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# Evaluating Efficiency of Nina Distribution Company Using Window Data Envelopment Analysis and Malmquist Index

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***Abstract*—**Achieving continuous sustained economic growth and following economic development can be the target for all countries which are looking for it. In this regard, distribution industry plays an important role in growth and development of any nation. So, estimating the efficiency and productivity of the so called industry and identifying factors influencing it, is very necessary. The objective of the present study is to measure the efficiency and productivity of seven branches of Nina Distribution Company using window data envelopment analysis and Malmquist productivity index from spring 2013 to summer 2015. In this study, using criteria of fixed assets, payroll personnel, operating costs and duration of collection of receivables were selected as inputs and people and net sales, gross profit and percentage of coverage to customers were selected as outputs. Then, the process of performance window data envelopment analysis was driven and process efficiency has been measured using Malmquist index. The results indicate that the average technical efficiency of window Data Envelopment Analysis (DEA) model and fluctuating trend is sustainable. But the average management efficiency in window DEA model is related with negative growth (decline) of about 13%. The mean scale efficiency in all windows, except in the second one which is faced with 8%, shows growth of 18% compared to the first window. On the other hand, the mean change in total factor productivity in all branches of the industry shows average negative growth (decrease) of 12% which are the result of a negative change in technology.

***Keywords*—**Nina Distribution Company branches, window data envelopment analysis, Malmquist productivity index.

## I. Introduction

ECONOMIC development of developing countries depends on improving efficiency and productivity in various economic and social sectors. Also, efficiency and effectiveness cause global competitive advantage across countries and paying attention to it is essential. Concepts of efficiency and effectiveness are widened by economic developments. The efficiency means comparing the performance of a single firm (organization) during two different time periods or comparing the efficiency of two organizations relative to one another at the same time. In other words, efficiency is to compare the efficacy. The measurement of productivity and efficiency is considered as a tool, not a goal. The main objective of a productive unit is reaching performance and profitability and in many cases, delivering service to the community. Therefore, from an economic perspective, measuring efficiency and productivity should not be isolated activities, but must be designed to transform data to objective and fruitful activities in order to improve productivity and thus improve the performance and profitability using the so called factors.

The aim of this study was to measure the efficiency of the Nina Distribution Company branches with window DEA method and Malmquist Index. Optimal use of existing facilities is an advanced practice to increase production and services and that's why resources experts make distinction between available resources with other duties of managers [28] or even in some cases, improving efficiency is considered as the main task of the director while the measurement of efficiency is equal to not-wasting resources in terms of numbers and figures. Efficiency index means comparing the performance of a single firm (organization) during two different time periods or comparing the efficiency of two organizations relative to one another at the same time, so this concept is very comprehensive and includes the performance.

## II. Theoretical Frameworks

Increasing efficiency of a firm is ensuring to find ways to promote competitiveness and profitability of it. Measuring efficiency inter- and intra-firms can assist in the diagnosis inefficient organization well. There are several performance measures in determining the efficiency of companies and financial agencies. The simplest one is using ratio index to the output. Development of mathematical models to measure the efficiency makes it possible to convert actual space to mathematical and statistical formats in practice and identify optimal behavior of firms in order to minimize the costs. DEA is a useful tool in assessing the performance of the production structure. In other words, DEA simply can be defined at least as a harmonious fusion of inputs to outputs in harmonious fusion. Farrel has introduced the efficiency of nonparametric methods for economic analysis in 1957 [21]. Based on the researches carried out by Debreu [28] and Koopman [29], Farrel's research was to measure the effectiveness of the firm so that he could investigate the multiple factors. Farrell [21] proposed that the efficiency of a firm consists of three elements:

1. Technical efficiency: Reflects the ability of a firm to get the maximum output from a given set of inputs. In other words, by assuming the same technology for all firms, not

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to waste inputs in the production of a certain amount of production takes more attention. Technical efficiency of output is calculated through production scale and technical relationships are based on prices, not costs.

2. Allocative efficiency: Reflects the ability of a firm to use the inputs in optimal proportions depending on the corresponding inputs price. This kind of efficiency is related with minimizing production costs by selecting the appropriate inputs for a given level of output according to a concerned price set for institutions.
3. Economic efficiency (cost): This function is associated with a combination of technical and allocative efficiency. An organization includes economic efficiency while it is perfect in both technical and allocative efficiencies. Economic efficiency (cost) is calculated by multiplying the product of technical and allocative efficiencies. Determination of efficiency can be done in two different ways as:

- input-oriented approach
- output-oriented approach

In the first method, assuming the outputs constant, minimizing inputs is used to achieve higher efficiency and the second method assumes inputs fixed and outputs are increased to achieve higher efficiency.

## III. Review of the Literature

In Iran, DEA was used for the first time by doctoral thesis of Alirezaie [6]. He studied the efficiency of a major bank branches in Canada with the total number of 1282 and imposed DEA investigation to find the relationship between the numbers of units unbiased decision-maker under investigation and ultimately provided practical recommendations for improvement of inefficient units.

Najafi et al. [5] examined 15 schools from the perspective of technical efficiency and then used their results to eliminate weaknesses and inefficient use of resources in schools.

Jelodar and Motevali [4] evaluated the performance of 12 academic units in Islamic Azad University. They used the Malmquist productivity index to calculate their efficiency between 2005 to 2009.The results showed that during the period, three academic units of Bouin Zahra, Firoozkooh and Varamin had optimal efficiency as compared to the others. Using the same campus, it became clear that Pardis, Nazar Abad and Hashtgerd made considerable progress in recent years.

Dastgir et al. [14] analyzed the financial statements of companies listed on the Tehran Stock Exchange by window DEA. For this purpose, they examined 100 companies' performances between 2005 and 2010. The results showed that the selected companies were not 100% efficient during this period.

Feng et al. [16] using non-parametric method, evaluated the efficiency of the supply chain of 17 wholesales in China. They considered the factories' raw materials, number of employees and amount of capital as input and the production plants and sales volume as outputs.

## IV. Distribution Industry (Distribution)

Distribution industry is one of the most important parts of any economy, because the distribution companies are considered as the main connectors between producer and consumer. In Iran, distribution industry is very important, because due to lack of development in manufacturing companies and sales organizations or business, these distribution companies are playing role and are responsible for selling products in the country practically. Thereby associated with domestic markets, the performance of these companies is a necessary condition to evaluate. Also, threats and pressure from competition between local companies in one hand and imports from the world market on the other hand, have prompted companies to pay attention to the right distribution of the product and how to make their competitive attitude and thus can significantly increase their competitiveness and sales. Thus to become faster, more versatile and able to compete and survive in a wide wave of the market, the firms are to provide and predict their performance and reorganize them according to the results of measurements of different models.

