem, an equivalent form of this problem can be derived;

$$\min_{\theta,\square} \theta,$$

$$\text{st} \quad -y_i + Y\square \geq 0,$$

$$\theta x_i - X\square \geq 0, \qquad (3.4)$$

$$\square \geq 0,$$

where θ is a scalar and □ is a Kx1 vector of constraints. The value of θ express the technical efficiency score for the i-th firm and the linear programming must be solved N times to estimate the value of θ for each firm. As Farrell (1957) stated out $\theta \leq 1$ will be found and $\theta=1$ indicates that the firm is technically efficient and the production point lies on the frontier. This envelopment form is more widely used since it requires less constraints compared to the multiplier form.

3.3.3 Variable Returns to Scale (VRS) Model

As mentioned earlier, CRS is appropriate when the DMUs are operating at the optimal scale. However, DMUs may not always operate at their optimal scales especially due to the increasing competition and the regulatory environment in the nation. For this reason, Banker, Charnes and Cooper (1984) provided an extension model of CRS which works under VRS assumption as well. In this model, the effects of scale efficiency change on the technical efficiency measures can be examined.

By adding the convexity constraint $N1'\lambda$ to the envelopment form discussed in CRS model, the VRS linear programming can be expressed as:

$$
\begin{aligned}
&\min_{\theta,\lambda} \theta, \\
\text{st} \quad & -y_i + Y\lambda \geq 0, \\
& \theta x_i - X\lambda \geq 0, \qquad\qquad (3.5) \\
& K1'\lambda = 1 \\
& \lambda \geq 0,
\end{aligned}
$$

where N1 is an Nx1 vector of unity. Technical efficiency scores obtained by this approach are greater than or equal to those obtained from CRS model since it envelopes the data points more compactly by forming a convex hull of linear planes.

Technical efficiency measure for a DMU under CRS and VRS measures may give different results. This difference is due to the scale efficiency effect in the production. The value of the scale efficiency can be calculated by the difference of technical efficiency obtained by VRS and CRS assumptions. So, as seen from equation 3.6, technical efficiency under CRS assumption is equal to the multiplication of technical efficiency under VRS and the scale efficiency.

$$TE_{CRS} = TE_{VRS} \text{ x } SE \quad (3.6)$$

The problem with the calculation of scale efficiency is, it does not give information whether the DMU is operating at increasing returns to scale (IRS) or decreasing returns to scale (DRS). So, in order to solve this problem, the constraint $N1'\square = 1$ should be changed with $N1'\square \leq 1$ in order to get:

$$
\begin{aligned}
&\min_{\theta,\square} \theta \\
&\text{st} \quad -y_i + Y\square \geq 0, \\
&\qquad \theta x_i - X\square \geq 0, \\
&\qquad N1' \leq 1, \qquad (3.7) \\
&\qquad \square \geq 0.
\end{aligned}
$$

3.4 Malmquist Productivity Index

Malmquist index was first introduced by Caves, Christensen and Diewert (1982a, b) and Fare (1994) applied DEA approach in order to measure the distance functions that are used in the formulation of Malmquist index. MPI is used to estimate the total factor productivity (TFP) changes of the DMUs. The main advantage of employing MPI is it decomposes the TFP into technical efficiency (catching-up) and technological components. Additionally, technical efficiency is also decomposed into pure efficiency change and scale efficiency change components.

As stated by Fare (1994), output oriented Malmquist index to measure TFP change between period t and t+1 is formulated as:

$$M_0\,(x^{t+1}, yt^{+1}, x^t, y^t) = [M_0^t\,(x^{t+1}, y^{t+1}, x^t, y^t) \text{ x } M_0^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t]^{1/2}$$

$$= \left[\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} x \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^t, y^t\right)} \right]^{1/2} \quad (3.8)$$

Equation 3.8 shows that $M_0^t(x^{t+1}, y^{t+1}, x^t, y^t)$ and $M_0^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t)$ are two indices measuring the productivity change for the periods t and t+1. When the value of M_0 is greater than 1 then productivity is expected to increase from period t to period t+1 but if M_0 is less than 1 then productivity is expected to decline in that periods. Additionally, equation 3.8 is the geometric mean of two TFP indices. The first TFP is set by the period t and the second by the t+1 technology.

