Research Paper

Dynamic DEA based on DMAIC model to evaluate passengers’ transportation in road transportation organization

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Abstract

In Iran, more than 94% of transportation is road transportation. The goal of this article is to assess and to rate road transportation companies of 31 country provinces and to determine the effect of integrating six sigma DMAIC cycle and dynamic data envelopment analysis (DDEA) on effective inputs and outputs. In this article the BCC output-oriented has been changed to dynamic model. According to the conducted sensitivity analysis in improvement phase, it is determined what changes should be made in the values of inputs and outputs for inefficient units to become efficient. DMAIC cycle control system is monitored through statistical control charts to be able to control and monitor the values of inputs and outputs. Integrating these methods help us with a more effective evaluation of dynamic environment and through sensitivity analysis in improvement phase, effectiveness and efficiency of units will increase and help to achieve the goals set.

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1. Introduction

Transportation has had a fundamental role in industrial and economic development of industrial societies. In Iran also, given the extent of soil and the climate variability, travelling and moving people and loads has traditionally been an important matter. Iran, as a developing country, has had a critical role in economic and social development by creating of efficient transportation system. Among the three methods of transportation – rail, airborne, and road – 94% is road transportation, 4% is rail transportation and 2% is airborne (WWW.rmto.ir). In 1394, about 576 million travels were made in the country and this amount will rise to 782 million travels in 1404. Accordingly, the necessity of attention to and consideration of the status of passenger services in passenger transportation section is to be
mentioned. At the moment, there are about 15562 passenger buses, 28355 minibuses and 38533 passenger fares. Passenger satisfaction of the quality of services provided to them can be used as an indicator of economic, social and human development. About the improvement of the quality of services provided to road transportation passengers, although actions were taken including a review of the criteria and establishment and operation of new transportation companies with especial welfare services in the past years, but still there is a long way to reach the desired quality. We must go beyond the standards of customer service to obtain customer satisfaction. More than 50% of public transportation road trips are carried out by bus (transportation statistical yearbook 1394) and this considerable value makes community expectations to be of great importance and clarifies studying the wishes and expectations of travelers of suburban transportation passengers by bus and the ways to meet this demand. In this study of identifying the factors of passenger satisfaction, we have tried to measure qualitative variables using six sigma and data envelopment analysis. Therefore, the purpose of this study is providing an integrated approach of six sigma method and DDEA in order to determine efficient and inefficient units and identify performance improvement indicators of transportation companies’ services in 31 provinces and obtaining the best solution to improve passengers’ transportation services.

The reason for using this method is that in transportation services’ sector, passengers vary during different seasons and periods, and dynamic methods provide reliable results to improve transportation services in different periods and effective inputs and outputs and efficient and inefficient units will be determined. In this study, we used a combination of DMAIC procedure steps and data envelopment analysis and in each of the dynamic phases, defined inputs and outputs are measured and analysis, monitor and improvement will be performed. Data collection tool is passenger transportation sector of statistical yearbook within four years and from 1391 to 1394. In this study, 31 provinces are considered as decision-making unit and DMUS unit in six sigma and data envelopment analysis integrated model. In the present study, we used dynamic output-oriented BCC envelopment model in order to calculate the efficiency of passenger transportation companies in 31 provinces of the country. We used this method because of variable returns to scale. In this study, the number of passengers and drivers are considered as inputs in data envelopment analysis and the number of passenger fleets is considered as a cross link i.e. as the input and output from 1391 to 1394. The number of suburban travels in geographic region of Iran was used as the output from 1391 to 1394.