## V. Efficiency of Distribution Companies

As a service industry interface, distribution industry has been searching for ways to reduce costs and increase efficiency. Fixed profit margin determined by the distribution companies and government agencies will cause the companies pay more attention to ways of reducing costs in order to increase profits. Identifying factors influencing the selection of appropriate methods to assess the efficiency and effectiveness of the measures is necessary to monitor their performance and reduce costs.

Efficiency referring to the maximize result is determined by the organization or economic entity which is associated with concepts such as effectiveness and efficiency, yet also differs with them. Measuring efficiency and productivity would be the most basic step to improve efficiency and productivity, which shows exactly what resources are spent and what has been achieved from it [3], [4].

## VI. DEA

One of the newest tools for measuring performance, is DEA, which is based on linear programming approach. DEA measures efficiency of decision-making through planning solutions for each unit compared to the other units. DMUs located on the frontier curve are effective conforms to choose the right combination of inputs to achieve an appropriate level of output [24]. In fact, the degree of efficiency of all DMUs is equal to the distance between the border of decision-making and efficiency [14].

We use DEA to make changes in the input or output and to help improve the efficiency of inefficient units [13]. DEA was introduced in (1978) by Charnes et al. [18] as a nonparametric linear programming approach that is capable of multiplying inputs and outputs to verify a model is known today as the CCR analysis that is based on borders. From then, so different models of the DEA are provided [18], [19].

With regard to the issues introduced in the second chapter, models of DEA method can be classified from two perspectives of "nature" and "returns to scale".

### A. View of Nature

In this view, models are categorized into "input-driven" and "output-driven" formats as:

- Input-driven (minimizing inputs): Keeping the input level is reduced by fixing inputs.
- Output-driven (maximizing output): Output level is increased with keeping inputs constant.

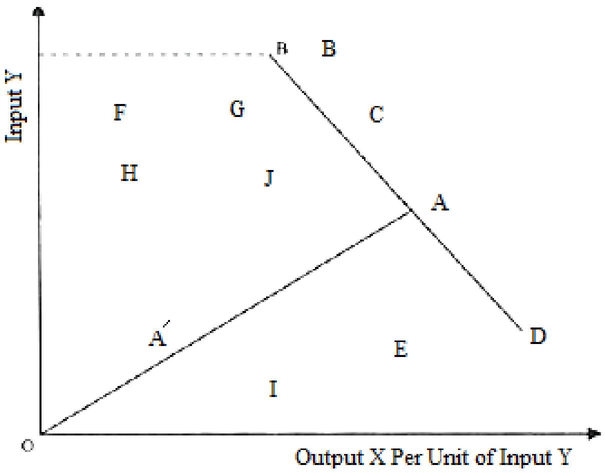


Fig. 1 The efficient frontier for a one input, two outputs state

### B. Returns to Scale View

According to the DEA models and production technology research units, yields are sorted to fixed or variable in CCR and BCC models. So 4 different modes of linear programming model are taken from the combination of these modes as Tables I-III.

In this study and in order to examine and analyze technical efficiency and Nina units scale during the determined period, both CCR model of CRS scale and also BCC model for each variable efficiency to VRS scale will be used for each season of the year. The window and DEA CCR models will be used not only to achieve a resolution to increase the degree of freedom in the performance of units during the period, but also analyzing the performance of the units between periods, as well as evaluating their technical efficiency and management and scale of each window is analyzed.

Output-driven output will be used when the decision-making units' executives are looking to understand whether the increase in their output is possible with the current status of the inputs or not. In fact, this approach is often used in strategic planning If one has little control over the output decision making units and their increase would not be possible, the input-driven model will be used [9].

## VII. Efficiency Measurement by DEA Method

Suppose we decided to have 10 units and each unit (DMU) uses an input (Z) to create two outputs of X and Y by obtaining two outputs related to inputs X and Y to Z, namely X/Z and Y/Z Y for each unit. In other words, by obtaining the amount of output per unit X for each Z output and Y amount of Z output per each DMU, Fig. 1 will be obtained.

## VIII. Window DEA Analysis

Window DEA is presented in the previous decade and divides a time period to more short-term ones (window) and considers each window as a separate unit. In fact, this method provides better comparability of decision-making through independent unit during the period of time that each window takes. The main feature of this method is that the DEA is fixed and does not consider the time factor into account, that this may cause deviation, because in dynamic situations it may ban the use of resources which are needed for reaching profitability in future periods. That's why Charnes et al. [17] propose the window DEA in 1985. This method has no restrictions on incoming and outgoing like other DEA models. In this way, each unit will be considered as an independent unit at all time periods. Performances in a period of time or longer periods of time with the same unit and other units in the specified period are compared according to the performance and can increase at the number of observations will be expected [7], [14].

DEA acts based on moving average which is useful for a single performance trend over time. Each unit is treated as an independent unit in a different period. In this case, in addition to the performance of other units, the performance of a single unit within a certain period is placed. This situation increases the number of data examined in the analysis. This is useful when studying small sample sizes change the width of the window and the number of time periods. An analysis of the actual window with a window width somewhere between a horizontal and all courses of study can be viewed as a special case of a sequential analysis However, subsequent analysis assumes that what has been feasible in the past, remains viable and therefore all previous observations can be included. But above issue is not true in the window that only considers the observations within a specific number of time periods (i.e., a window) and the number of observations remains constant in every analysis. With a defined window of observations in that window, a mean behavior was seen and therefore it was considered as a cross-sectional analysis between the given analyzed time. Notably, since all the units in a window are measured relative to each other, this approach implicitly assumes that there is no technical change in any of the windows. This is a general problem in Window DEA and is even more acute when window DEA and Malmquist Index analysis methods will be applied estimate technical changes. This problem is reduced by reducing the width of the window, and the window must be chosen in such a way to validate the analysis window or ignoring the technical changes will be reasonable. To view this content formula, assume N single decision-maker, DMU (n = 1,2, ..., N) in the period T (t = 1,2, ..., T) have been observed to exist and all of them user input unit to produce S output ones. Thus, the sample including T ×

N will be observed and a and n are in period t, the $DMU_t^n$ has a dimensional input vector $X_t^n = X_{1t}^n, X_{2t}^n, \ldots, X_{rt}^n)$ as well as an s-dimensional vector outputs are as:

$$Y_t^n = Y_{1t}^n, Y_{2t}^n, \ldots, Y_{rt}^n)' \quad (1)$$

Windows, which started since k, 1≤ K ≤ T includes width W, 1 ≤ W ≤ T-K and is identified with KW and has observable N×W.