As mentioned before, MPI has a very important feature where equation 3.8 can be decomposed into two components: technical efficiency change (EFCH) and technical change (TECH). EFCH is also known as the catching up effect and it measures the difference in distances between efficient frontier and the operating units during the periods of t and t+1. TECH defines the change in the production technology which may cause a shift in the production frontier. So, the decomposition of equation 3.8 into its components can be illustrated as follows:

$$M_0 (x^{t+1}, y^{t+1}, x^{t,} y^t) = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} x \left[\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)} x \frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}\right]^{1/2} \quad (3.9)$$

$$\text{where EFCH}=\frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} \quad (3.10)$$

$$\text{and TECH}=\left[\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)} x \frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}\right]^{1/2} \quad (3.11)$$

When the score of EFCH is greater than 1 than it indicates that there is an increase in the level of technical efficiency. If the score of EFCH is less than unity, than it indicates that there is a decrease in the level of technical efficiency and finally if the score is unit then there is no change in technical efficiency between two periods. TECH may take the same values as EFCH and the values of greater than 1, 0 or less than 1 indicates the technical progress in the production, technical stagnation or decline in the technical progress respectively.

Another advantage of MPI is it provides a decomposition of the EFCH as well. The decomposition of EFCH is important because it gives the reasons that why EFCH is in progress or regress. So, there are two components of EFCH: pure efficiency change (PCH) and scale efficiency change (SCH). Pure efficiency change also take values of greater than unity, unity or less than unity. So if the score of PCH is greater than 1, it indicates that there is a specialization or good managerial practice in this DMU. If it is less than one, then it indicates that there is a lack of specialization or managerial skills in the DMU. Finally, if it is unity, than it means that the specialization or managerial skills have no effects on EFCH. SCH also takes the same values. If the score of SCH is greater than unity, it means that this DMU benefits from the scale efficiency which contributes to the improvement of EFCH. And if it is less than one, then it indicates that there is an operating scale problem of that DMU. And finally if it is unity, then the operating scale of the DMU has no effect on EFCH. The formulation of PCH and SCH is as follows:

$$\text{PCH} = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1} \middle| VRS\right)}{D_0^{t}\left(x^{t}, y^{t} \middle| VRS\right)} \tag{3.12}$$

$$\text{and SCH} = \left[\frac{D_0^{t}\left(x^{t}, y^{t} \middle| VRS\right)}{D_0^{t}\left(x^{t}, y^{t}\right)} x \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1} \middle| VRS\right)}\right]^{1/2} \tag{3.13}$$

where $D_0(\bullet|VRS)$ indicates the distance functions calculated under the assumption of variable returns to scale (VRS).

Chapter 4

EMPIRICAL RESULTS AND ANALYSIS

4.1 Introduction

This chapter represents the empirical results of the methodologies that has been employed in this study. The following section describes the sample data that is used in the study. It defines the summary of the descriptive statistics which includes the mean, minimum, maximum and standard deviation of each input and output variables. As stated before, the data is consisted of interest and non-interest expenses as input variables and interest and non-interest income as output variables for 15 commercial banks operating in T.R.N.C. banking industry in the interval 2003-2011. Section 4.3 shows the empirical findings of DEA including technical efficiency under CRS and VRS assumptions and the operating scales of the each bank in the T.R.N.C banking system. Efficiency of the whole sector is also estimated in this section. Section 4.4 represents the empirical results of MPI. It includes the total factor productivity (TFP) of each bank during the study period. The decomposition of TFP into technical efficiency and technological components are also estimated in the entire section. Additionally, technical efficiency change is also decomposed into pure efficiency and scale efficiency components. The contribution of the study for the policymakers and bank managers are also represented in this section.

4.2 Data

This study is trying to estimate the efficiency and productivity growth of 15 commercial banks operating in T.R.N.C banking industry over the period 2003-2011. The data used in this study is obtained from the Central bank of T.R.N.C. This study employs intermediation approach including the interest and non-interest income as output variables and interest and non-interest expenses as input variables. Table 1 shows the descriptive summary statistics of the data used in this study. All the values of input and output variables in Table 1 are measured in TL.

The first column in Table 1 shows the mean values of input and output variables. Interest and non-interest income are abbreviated as y_1 and y_2 respectively where x_1 and x_2 represents interest and non-interest expenses. The mean value of the interest income for the T.R.N.C. banking industry during 2003-2011 is 37.127.548 TL and the mean value of non-interest income is 13.273.932 TL. It shows that majority of the income in the banking industry is interest income rather than non-interest income. The mean values of interest and non-interest expenses are 23.664.398 TL and 22.410.397 TL respectively.