Matrix inputs for window analysis is as:

$$X_{kw} = \begin{pmatrix} x_k^1, x_k^2, \ldots, x_k^n, x_{k+1}^1, x_{k+1}^2, \ldots, x_{k+1}^n, \\ x_{k+w}^1, x_{k+w}^2, \ldots, x_{k+w}^n \end{pmatrix} \quad (2)$$

and output matrices are as:

$$Y_{kw} = \begin{pmatrix} y_k^1, y_k^2, \ldots, y_k^n, y_{k+1}^1, y_{k+1}^2, \ldots, y_{k+1}^n, \\ y_{k+w}^1, y_{k+w}^2, \ldots, y_{k+w}^n \end{pmatrix} \quad (3)$$

Window Analysis allows to view trends over time and also provides enterprise efficiency which can be deduced if firms have moved in order to increase productivity [1], [20].

Two main advantages in the use of window analysis are:

- With the increasing of the number of DMU, more and more inputs and outputs can be implemented in the window analysis. When the total number of incoming and outgoing data in envelopment analysis will be more than half of the number of decisions, the correlation between the actual value and the value of the acquired DEA models becomes smaller. It reduces the detection power, but analysis deals a difficulty as a result of replacing the windows with the same performance values at different times and different DMU. Thus, the DMU increases and this can compensate for shortcomings in the DEA model [21]. In other words, by increasing the number of variables in the DEA, degrees of freedom in window analysis will prevail.
- It helps the stability and reliability performance of any organization pursue would be certain in any period of time. In general, the window analysis is a dynamic model that analyzes a series of decisions related to the organization.

Window technique was initially introduced by Charnes [17] as the analysis window. In this method, each DMU is evaluated in such a way that it includes a different identity. It helps the performance of each DMU be useful. Window analysis gives us an opportunity between pure technical efficiency, technical efficiency and scale efficiency of distinction. On the other hand, this method is suitable for small sample size, since that causes a greater degree of freedom in samples [18].

## IX. Malmquist Productivity Index (MPI)

Malmquist Index [11] was introduced in 1953 as an indicator of quality. This index was used for measurement and analysis of productivity. In 1982, Caves et al. [27] introduced this indicator in the literature on productivity. For the first time, they used a calculated index in the experiment in planning a parametric approach [22], [23].

In 1994, Fare et al. [26] divided productivity changes into two functional change in performance and changes in analysis technology and non-parametric programming models used to calculate it [10].

Malmquist index is used to analyze the changes in efficiency and productivity over time. This productivity index is separated into two major components, namely developments in technology and changes in performance. In other words, this analysis allows us to separate jumps on the performance border (change in performance) to improve the performance efficiency of the borders. The two parts are completely different of analytical and policy-making basis and require different measures. The resulting change in performance and changes in the performance efficiency is called the total efficiency which is measured by Malmquist Index.

A lot of information can be derived from Malmquist productivity index. Malmquist Index not only changes the pattern of productivity and offers new perceptions of the management conclusions, but also provides strategic orientation decision unit for every period of time. Using this index, we can evaluate the strategic orientation of the organization in the past period, and to choose the right direction for the coming time [25].

Finally, it should be noted that the use of Malmquist Index to assess the efficiency of business units can be useful only when the returns are constant related to scale. When variable return on scale (VRS) is not fixed, this index cannot give us proper measurement of productivity. To explain the concept of Malmquist Index, case with one input and one output will be offered.

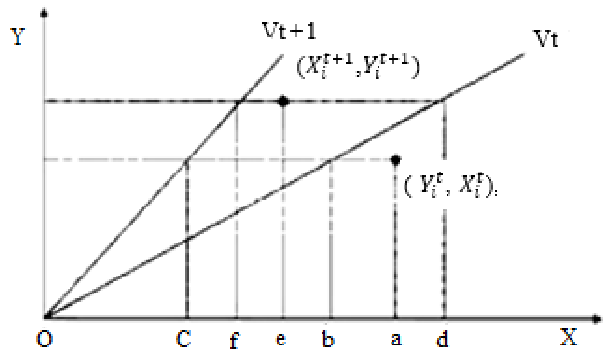


Fig. 2 Changes in productivity and efficiency

Vt line in Fig. 2 represents the production frontier in period t. Vt shows the border in time t + 1. The improved technology (Vt + 1) decreases the amount of required inputs to produce the outputs of Vt. Suppose a hypothetical company including combination of the input and output ( $Y_i^t$, $X_i^t$), in period t and ($X_i^{t+1}$,$Y_i^{t+1}$) in the period t + 1. Two changes happened during t and t + 1 as: First, because of advances in technology, more output per input during period t to t + 1 is produced. In fact, the combination of its input - output during the period t to t + 1 makes the use of technology unjustified. Second, the company has also experienced changes in functional performance, because the operating point of the period t + 1 is closer to the border than to period t.

Analysis of Malmquist Index is based on the use of distance functions. In the definition of Malmquist Index, the distance function will be adjusted with respect to the composition. Distance functions is defined according to two different time periods as Dt( $Y_i^{t+1}$ , $X_i^{t+1}$ (and Dt+1($X_i^t, Y_i^t$ ), where Dt(Dt+1) is a function of distance to the border at the time t(t+1) and Xt,Yt (Xt + 1,Yt + 1) are input and output vectors at time t (t + 1).

Function $D^{t+1}$ $(Y_i^t, X_i^t)$ evaluates technology courses and handles input - output in period t to t + 1. While the function $D^t$ $(Y_i^{t+1}$ , $X_i^{t+1}$ (evaluates category input, the output of a given year over the border in the same year are shown as Dt ($X_i^t$s, $Y_i^t$) and $D^t$ ($Y_i^{t+1}$ , $X_i^{t+1}$), respectively. According to Fig. 2, we have:

$$D^{t+1}\ (x_{\rm i}^{t}\ ,\ y_{\rm i}^{t}\ ) = \frac{oa}{oc}, D^{t}\ (x_{\rm i}^{t+1}\ ,\ y_{\rm i}^{t+1}) = \frac{\rm oe}{\rm od} \quad (4)$$

$$D^{t+1}\ (x_{\rm i}^{t+1}\ ,\ y_{\rm i}^{t+1}) = \frac{\rm oe}{\rm of}, \ D^{t}\ (x_{\rm i}^{t}\ ,\ y_{\rm i}^{t}\ ) = \frac{oa}{ob} \quad (5)$$

Malmquist Index can be attributed to technology in period t t +1 and is defined as:

$$M^{t} = \frac{D^{t}\ (x^{t}, y^{t})}{D^{t}\ (x_{\rm i}^{t+1}, y_{\rm i}^{t+1})} \text{ OR } M^{t+1} = \frac{D^{t+1}\ (x^{t}, y^{t})}{D^{t+1}\ (x_{\rm i}^{t+1}, y_{\rm i}^{t+1})} \quad (6)$$

where: Mt measures productivity growth between periods t and t +1 with the use of technology as a reference period t and 1 + $M^t$ measures this value by using technology as a reference period t +1.

In order to avoid arbitrary choice of reference technology, Malmquist defines TFP index as the geometric mean and $M^t$ converts to $M^{t+1}$.

$$M_0 = [M^t\, M^{t+1}]^{1/2} = \left[\frac{D_0^t\,(x_0^{t+1}, y_0^{t+1})D_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{D_0^t\,(x_0^t, y_0^t)D_0^{t+1}(x_0^t, y_0^t)}\right]^{\frac{1}{2}} \quad (7)$$

Farrel et al. said that if M0> 1, it indicates increased productivity improvements, M0 <1 indicates a decline in productivity and efficiency M0 = 1 reflects unchanged variables during the two periods [21].

According to Farrel [21], Malmquist Index is divided into two components:

$$M_0 = \frac{D_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{D_0^t\,(x_0^t, y_0^t)} \left|\frac{D_0^{t+1}\,(x_0^{t+1}, y_0^{t+1})D_0^t(x_0^t, y_0^t)}{D_0^{t+1}\,(x_0^{t+1}, y_0^{t+1})D_0^{t+1}(x_0^t, y_0^t)}\right|^{1/2} \quad (8)$$

The first component namely technical efficiency change or TEC0 measures change in yield efficiency and the second component, FS0 measures mutation (transfer) technology on the border between the two periods t and t +1. FS0 value greater than one indicates a positive mutation or performance enhancements and much smaller FS0 than criteria shows a negative leap or performance backward and FS equal 1 reflects a lack of mutations in the border. According to the analysis of productivity changes into two parts and changes in functional performance and technological change and degradation of operational performance, the two components of change in the efficiency and scale of change in administrative efficiency or total factor productivity changes can be written as:

Change in efficiency scale efficiency × Change in management nature changes × Change in Technology = total productivity

The advantage of using performance index is that this special index is prepared to change the functionality it provides, this indicator can also be calculating by using the technique of linear programming and econometric techniques. Other advantage of this method is that it measures productivity growth by comparing the present ratio of output to input for the best performance of border [12].

According to the above mentioned issues, it can be concluded that in the Malmquist productivity measurement, changes are used to determine the main source of productivity growth.

Malmquist Index helps in measuring change in productivity during a period. It also helps in the analysis of productivity changes to determine their impact on technology performances. The effect of the performance is also analyzed to determine the main source of improvement.

## X. Research Hypotheses

The main question: How is the efficiency of Nina Distribution Company branches during the summer seasons of the years 2013 to 2015 using an integrated approach window DEA and Malmquist Index?

The minor questions:

a) What is the efficacy amount of different periods (various windows) for Nina distribution company branches?
b) What is the efficiency with Malmquist Index?
c) What approaches and strategies are used to improve the examined company's performance?

## XI. Selecting the Input and Output Factors

Each applied research requires studying and understanding of the parameters in the working area of research. Agents must be selected properly to be representative indicators and to reduce the amount of input and output [21]. Selection of the input and output indicators will be based on two main criteria [15] as:

a) Previous studies
b) Availability of reliable sources of information

In this study, the following steps will be carried out to determine the input and output: Previous studies can be used to provide inputs and outputs by examining a set of conducted variables.

Inputs and outputs available with information obtained from various studies are compared with financial statements and profit and loss statement in broadcast companies and according to company executives and experts and a set of inputs and outputs will be selected. So, in an operational definition of the criteria for this classification, the variables that companies are trying to minimize are called inputs and those that firms sought to maximize are classified as outputs [2].

Input and output variables of this study are as:

### *A. Input Variables*

1- The registered value of fixed assets, including vehicles, equipment such as computers and....
2- The ratio of operating expenses to total personnel.
3- The salary costs of the personnel.
4- Average collection period.

### *B. Output Variables*

1- Net sales of personnel
2- Profit margin to the number of personnel
3- Customers coverage

Fig. 3 shows the pattern of input and output parameters.