In the second and third column of Table 1, the minimum and the maximum values of the input and output variables are presented. The minimum value of interest income is 50.262 TL which is attributed to DMU15 in 2003 and the maximum is 376.318.608 TL in 2003 for DMU2. The minimum value of non-interest income is 129.803 TL for DMU11 in 2003 and the maximum value is 254.806.923 TL in 2011 for DMU3.

Table 4.1 Descriptive Statistics of T.R.N.C Banks (2003-2011)

	Mean	Min.	Max.	St. dev.
y1	37.127.548	50.262	376.318.608	67.664.702
y2	13.273.932	129.803	254.806.923	29.696.692
x1	23.664.398	1.155	300.814.063	36.859.444
x2	22.410.397	281.515	273.237.899	36.859.444

Note: y1 and y2 represents interest and non-interest incomes respectively where x1 and x2 represents interest and non-interest expenses.

The minimum value of interest expense is 1.155 TL for DMU7in 2004 and the maximum value is 300.814.063 TL for DMU2 in 2003. Finally, the minimum value of non-interest expense is 281.515 TL for DMU15 in 2003 and the maximum value is 273.237.899 TL for DMU3 in 2011.

Appendix A1 to Appendix A4 represents the summary statistics of each input and each output variables for the banks over the period 2003-2011. The growth of each variable is also calculated in the appendixes.

Appendix A1 shows the summary statistics of interest income for 15 commercial banks in the industry during 2003-2011. The interest income of DMU8 grew %632 from 2003 to 2011 however the interest income of DMU12 decreased by %66 during the entire period.

Appendix A2 provides the summary statistics of non-interest income in the T.R.N.C. banking industry in the interval 2003-2011. The highest growth in the non-interest income is achieved by DMU3 at an amount of %4482 and the lowest increase is in the variable is attributed to DMU10 by %65.

Appendix A3 gives the detailed summary statistics of interest expenses of each bank during 2003-2011. The interest expense of DMU8 grew by %722 in the entire period and the interest expense of DMU12 decreased by almost %1 from 2003 to 2011.

Finally, Appendix A4 shows the summary statistics of non-interest expense in the T.R.N.C banking industry where it grew by %2000 for DMU3 and %22 for DMU7 during 2003-2011.

The following section will discuss the empirical results of DEA including the technical efficiency and the operating scales of T.R.N.C banks in the industry.

4.3 Data Envelopment Analysis (DEA) Results

This section represents the empirical results obtained by output oriented DEA under the assumptions of variable returns to scale (VRS) and constant returns to scale (CRS). All the computations are done by the software DEAP version 2.1 developed by Tim Coelli (1996). In the first part of the section, the operating scales of the banks including constant returns to scale (CRS) and increasing returns to scale (IRS) and decreasing returns to scale (DRS) and additionally the frequency distribution of the operating scales are defined. Then the technical efficiency score of each bank and the whole industry under the assumptions of CRS and VRS are estimated.

Table 4.2 and 4.3 show the operating scales and the frequency distribution of the operating scales in the T.R.N.C. banking industry respectively. Banks that are operating under CRS shows that they are scale efficient and they have scale efficiency score of unity. At this stage of the production, average productivity is maximized therefore it is the most productive stage. The scale inefficient banks are operating under VRS technology and they have scores less than unity. The banks operating under VRS technology may have two operating stages:

Table 4.2 Operating Scales of T.R.N.C. Banks (2003-2011)

Banks	2003	2004	2005	2006	2007	2008	2009	2010	2011
DMU1	CRS	CRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
DMU2	CRS	CRS	CRS	CRS	CRS	CRS	CRS	DRS	CRS
DMU3	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	CRS
DMU4	DRS	DRS	DRS	DRS	IRS	DRS	DRS	DRS	CRS
DMU5	CRS	DRS	DRS	CRS	DRS	IRS	DRS	CRS	CRS
DMU6	DRS	DRS	DRS	DRS	CRS	DRS	DRS	DRS	DRS
DMU7	CRS	CRS	CRS	CRS	CRS	CRS	CRS	CRS	CRS
DMU8	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
DMU9	DRS	DRS	DRS	DRS	DRS	DRS	DRS	IRS	CRS
DMU10	DRS	DRS	DRS	DRS	IRS	IRS	IRS	IRS	IRS
DMU11	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS
DMU12	IRS	DRS	DRS	DRS	IRS	IRS	DRS	CRS	CRS
DMU13	IRS	IRS	DRS	DRS	DRS	DRS	CRS	DRS	DRS
DMU14	CRS	CRS	CRS	CRS	CRS	CRS	CRS	CRS	CRS
DMU15	CRS	CRS	CRS	CRS	CRS	IRS	CRS	IRS	CRS

Note: Obtained by DEAP version 2.1 by Tim Coelli (1996).