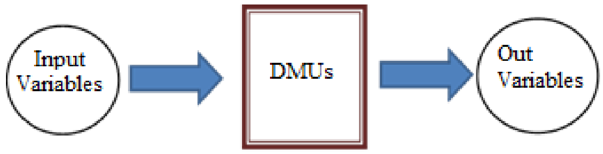


Fig. 3 Model of inputs and outputs

TABLE I
AVERAGE DMU TECHNICAL EFFICIENCY IN EACH WINDOW

| Rank | Branch name | Spring 2013 | Summer 2013 | Autumn 2013 | Winter 2014 | Spring 2014 | Summer 2014 | Autumn 2014 | Winter 2015 | Spring 2015 | Summer 2015 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **Kerman Province** | 1/00 | 1/00 | 1/09 | 1/18 | 1/00 | | | | | | **1/05** |
| | | | 1/00 | 1/09 | 1/14 | 1/00 | 1/14 | | | | | **1/07** |
| | | | | 1/00 | 1/06 | 1/00 | 1/09 | 1/00 | | | | **1/03** |
| | | | | | 1/05 | 1/00 | 1/02 | 1/00 | 1/20 | | | **1/05** |
| | | | | | | 1/00 | 1/02 | 1/00 | 1/20 | 1/00 | | **1/04** |
| | | | | | | | 1/00 | 1/00 | 1/20 | 1/00 | 1/00 | **1/04** |
| | **Mean of each season** | **1/00** | **1/00** | **1/06** | **1/11** | **1/00** | **1/05** | **1/00** | **1/20** | **1/00** | **1/00** | **1/05** |
| **2** | **Alborz Province** | 1/00 | 1/00 | 1/26 | 2/21 | 1/00 | | | | | | **1/29** |
| | | | 1/00 | 1/25 | 2/03 | 1/00 | 1/30 | | | | | **1/32** |
| | | | | 1/00 | 1/20 | 1/00 | 1/08 | 1/07 | | | | **1/07** |
| | | | | | 1/09 | 1/00 | 1/03 | 1/07 | 1/06 | | | **1/05** |
| | | | | | | 1/00 | 1/03 | 1/08 | 1/09 | 1/00 | | **1/04** |
| | | | | | | | 1/00 | 1/00 | 1/05 | 1/00 | 1/10 | **1/03** |
| | **Mean of each season** | **1/00** | **1/00** | **1/17** | **1/63** | **1/00** | **1/09** | **1/06** | **1/07** | **1/00** | **1/10** | **1/13** |
| **3** | **Fars Province** | 1/00 | 1/00 | 1/00 | 2/20 | 1/33 | | | | | | **1/31** |
| | | | 1/00 | 1/00 | 2/20 | 1/32 | 1/62 | | | | | **1/43** |
| | | | | 1/00 | 1/29 | 1/09 | 1/33 | 1/32 | | | | **1/21** |
| | | | | | 1/00 | 1/00 | 1/15 | 1/15 | 1/71 | | | **1/20** |
| | | | | | | 1/00 | 1/15 | 1/15 | 1/71 | 1/19 | | **1/24** |
| | | | | | | | 1/00 | 1/01 | 1/54 | 1/06 | 1/32 | **1/19** |
| | **Mean of each season** | **1/00** | **1/00** | **1/00** | **1/68** | **1/15** | **1/25** | **1/16** | **1/65** | **1/13** | **1/32** | **1/26** |
| **4** | **Mazandaran Privince** | 1/13 | 1/28 | 1/36 | 3/09 | 1/26 | | | | | | **1/62** |
| | | | 1/25 | 1/36 | 3/09 | 1/25 | 2/18 | | | | | **1/83** |
| | | | | 1/00 | 1/73 | 1/00 | 1/56 | 1/38 | | | | **1/33** |
| | | | | | 1/20 | 1/00 | 1/10 | 1/06 | 1/50 | | | **1/17** |
| | | | | | | 1/00 | 1/10 | 1/06 | 1/50 | 1/48 | | **1/23** |
| | | | | | | | 1/00 | 1/00 | 1/40 | 1/34 | 1/62 | **1/27** |
| | **Mean of each season** | **1/13** | **1/27** | **1/24** | **2/28** | **1/10** | **1/39** | **1/13** | **1/47** | **1/41** | **1/62** | **1/41** |
| **5** | **Khorasan Province** | 1/32 | 1/18 | 1/40 | 2/37 | 1/50 | | | | | | **1/55** |
| | | | 1/18 | 1/40 | 2/37 | 1/47 | 1/83 | | | | | **1/65** |
| | | | | 1/13 | 1/27 | 1/25 | 1/48 | 1/46 | | | | **1/32** |
| | | | | | 1/07 | 1/10 | 1/17 | 1/21 | 1/60 | | | **1/23** |
| | | | | | | 1/10 | 1/17 | 1/21 | 1/60 | 1/88 | | **1/39** |
| | | | | | | | 1/03 | 1/07 | 1/47 | 1/66 | 1/78 | **1/40** |
| | **Mean of each season** | **1/32** | **1/18** | **1/31** | **1/77** | **1/29** | **1/33** | **1/24** | **1/56** | **1/77** | **1/78** | **1/42** |
| **6** | **Esfahan Province** | 1/00 | 1/10 | 1/36 | 2/03 | 1/43 | | | | | | **1/38** |
| | | | 1/06 | 1/36 | 1/98 | 1/43 | 1/56 | | | | | **1/48** |
| | | | | 1/01 | 1/85 | 1/20 | 1/44 | 1/43 | | | | **1/39** |
| | | | | | 1/85 | 1/06 | 1/33 | 1/35 | 1/79 | | | **1/47** |
| | | | | | | 1/06 | 1/33 | 1/35 | 1/79 | 1/64 | | **1/43** |
| | | | | | | | 1/18 | 1/19 | 1/68 | 1/51 | 1/56 | **1/42** |
| | **Mean of each season** | **1/00** | **1/08** | **1/24** | **1/93** | **1/24** | **1/37** | **1/33** | **1/75** | **1/57** | **1/56** | **1/43** |
| **7** | **Teharn Province** | 1/06 | 1/00 | 1/24 | 2/85 | 1/86 | | | | | | **1/60** |
| | | | 1/00 | 1/22 | 2/72 | 1/78 | 2/94 | | | | | **1/93** |
| | | | | 1/00 | 2/35 | 1/32 | 2/52 | 2/73 | | | | **1/98** |
| | | | | | 2/31 | 1/10 | 2/19 | 2/28 | 2/26 | | | **2/03** |
| | | | | | | 1/10 | 2/19 | 2/28 | 2/24 | 2/85 | | **2/13** |
| | | | | | | | 1/78 | 2/05 | 1/67 | 2/15 | 2/52 | **2/03** |
| | **Mean of each season** | **1/06** | **1/00** | **1/15** | **2/56** | **1/43** | **2/32** | **2/34** | **2/06** | **2/50** | **2/52** | **1/95** |

## XII. Research Finding

In this study, seven branches of Nina Company that have similar situations during 10 seasons have been evaluated (from spring 2013 to summer 2015). In order to obtain performance of any window, scheduled model will be solved for 35 units. Since the period of the study is divided into six windows (for each model); therefore, 210 programming model is solved. After running the models, the average annual ranking of the criteria unit will be calculated.

### *A. Technical Efficiency in Window DEA Model*

In the window 1 to 6 from Table I, the number of DMU that is based on the model window DEA and the boundary of technical efficiency are as 11, 7, 9, 6, 7 and 10, respectively.

The maximum and minimum efficiency is observed for Kerman and Tehran provinces, respectively.

### *B. Pure Technical Efficiency (Management) in Window DEA Model*

In Table II, windows 1 to 6 in management performance of branches show that the average pure technical efficiency has been decreased.

Management performance of windows 1 to 6 in Kerman is equal to 1.03. This represents the location of DMU near the border of efficiency in all research windows. In contrast, Tehran includes the lowest level of management efficiency by an average of 1.33.

Ranking branches in terms of performance management are shown in Table II.

TABLE II
Average Pure Technical Efficiency (management) DMU in Each Window

| Rank | Branch name | Spring 2013 | Summer 2013 | Autumn 2013 | Winter 2014 | Spring 2014 | Summer 2014 | Autumn 2014 | Winter 2015 | Spring 2015 | Summer 2015 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **Kerman Province** | 1/00 | 1/00 | 1/04 | 1/11 | 1/00 | | | | | | **1/03** |
| | | | 1/00 | 1/04 | 1/11 | 1/00 | 1/07 | | | | | **1/04** |
| | | | | 1/00 | 1/06 | 1/00 | 1/06 | 1/00 | | | | **1/02** |
| | | | | | 1/02 | 1/00 | 1/00 | 1/00 | 1/09 | | | **1/02** |
| | | | | | | 1/00 | 1/00 | 1/00 | 1/09 | 1/00 | | **1/02** |
| | | | | | | | 1/00 | 1/00 | 1/09 | 1/00 | 1/00 | **1/02** |
| | **Mean of each season** | **1/00** | **1/00** | **1/03** | **1/07** | **1/00** | **1/03** | **1/00** | **1/09** | **1/00** | **1/00** | **1/03** |
| **2** | **Mazandaran** | 1/00 | 1/00 | 1/00 | 1/11 | 1/05 | | | | | | **1/03** |
| | **Province** | | 1/00 | 1/00 | 1/11 | 1/04 | 1/09 | | | | | **1/05** |
| | | | | 1/00 | 1/08 | 1/00 | 1/05 | 1/20 | | | | **1/07** |
| | | | | | 1/00 | 1/00 | 1/01 | 1/00 | 1/12 | | | **1/03** |
| | | | | | | 1/00 | 1/01 | 1/00 | 1/11 | 1/15 | | **1/05** |
| | | | | | | | 1/00 | 1/00 | 1/10 | 1/16 | 1/35 | **1/12** |
| | **Mean of each season** | **1/00** | **1/00** | **1/00** | **1/07** | **1/02** | **1/03** | **1/05** | **1/11** | **1/16** | **1/35** | **1/06** |
| **3** | **Alborz Province** | 1/00 | 1/00 | 1/06 | 1/29 | 1/00 | | | | | | **1/07** |
| | | | 1/00 | 1/06 | 1/29 | 1/00 | 1/02 | | | | | **1/08** |
| | | | | 1/00 | 1/20 | 1/00 | 1/02 | 1/05 | | | | **1/05** |
| | | | | | 1/09 | 1/00 | 1/00 | 1/05 | 1/05 | | | **1/04** |
| | | | | | | 1/00 | 1/00 | 1/08 | 1/06 | 1/00 | | **1/03** |
| | | | | | | | 1/00 | 1/00 | 1/00 | 1/00 | 1/08 | **1/02** |
| | **Mean of each season** | **1/00** | **1/00** | **1/04** | **1/22** | **1/00** | **1/01** | **1/04** | **1/04** | **1/00** | **1/08** | **1/07** |
| **4** | **Fars Province** | 1/00 | 1/00 | 1/00 | 1/06 | 1/02 | | | | | | **1/01** |
| | | | 1/00 | 1/00 | 1/06 | 1/02 | 1/13 | | | | | **1/04** |
| | | | | 1/00 | 1/06 | 1/00 | 1/12 | 1/19 | | | | **1/07** |
| | | | | | 1/00 | 1/00 | 1/10 | 1/13 | 1/26 | | | **1/10** |
| | | | | | | 1/00 | 1/11 | 1/13 | 1/26 | 1/00 | | **1/10** |
| | | | | | | | 1/00 | 1/00 | 1/22 | 1/00 | 1/24 | **1/09** |
| | **Mean of each season** | **1/00** | **1/00** | **1/00** | **1/04** | **1/01** | **1/09** | **1/11** | **1/25** | **1/00** | **1/24** | **1/07** |
| **5** | **Khorasan Province** | 1/18 | 1/12 | 1/03 | 1/01 | 1/14 | | | | | | **1/10** |
| | | | 1/12 | 1/03 | 1/01 | 1/14 | 1/12 | | | | | **1/08** |
| | | | | 1/01 | 1/00 | 1/07 | 1/09 | 1/11 | | | | **1/06** |
| | | | | | 1/00 | 1/04 | 1/03 | 1/06 | 1/19 | | | **1/07** |
| | | | | | | 1/04 | 1/03 | 1/06 | 1/16 | 1/44 | | **1/15** |
| | | | | | | | 1/00 | 1/01 | 1/16 | 1/37 | 1/36 | **1/18** |
| | **Mean of each season** | **1/18** | **1/12** | **1/02** | **1/00** | **1/09** | **1/05** | **1/06** | **1/17** | **1/40** | **1/36** | **1/11** |
| **6** | **Esfahan Province** | 1/00 | 1/07 | 1/30 | 1/47 | 1/22 | | | | | | **1/21** |
| | | | 1/05 | 1/27 | 1/47 | 1/20 | 1/27 | | | | | **1/25** |
| | | | | 1/00 | 1/49 | 1/18 | 1/26 | 1/32 | | | | **1/25** |
| | | | | | 1/45 | 1/00 | 1/24 | 1/31 | 1/37 | | | **1/28** |
| | | | | | | 1/00 | 1/25 | 1/31 | 1/35 | 1/41 | | **1/26** |
| | | | | | | | 1/18 | 1/15 | 1/35 | 1/41 | 1/29 | **1/28** |
| | **Mean of each season** | **1/00** | **1/06** | **1/19** | **1/47** | **1/12** | **1/24** | **1/27** | **1/36** | **1/41** | **1/29** | **1/26** |
| **7** | **Tehran Province** | 1/00 | 1/00 | 1/00 | 1/19 | 1/15 | | | | | | **1/07** |
| | | | 1/00 | 1/00 | 1/19 | 1/14 | 1/52 | | | | | **1/17** |
| | | | | 1/00 | 1/23 | 1/10 | 1/53 | 1/57 | | | | **1/28** |
| | | | | | 1/21 | 1/09 | 1/50 | 1/53 | 1/49 | | | **1/36** |
| | | | | | | 1/09 | 1/49 | 1/53 | 1/48 | 1/98 | | **1/52** |
| | | | | | | | 1/41 | 1/48 | 1/40 | 1/84 | 1/88 | **1/60** |
| | **Mean of each season** | **1/00** | **1/00** | **1/00** | **1/20** | **1/11** | **1/49** | **1/53** | **1/46** | **1/91** | **1/88** | **1/33** |