The first one is the IRS in which the average productivity is less than the marginal productivity. The banks operating under IRS are expected to increase their operating scales. The second one is DRS in which the marginal productivity is less than the average productivity and the banks are expected to decrease their operating scales.

Table 4.3 shows the frequency distribution of the operating scales. It reveals that out of 135 observations, 46 were operating under CRS technology. It means that, in almost %34 of the total observations banks are operating at the optimal and most productive scale and in the rest %66 they are operating under VRS technology so they are scale inefficient banks. %27 of the scale inefficient banks are operating under IRS and the rest %73 are operating under DRS. This results suggest that

T.R.N.C. banking industry operated under DRS technology in the interval 2003-2011. So, the banks in the industry should decrease their operating scales.

Finally to sum up, when the operating scale of the T.R.N.C. banks are examined, it is found that almost %34 of the total observations are operating under CRS however the rest are operating under VRS so they are inefficient.

Table 4.3 Frequency Distribution of Scales of Banks

Period	CRS	VRS	IRS	DRS
2003	6	9	3	6
2004	5	10	2	8
2005	4	11	1	10
2006	5	10	1	9
2007	5	10	4	6
2008	3	12	5	7
2009	5	10	2	8
2010	4	11	4	7
2011	9	6	2	4

Note: Obtained by author.

The results showed that %73 of the observations are operating under DRS so that the banks in T.R.N.C. should reduce their operating scales and operate under a smaller scale.

Table 4.4 and 4.5 represents the technical efficiency scores of T.R.N.C banks under both CRS and VRS assumptions. Technical efficiency score of unity is attached to the efficient banks and scores below unity mark inefficient banks. In the light of this information, Table 4.4 shows that the DMU7 and DMU14 are fully efficient because the average technical efficiency scores are unity for each bank under CRS technology in the interval 2003-2011. DMU2 follows them with a score of 0.99 under CRS assumption. DMU12 had the lowest mean technical efficiency score by

0.58. It suggests that DMU12 could be able to produce %41.7 more output with the given level of inputs. The highest mean efficiency score in T.R.N.C banking industry is 0.96 in 2011 and the lowest mean score is 0.81 in 2010 under CRS assumption.

Table 4.4 Technical Efficiency Scores under CRS (2003-2011)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean
DMU1	1,00	1,00	0,74	0,80	0.824	0,86	0,91	0,80	0,85	0,87
DMU2	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,87	1,00	0,99
DMU3	0,81	0,78	0,82	0,89	0.820	0,80	1,00	0,42	1,00	0,82
DMU4	0,64	1,00	0,78	0,81	0.893	0,89	0,91	0,79	0,95	0,85
DMU5	1,00	0,93	0,89	1,00	0.880	0,96	0,88	1,00	1,00	0,96
DMU6	0,94	0,99	0,71	0,84	1,00	0,89	1,00	0,79	0,92	0,90
DMU7	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
DMU8	0,78	0,99	0,97	0,90	0,87	0,86	0,84	0,80	0,99	0,89
DMU9	0,77	0,92	0,68	0,97	0,81	0,87	0,76	0,88	1,00	0,85
DMU10	0,57	0,77	0,57	0,55	0,99	0,77	0,89	0,76	0,94	0,76
DMU11	0,75	0,98	0,81	0,80	0,69	0,79	0,78	0,98	0,86	0,83
DMU12	0,53	0,28	0,53	0,65	0,54	0,50	0,23	1,00	1,00	0,58
DMU13	0,89	0,90	0,83	0,88	0,79	0,76	1,00	0,79	0,92	0,86
DMU14	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
DMU15	1,00	1,00	1,00	1,00	1,00	0,94	1,00	0,19	1,00	0,90
Mean	0,84	0,90	0,82	0,87	0,88	0,86	0,88	0,81	0,96	

Note: Calculated by DEAP version 2.1 by Tim Coelli (1996).

Table 4.5 shows the technical efficiency scores obtained under VRS technology during 2003-2011. The average of efficiency scores of the DMU2, DMU3, DMU7 and DMU14 are equal to unity so they are technically efficient under VRS during 2003-2011.

The average efficiency score of DMU12 is 0.61 under VRS in the interval which is the lowest performance among the whole banks in the industry. The result suggests that DMU12 could be able to produce %39 more output with the given level of inputs. Table 4.5 also revealed that the average efficiency in Northern Cyprus banking industry vary between 0.90 (2010) and 0.98 (2011) in the interval 2003-2011. The efficiency scores under VRS are higher than the efficiency scores obtained under CRS as expected.