TABLE III
AVERAGE DMU SCALE EFFICIENCY IN EACH WINDOW

| Rank | Branch name | Spring 2013 | Summer 2013 | Autumn 2013 | Winter 2014 | Spring 2014 | Summer 2014 | Autumn 2014 | Winter 2015 | Spring 2015 | Summer 2015 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Kerman Province | 1/00 | 1/00 | 1/05 | 1/06 | 1/00 | | | | | | **1/02** |
| | | | 1/00 | 1/05 | 1/03 | 1/00 | 1/07 | | | | | **1/03** |
| | | | | 1/00 | 1/00 | 1/00 | 1/03 | 1/00 | | | | **1/01** |
| | | | | | 1/03 | 1/00 | 1/02 | 1/00 | 1/10 | | | **1/03** |
| | | | | | | 1/00 | 1/02 | 1/00 | 1/10 | 1/00 | | **1/02** |
| | | | | | | | 1/00 | 1/00 | 1/10 | 1/00 | 1/00 | **1/02** |
| | Mean of each season | **1/00** | **1/00** | **1/03** | **1/03** | **1/00** | **1/03** | **1/00** | **1/10** | **1/00** | **1/00** | **1/02** |
| **2** | Alborz Province | 1/00 | 1/00 | 1/19 | 1/71 | 1/00 | | | | | | **1/18** |
| | | | 1/00 | 1/17 | 1/57 | 1/00 | 1/27 | | | | | **1/20** |
| | | | | 1/00 | 1/00 | 1/00 | 1/06 | 1/02 | | | | **1/02** |
| | | | | | 1/00 | 1/00 | 1/03 | 1/02 | 1/01 | | | **1/01** |
| | | | | | | 1/00 | 1/03 | 1/01 | 1/03 | 1/00 | | **1/01** |
| | | | | | | | 1/00 | 1/00 | 1/05 | 1/00 | 1/01 | **1/01** |
| | Mean of each season | **1/00** | **1/00** | **1/12** | **1/32** | **1/00** | **1/08** | **1/01** | **1/03** | **1/00** | **1/01** | **1/07** |
| **3** | Fars Province | 1/00 | 1/03 | 1/05 | 1/38 | 1/17 | | | | | | **1/12** |
| | | | 1/01 | 1/07 | 1/35 | 1/19 | 1/23 | | | | | **1/17** |
| | | | | 1/01 | 1/24 | 1/03 | 1/15 | 1/08 | | | | **1/10** |
| | | | | | 1/27 | 1/06 | 1/07 | 1/03 | 1/30 | | | **1/15** |
| | | | | | | 1/06 | 1/06 | 1/02 | 1/33 | 1/16 | | **1/13** |
| | | | | | | | 1/00 | 1/03 | 1/25 | 1/07 | 1/21 | **1/11** |
| | Mean of each season | **1/00** | **1/02** | **1/04** | **1/31** | **1/10** | **1/10** | **1/04** | **1/29** | **1/12** | **1/21** | **1/13** |
| **4** | Mazandaran Privince | 1/00 | 1/00 | 1/00 | 2/09 | 1/31 | | | | | | **1/28** |
| | | | 1/00 | 1/00 | 2/09 | 1/30 | 1/44 | | | | | **1/36** |
| | | | | 1/00 | 1/23 | 1/09 | 1/19 | 1/11 | | | | **1/12** |
| | | | | | 1/00 | 1/00 | 1/04 | 1/01 | 1/36 | | | **1/08** |
| | | | | | | 1/00 | 1/04 | 1/01 | 1/36 | 1/19 | | **1/12** |
| | | | | | | | 1/00 | 1/01 | 1/26 | 1/06 | 1/06 | **1/08** |
| | Mean of each season | **1/00** | **1/00** | **1/00** | **1/60** | **1/14** | **1/14** | **1/04** | **1/33** | **1/13** | **1/06** | **1/17** |
| **5** | Khorasan Province | 1/12 | 1/05 | 1/36 | 2/35 | 1/32 | | | | | | **1/44** |
| | | | 1/05 | 1/36 | 2/35 | 1/30 | 1/63 | | | | | **1/54** |
| | | | | 1/13 | 1/27 | 1/17 | 1/35 | 1/31 | | | | **1/25** |
| | | | | | 1/07 | 1/06 | 1/13 | 1/13 | 1/35 | | | **1/15** |
| | | | | | | 1/06 | 1/13 | 1/14 | 1/38 | 1/31 | | **1/20** |
| | | | | | | | 1/03 | 1/06 | 1/26 | 1/22 | 1/30 | **1/17** |
| | Mean of each season | **1/12** | **1/05** | **1/28** | **1/76** | **1/18** | **1/26** | **1/16** | **1/33** | **1/26** | **1/30** | **1/29** |
| **6** | Esfahan Province | 1/13 | 1/28 | 1/36 | 2/79 | 1/20 | | | | | | **1/55** |
| | | | 1/25 | 1/36 | 2/79 | 1/20 | 2/01 | | | | | **1/72** |
| | | | | 1/00 | 1/60 | 1/00 | 1/48 | 1/15 | | | | **1/25** |
| | | | | | 1/20 | 1/00 | 1/09 | 1/06 | 1/34 | | | **1/14** |
| | | | | | | 1/00 | 1/09 | 1/06 | 1/36 | 1/28 | | **1/16** |
| | | | | | | | 1/00 | 1/00 | 1/27 | 1/16 | 1/20 | **1/13** |
| | Mean of each season | **1/13** | **1/26** | **1/24** | **2/10** | **1/08** | **1/33** | **1/07** | **1/32** | **1/22** | **1/20** | **1/33** |
| **7** | Teharn Province | 1/06 | 1/00 | 1/24 | 2/39 | 1/62 | | | | | | **1/46** |
| | | | 1/00 | 1/22 | 2/28 | 1/57 | 1/94 | | | | | **1/60** |
| | | | | 1/00 | 1/92 | 1/20 | 1/64 | 1/74 | | | | **1/50** |
| | | | | | 1/92 | 1/02 | 1/46 | 1/49 | 1/52 | | | **1/48** |
| | | | | | | 1/02 | 1/47 | 1/49 | 1/51 | 1/44 | | **1/38** |
| | | | | | | | 1/27 | 1/38 | 1/19 | 1/17 | 1/34 | **1/27** |
| | Mean of each season | **1/06** | **1/00** | **1/15** | **2/13** | **1/28** | **1/56** | **1/53** | **1/41** | **1/30** | **1/34** | **1/45** |

### *C. Scale Efficiency in Window DEA Model*

In the window 1 to 6 from Table I, the number of DMU that is based on the model window DEA and the boundary of technical efficiency are as 11, 7, 9, 6, 7 and 10 respectively, that the technical is showing the same trend of efficiency except in the second window. In each window 24% of the DMU on the border and 76% of them are inefficient. They are inseparable in the rating performance relative to each other.