Table 4.5 Technical Efficiency Scores under VRS (2003-2011)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean
DMU1	1,00	1,00	0,97	1,00	1,00	0,94	1,00	0,98	0,88	0,98
DMU2	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
DMU3	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
DMU4	0,97	1,00	0,91	0,86	0,90	0,92	0,91	0,82	0,95	0,91
DMU5	1,00	0,93	0,94	1,00	1,00	0,96	0,90	1,00	1,00	0,97
DMU6	1,00	1,00	1,00	0,98	1,00	0,98	1,00	1,00	1,00	0,99
DMU7	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
DMU8	1,00	1,00	1,00	0,96	0,99	0,95	1,00	1,00	1,00	0,99
DMU9	1,00	0,93	0,83	1,00	0,84	1,00	0,77	0,89	1,00	0,92
DMU10	1,00	0,77	0,62	0,56	1,00	0,78	0,93	0,76	0,97	0,82
DMU11	1,00	1,00	1,00	1,00	0,84	1,00	0,91	1,00	0,97	0,97
DMU12	0,55	0,29	0,57	0,69	0,57	0,53	0,26	1,00	1,00	0,61
DMU13	0,92	0,92	0,88	0,89	0,85	0,79	1,00	0,87	0,93	0,89
DMU14	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
DMU15	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,22	1,00	0,91
Mean	0,96	0,92	0,92	0,93	0,93	0,92	0,91	0,90	0,98	

Note: Calculated by DEAP version 2.1 by Tim Coelli (1996).

Finally to sum up, the output oriented DEA results under the assumption of intermediation approach are obtained for both CRS and VRS technologies. The results under CRS shows that the mean technical efficiency vary between 0.81-0.96 in T.R.N.C banking industry during 2003-2011. Looking at the bank specific performances, the best performances are achieved by DMU7 and DMU14 with a mean technical efficiency score of unity and followed by DMU2 with a mean efficiency score of 0.99. The worst performance was with a mean score of 0.58 by DMU12. The results under VRS technology represents that, the mean technical efficiency in the banking industry vary between 0.90 and 0.98. The best performances are achieved by DMU2, DMU3, DMU7 and DMU14. The lowest mean technical efficiency score was obtained by DMU12 by 0.61.

4.4 Malmquist Productivity Index (MPI) Results

This section represents the estimates of Malmquist Productivity index which includes the productivity growth of 15 commercial banks in T.R.N.C. banking industry. The empirical results obtained by MPI also contain the decomposition of total factor productivity change (TFPCH) into the components which are technical efficiency change (EFCH) and technological change (TECH). Technical efficiency is also decomposed into pure technical and scale efficiency components. The increase in the pure technical efficiency is attributed to the specialization, managerial practices and good managerial skills. Scale efficiency component is related with the operating scale of the DMU.

Table 4.6 shows the bank means of productivity growth and its components in the interval 2003-2011. Bank means of productivity growth provides the mean productivity growth of each bank from 2003 to 2011. The result shows that the average productivity in T.R.N.C. banking industry was increased by %1 during 2003-2011. The decomposition of TFPCH reveals that the productivity gain was mainly attributable to increase in technical efficiency (%2) rather than the technological component. During that period, technological component decreased by 1 %.

Table 4.6. Bank Means of Productivity Growth and its Components (2003-2011)

	EFFCH	TECH	PECH	SECH	TFPCH
DMU1	0,98	0,96	0,99	1,00	0,94
DMU2	1,00	0,93	1,00	1,00	0,93
DMU3	1,03	1,02	1,00	1,03	1,05
DMU4	1,05	0,95	1,00	1,06	0,99
DMU5	1,00	0,98	1,00	1,00	0,98
DMU6	1,00	0,96	1,00	1,00	0,96
DMU7	1,00	1,11	1,00	1,00	1,11
DMU8	1,03	1,00	1,00	1,03	1,03
DMU9	1,03	0,98	1,00	1,03	1,01
DMU10	1,07	0,95	1,00	1,07	1,01
DMU11	1,02	0,98	1,00	1,02	1,00
DMU12	1,08	1,05	1,08	1,01	1,14
DMU13	1,01	0,97	1,00	1,00	0,98
DMU14	1,00	1,03	1,00	1,00	1,03
DMU15	1,00	0,97	1,00	1,00	0,97
Mean	1,02	0,99	1,00	1,02	1,01

Note: EFFCH is technical efficiency change, TECHCH is the technological change, PECH is pure efficiency change, SECH is scale efficiency change and TFPCH is total factor productivity change (Malmquist productivity index).

Additionally, the decomposition of EFCH shows that the increase in efficiency is mainly due to the increase in the scale efficiency (%2) rather than the pure efficiency change during the study period.

Table 4.6 also reveals that the TFPCH of Northern Cyprus banks vary between 0.93 and 1.14. TFPCH of 0.93 is attained by DMU2 and it means that on average the productivity of DMU2 decreased by %7 in the interval 2003-2011. The highest productivity of 1.14 is attained by DMU12 which means that on average, the productivity of DMU12 has increased by %14 during 2003-2011.

Bank specific performances show that except DMU7 and DMU14, TFP gains are attributed to the efficiency gains rather than technological advances and the productivity regresses are due to the decrease in the technological levels. However for DMU14and DMU7, the productivity gain is wholly due to the technological advancements rather than the efficiency component. Furthermore, except DMU12, the gain in technical efficiency is due to the improvement in scale efficiency rather than the managerial practices. The improvement of technical efficiency of DMU12 is due to the specialization and the managerial practices rather than the scale efficiency.

Table 4.7 shows the annual means of productivity growth and its components in the interval 2003-2011. Annual means of productivity growth provides the TFPCH and the change in its components for the T.R.N.C. banking industry for each period.

Table 4.7 reveals that the highest gain in the productivity is %26 during 2003-2004. This result suggests that the productivity in the T.R.N.C. banking industry increased by %26 between 2003 and 2004. The lowest productivity level in the banking industry is 0.87 from 2008 to 2009. So, the result suggests that the productivity in the T.R.N.C. banking industry decreased by %13 from 2008 to 2009. The highest efficiency change is experienced between 2010 and 2011 by %27 and the highest technological change is achieved between 2009 and 2010.

Table 4.7. Annual Means of Productivity Growth and Its Components (2003-2011)

Period	EFFCH	TECH	PECH	SECH	TFPCH
2	1,05	1,20	0,93	1,13	1,26
3	0,93	0,94	1,01	0,91	0,88
4	1,07	0,83	1,02	1,05	0,89
5	1,00	0,96	1,01	1,00	0,97
6	0,98	1,22	0,99	1,00	1,20
7	0,99	0,88	0,96	1,03	0,87
8	0,90	1,27	0,98	0,92	1,14
9	1,27	0,73	1,14	1,12	0,93
Mean	1,02	0,99	1,00	1,02	1,01

Note: EFFCH is technical efficiency change, TECHCH is the technological change, PECH is pure efficiency change, SECH is scale efficiency change and TFPCH is total factor productivity change (Malmquist productivity index).

To sum up, T.R.N.C. banking industry has a very slight change in the level productivity in the interval 2003-2011. The productivity gain is almost %1 which is mainly due to the improvement in the efficiency level of the T.R.N.C. banking industry rather than the technological advancements. Additionally, the improvement of the efficiency is attributed to the scale efficiency rather than the managerial practices or the specialization.

Chapter 5

CONCLUSION

Financial institutions play an important role in the development of the nation's economy. Especially, in a country under embargoes like T.R.N.C., banks and other financial institutions are very crucial for the well being of the economy. However, financial institutions in T.R.N.C. have much more limited resources than other countries. Thus, the limited resources should be used efficiently and contributes to the productivity of the DMUs. For these reasons, this study aimed to investigate efficiency and the productivity growth in the T.R.N.C. banking industry during the period 2003-2011. The study employees non-parametric DEA together with MPI under the assumptions of CRS and VRS. Under the intermediation approach, input and output vectors include interest and non-interest expenses and interest and non-interest incomes respectively.

The empirical DEA results reveal that only one-third of the banks in T.R.N.C. banking industry operate under CRS and the rest %66 works under VRS technology. %73 of the banks that are operating under VRS works under DRS technology and the rest works under IRS technology. So as a policy implication, this study suggests that the banks working under DRS technology should decrease their operating scales and banks that are working under IRS technology should increase their production capacity.

The empirical DEA results about the efficiency of the T.R.N.C. banking industry state that the mean value of technical efficiency of T.R.N.C. banking industry varies between 0.81 and 0.96 under CRS technology. This result shows that the mean level of technical efficiency in T.R.N.C. banking industry is less than unity so they are inefficient. The bank specific performances show that under CRS technology, DMU14 and DMU7 are fully efficient and they are followed by DMU2 by a score of 0.99. Again under CRS technology, DMU12 has the lowest relative mean technical efficiency (0.58) among the banks in the banking industry. So, in order to be as efficient as DMU14 or DMU7, DMU12 should produce %42 more output with the given level of inputs.