## XIII. WINDOW DEA MODELS

It should be noted that in output-driven mode, as diagram lines go farther than 1, the process decreases and in contrast, as the come closer to 1, the process would be increased. But pure technical efficiency shows downtrend during the period. Also, scale performance will show incremental mode in all other windows except over the first window (Fig. 4).

### *A. Changes in Total Productivity Based on Malmquist Index*

Changes in total factor productivity for each unit based on Malmquist Index in any season or season basis (Spring 2013) are calculated with the help of software and reflected in Table IV. Since the Malmquist Index of geometric mean of input-outputs in DEA is used, so in calculating Malmquist index, input or output shaft axis of the model will have no effect on the results [8].

In this section, calculations were based on the output of smaller values in which a decrease greater than one indicates growth and equal to one represents no change compared to the base year in total factor productivity.

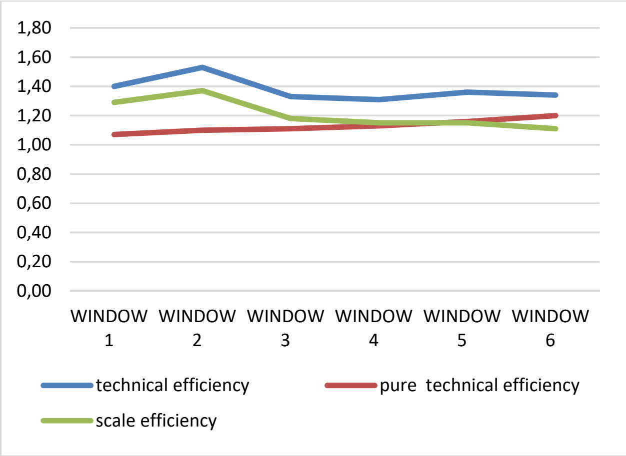


Fig. 4 The trend of technical, pure and scale efficiency during the seasons of research in windows

TABLE IV
CHANGES IN TOTAL PRODUCTIVITY OF BRANCHES IN SPRING 2013 TO SUMMER 2015

| Branches | TEC | Techch | Pech | Sech | M |
|---|---|---|---|---|---|
| Kerman | 1.000 | 0.968 | 1.000 | 1.000 | 0.968 |
| Esfahan | 1.000 | 0.915 | 1.000 | 1.000 | 0.915 |
| Khorasan | 1.004 | 0.885 | 1.001 | 1.003 | 0.888 |
| Tehran | 0.962 | 0.907 | 0.970 | 0.992 | 0.872 |
| Alborz | 1.000 | 0.864 | 1.000 | 1.000 | 0.864 |
| Fars | 1.000 | 0.832 | 1.000 | 1.000 | 0.832 |
| Mazandaran | 0.995 | 0.830 | 0.996 | 0.998 | 0.826 |
| Mean | 0.994 | 0.885 | 0.995 | 0.999 | 0.880 |

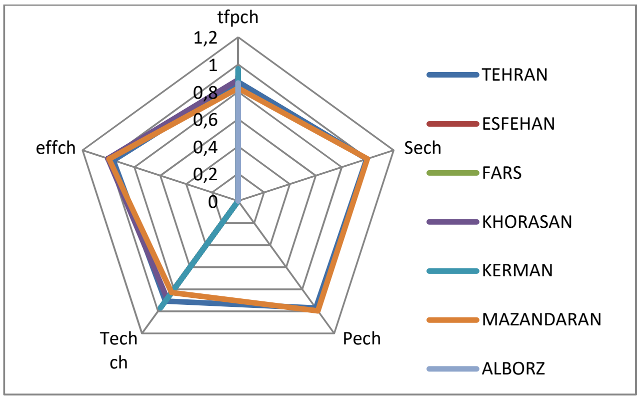


Fig. 5 Diagram of total factor productivity and its components to separate branches

## XIV. CHANGES IN PRODUCTIVITY IN BRANCHES OF NINA DISTRIBUTION COMPANY

The mean changes in total factor productivity and its components for each branch are reflected in Table IV. But the least negative growth rate of TFP in the studied period is associated with Kerman Branch (968/0). The Fars Branch had the highest negative growth in total factor productivity (832/0), which has been caused by the decline in performance technology. While about 71% (5 branches) of the branches have negative productivity growth in terms of technical performance and their technical efficiency is negative.

The changes in the performance of the separate branches are presented as follows: According to Fig. 5, changes in the performance of Tehran (962/0) resulted from a reduction in the scale efficiency (992/0) while the efficiency of its management showed a reduction (970/0). Isfahan, Fars and Khorasan have the performance of 1, 1, 1.4 which are the result of an increase in performance and scale and efficiency of their management remained unchanged. At last, Mazandaran has experienced dipped efficiency (995/0) as a result of the reduction in scale (998/0) and performance management (996/0) function which impaired its performance.

## XV. CONCLUSION

The results showed that in the name of efficiency, DEA includes efficiency with regard to net sales, profit and coverage of clients as output variables and the average collection of operating costs to individuals, legal costs and wages of fixed assets as inputs. In other words, this method can be used as a supplement to traditional methods used in the analysis of financial statements. Using this method instead of the traditional ones resolves the problem. In the presented method, performance score allocated to each unit can be compared to a business unit.

## XVI. SUGGESTIONS

Average technical efficiency, manage and scale research units during the quarter are 21%, 81% and 54%, respectively indicating that the scale efficiency has the greatest impact on the loss of technical efficiency. And it also means that sub-branches are empty in technical spaces and in terms of scale and management when the other conditions are considered fixed.

The average productivity of all branches has been decreased. In other words, all 7 branches have negative growth of total productivity.

Results of the assessment indicate that productivity of Nina distribution company had an average of 880/0 which is the result of an 885/0 decrease in technology performance and a reduction in the technical performance of the two components of performance and management are 995/0 and 999/0 at the performance scale respectively.

Note that in this study, the average productivity growth of a total branch such as Kerman is due to its high efficiency growth, and managed efficiency over the other branches which ultimately can improve its situation largely.

In general, the overall findings indicate that productivity growth in terms of capacity and performance in branches that are selling at a higher level will be relatively higher than other branches. It can be suggested that in economic reality, sales unit of larger-scale distribution in Nina Company will include relative productivity and higher efficiency.

It would be useful if the distribution branches avoid wasting resources and use transportation equipment including light and heavy vehicles in optimal extent.

The branches should hold proper training and continuous academic courses and utilize new distribution methods to train their manpower and try to increase their labor productivity.

Broadcasting companies should increase their efficiency using new technologies, especially in the IT sector related to the distribution of goods.

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