The DEA efficiency results under VRS technology reveals that the mean technical efficiency score of T.R.N.C. banking industry vary between 0.90 and 0.98. So, on average, also under VRS technology T.R.N.C. banking industry is technically inefficient. Bank specific performances show that the relative mean technical efficiency score of DMU14, DMU7, DMU2 and DMU3 are unity so they are fully efficient. The relative mean technical efficiency score of DMU12 is 0.61 under VRS technology in the interval 2003-2011. So, DMU12 should be able to produce %39 more with the given level of inputs.

The empirical results of MPI reveal that on average, the productivity growth of T.R.N.C. banking industry increased by %2 during 2003-2011. Although technological level decreased by %1, technical efficiency increased by %2 and as a result TFP increased by %2. The increase in the technical efficiency is mainly due to the increase in the scale efficiency component rather than the pure efficiency component. Another outcome of the MPI results provides that 7 banks out of 15 commercial banks had productivity regress, one bank had no productivity change and 7 banks had productivity gain in the interval 2003-2011. The highest mean productivity growth is achieved by DMU12 by %14 during the period 2003-2011. The worst productivity performance is attributed to DMU2 by %7 decrease in the performance.

Annual means of productivity growth show that the best productivity performance in the T.R.N.C. banking industry is achieved during 2003-2004 by %26 and the worst performance is during 2008-2009 by %13 decrease in the productivity level.

From the policy implication point of view, as stated earlier, %66 of the banks in the T.R.N.C. banking industry are scale inefficient and they have to change their operating scales. Additionally, bank managers have to increase the technological levels of their banks because technological levels did not have any contribution to the productivity gain in the T.R.N.C. banking industry. Finally, the input variables of interest and non-interest expenses should be used more efficiently in the banking industry. The banks should produce more outputs with this level of inputs or should decrease the level of inputs used in order to produce same level of output.

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APPENDICES

Appendix A1: Descriptive Statistics for Interest Income in the T.R.N.C. Banking Industry (In 000)

Banks	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth
DMU1	46,830	49,228	56,356	68,862	84,976	89,260	84,339	69,352	66,313	0.42
DMU2	376,319	328,444	324,161	188,843	255,682	291,945	239,736	207,604	221,759	-0.41
DMU3	23,870	25,829	26,492	32,326	40,124	42,477	34,036	28,565	31,651	0.33
DMU4	16,146	16,067	13,252	16,020	14,945	17,705	20,945	24,570	27,359	0.69
DMU5	15,995	16,151	18,263	24,246	32,963	35,093	36,910	33,591	36,256	1.27
DMU6	14,524	14,318	18,337	27,643	36,932	55,315	65,267	67,052	81,377	4.60
DMU7	148	182	157	184	243	191	278	200	176	0.19
DMU8	8,978	11,421	15,860	23,328	30,014	43,853	49,243	52,158	65,738	6.32
DMU9	6,890	7,510	9,597	17,686	20,883	21,428	21,318	24,273	29,109	3.22
DMU10	6,557	8,316	10,542	7,629	15,092	10,409	11,647	10,819	13,129	1.00
DMU11	829	1,573	1,932	3,197	4,334	5,215	5,341	7,449	6,022	6.26
DMU12	2,381	1,341	1,784	1,511	1,739	1,806	1,872	1,502	815	-0.66
DMU13	5,938	8,806	12,285	17,851	23,520	31,355	33,129	26,688	27,407	3.62
DMU14	3,568	4,845	7,429	8,613	8,533	11,337	12,146	13,786	14,819	3.15
DMU15	50	107	142	204	136	368	358	161	193	2.86

Appendix A2: Descriptive Statistics for Non-Interest Income in the T.R.N.C. Banking Industry (In 000)

Banks	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth
DMU1	2,697	6,042	15,595	18,180	14,163	23,185	17,426	21,027	27,938	9.36
DMU2	8,519	18,426	16,893	31,771	16,472	54,798	31,941	34,629	62,677	6.36
DMU3	5,561	9,437	24,909	36,048	18,233	36,074	132,242	162,500	254,807	44.82
DMU4	3,828	7,012	10,983	10,562	5,478	6,540	7,274	7,141	8,834	1.31
DMU5	1,462	3,901	3,823	6,472	7,692	7,772	8,542	9,896	6,238	3.27
DMU6	3,462	7,285	8,501	9,494	14,149	22,893	18,915	39,869	88,323	24.51
DMU7	518	506	499	931	230	4,986	779	832	1,015	0.96
DMU8	2,066	3,043	5,441	10,191	8,859	10,691	19,251	24,378	29,601	13.33
DMU9	2,538	4,394	4,105	10,643	4,403	15,328	12,149	7,564	12,850	4.06
DMU10	3,037	3,634	3,959	3,240	5,784	4,604	3,340	3,411	5,004	0.65
DMU11	130	276	373	745	666	810	1,070	1,056	1,674	11.88
DMU12	210	656	902	1,498	994	1,282	1,497	10,171	831	2.96
DMU13	402	1,092	1,939	4,837	5,130	7,587	11,449	7,811	8,469	20.07
DMU14	1,337	1,861	2,315	1,480	1,873	1,860	2,279	3,337	8,554	5.40
DMU15	833	3,515	3,384	2,557	2,228	2,690	2,029	1,576	2,385	1.86

Appendix A3: Descriptive Statistics for Interest Expense in the T.R.N.C. Banking Industry (In 000)

Banks	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth
DMU1	31,286	23,962	38,034	38,945	52,056	60,165	50,858	37,393	39,700	0.27
DMU2	300,814	244,938	235,711	128,213	174,835	199,689	174,403	135,288	143,522	-0.52
DMU3	14,796	13,906	14,633	18,656	21,802	23,588	17,388	12,612	12,537	-0.15
DMU4	17,035	10,797	8,116	9,735	9,784	10,019	12,624	14,563	15,077	-0.11
DMU5	9,132	8,167	10,052	13,252	17,372	22,341	22,251	18,832	20,369	1.23
DMU6	8,112	6,560	7,880	14,557	21,568	38,202	41,969	35,531	42,098	4.19
DMU7	41	1	1	2	17	2	7	10	46	0.12
DMU8	4,038	4,502	6,623	12,940	15,578	25,399	25,108	23,306	33,198	7.22
DMU9	4,786	4,106	4,506	8,529	12,245	15,653	17,579	15,390	16,908	2.53
DMU10	8,268	6,677	7,434	7,529	9,691	9,570	7,960	6,141	7,626	-0.08
DMU11	535	617	730	1,456	2,064	2,825	2,733	2,435	2,896	4.41
DMU12	2,361	1,232	977	912	919	942	921	381	20	-0.99
DMU13	4,106	4,691	6,494	10,237	14,023	21,064	20,584	13,225	13,670	2.33
DMU14	850	1,119	2,327	2,373	825	591	726	1,100	1,669	0.96
DMU15	148	198	269	605	282	322	330	509	270	0.82

Appendix A4: Descriptive Statistics for Non-Interest Expense in the T.R.N.C. Banking Industry (In 000)

Banks	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth
DMU1	11,180	15,645	28,808	45,210	39,920	45,995	41,026	43,121	47,575	3.26
DMU2	78,126	93,570	94,009	61,688	74,887	98,267	84,787	96,877	112,252	0.44
DMU3	13,012	15,795	30,710	46,889	32,280	53,800	147,099	176,319	273,238	20.00
DMU4	7,977	7,568	14,534	17,274	9,575	11,359	12,246	14,696	16,145	1.02
DMU5	5,394	6,700	7,159	11,088	16,816	14,592	19,368	13,568	17,098	2.17
DMU6	6,537	7,646	14,803	20,030	21,700	35,203	30,532	47,377	106,461	15.29
DMU7	958	729	681	1,113	832	4,430	1,077	1,020	1,170	0.22
DMU8	6,668	5,061	6,836	17,087	17,463	23,970	36,613	37,950	41,559	5.23
DMU9	4,183	4,475	7,048	15,359	11,077	20,148	20,630	11,222	16,709	2.99
DMU10	4,330	5,068	8,323	8,540	8,920	7,578	6,235	7,256	7,896	0.82
DMU11	472	675	1,182	2,200	2,400	2,906	3,308	4,385	4,309	8.13
DMU12	1,747	3,005	2,458	3,020	2,492	3,543	9,895	2,514	2,630	0.51
DMU13	1,962	3,185	5,317	9,999	13,027	18,993	16,741	17,797	17,391	7.86
DMU14	2,473	2,793	2,890	4,806	3,721	6,695	6,813	10,401	13,256	4.36
DMU15	282	1,732	3,066	2,156	2,207	2,593	2,053	2,061	2,116	6.50