2. Literature review

Jafarian Moghaddam and Gheysari (2010) conducted a study called fuzzy data envelopment analysis multi-objective dynamic method. In their study they attempted to provide multi-objective DEA models in fuzzy dynamic environment to apply data changes to DEA models during the evaluation period. The results of conducting their suggested model indicated that besides reducing the runtime of the model and determining simultaneous efficiency rating of all units, model differentiating power is improved. Mir Fakhruddini and Azizi (1394) developed a model to evaluate and rate companies in science and Technology Park with a six sigma and Data envelopment analysis integrated approach. Using a survey of experts and fuzzy Delphi method, we extracted the effective criteria in evaluating the performance of companies located in science and Technology Park. Then data envelopment analysis executive procedures were combined with each of DMAIC cycle steps and used appropriate six sigma tools in this cycle. The results of their study helped the mangers of science and Technology Park identify efficient and inefficient companies and effective inputs and outputs. Kumar et al. (2007) selected six sigma Project in automobile battery
industry for their study. Chakravorty (2009) shared his experiences of implementing six sigma in network technology services in the U.S in the form of an article named (six sigma plans: an implementation model) and developed an effective implementation model using the successful six Sigma program in a network technology company and provided a model for six sigma programs implementation efficient guide to reduce instability and inconsistency or operation-related waste. Lotfi et al.(2017) Efficiency is measured using multi-directional efficiency analysis in railway operation 23 European countries. Fang and Antony (2010) conducted a study named (measuring healthcare efficiency using DEA and six sigma integrated technique). Fang and Antony (2010) and Arani (2017) properly preformed DEA implementation process measurement, analysis, improvement and control and indicated how to integrate DEA and six Sigma frameworks in order to measure healthcare services’ performance. AmirSaeed Nooramin et al. (2011) studies marine terminals and minimizing trucks waiting in line using six sigma DMAIC method. Lozano et al. (2013) evaluated airport performance with non-deterministic outputs using network data envelopment analysis model. Feng et al (2010) and Meza and jeong (2013) used six Sigma project performance evaluation model for Johnson space center and used DEA to develop six sigma model. Ali yousefi and Hadi Venechhe (2014) used DMAIC phases (define, measure, analyze, improve and monitor) in their study with use of statistical methods and quality management principles to optimize processes and products. Ali yousefi and Hadi Venechhe (2014) used the three techniques of ANP, TOPSIS and DEA and compared the results and the effective method was determined. Azadi et al. (2014) used data envelopment analysis two-step model to meet the needs of green supply chain management and for transportation companies. Pour Mahmoud (2015) developed a new DDEA model to rank the decision-making units. You et al. (2016) evaluated the dynamic performance of Taiwan passenger buses using data envelopment analysis. Min and Joo (2016) evaluated the comparative performance of airlines at the airports of the world using data envelopment analysis. Merkert, and Assaf (2015) measured the quality of services in international airports using data envelopment analysis model. Azadeh, Nasirian, Salehi and Kouzehchi (2016) presented an article named (integrating PCA and DEA) to identify and improve the effect of performing six sigma on the features of the job in automobile industry. In this article they used an integrated approach based on data envelopment analysis and PCA analysis in order to study the effect of six sigma establishment in job features in automobile industry. Esfandiarj et al., (2017) conducted a research named stable data envelopment analysis two-stage models under discrete indeterminate data. In this study, using Stackelberg methods and focused game theory, two stable DEAs are suggested for measuring two-stage processes’ performance. These developed models calculated performance ratings for decision making units that include discrete indeterminate data on input and output parameters. These methods are based on stable optimization approach that was developed by Malvi in 1995 and use probable scenarios. These two suggested stable methods are used for a data set in real conditions related to 20 bank branches in east Virginia. Yang T-Zheng et al (2016) used DDEA for passenger facility charges and improvement program in the U.S airport. Yanming Shaw et al. (2016) evaluated the performance of 477 air routes in 82 airports. Venkatesh et al. (2016) decreased short-term and long-term efficiency costs using data envelopment analysis in Indian Transportation Companies. Piter Wanke et al. (2016) A fuzzy model was used to analyze the data envelopment analysis model at Nigerian airport. Nazari ShirKhohi and Keramati (2017) presented a study named ((modeling for customer satisfaction and designing a new product)) using fuzzy regression algorithm – DEA and in this study we used the well-known fuzzy regression to understand the relationship between customer satisfaction and new product design. To select the best FR model, we used data envelopment analysis, and to predict customer satisfaction and design a new product in refrigerator industry, we used a real case study in which flexible algorithms are used. Min
and Ahn (2017) dynamically evaluated public transportation systems in America using data envelopment analysis and Malmquist productivity index. In table 1 we study the methods and Models in the past articles from 2007 to 2017 in science direct, Omega, Taylor & Francis, Emerald, Springer databases to integrate six sigma and data envelopment methods and data analysis envelopment articles in transportation case study.

### Table 1 – Research Gap In Literature

| Author          | DEA       | Six Sigma | Transportation | Input                          | Middle                  | Output                          | Case Study               | Sample Size | Model Type               |
|-----------------|-----------|-----------|----------------|-------------------------------|-------------------------|---------------------------------|--------------------------|-------------|--------------------------|
| Azadeh et al. (2016) | ✓         | ✓         | ✓              | Job satisfaction, job safety. Job stress | -                       | Cooperation, work development, work improvement conditions, | Automobile industry | 28          | CCR output-oriented, BCC output-oriented |
| Meza & Jwing (2013) | ✓         | ✓         | ✓              | Working hours, CSFs            | -                       | Cost                            | NASA projects           | 18          | CCR output-oriented      |
| Fang & Anthony (2010) | ✓         | ✓         | ✓              | Budget                        | -                       | Consultation, new patient, establishment | Medical clinic          | 22          | BCC input oriented       |
| Kumar et al. (2007) | ✓         | ✓         | ✓              | Cost-number of black and green belts, period of time | -                       | Customer satisfaction, sigma level improvement, increasing productivity, financial effect, business strategy effect | Automobile battery in Asia | 20          | CCR input oriented       |
| Olfat et al. (2016) | ✓         | ✓         | ✓              | Budget, policy making         | Number of flights, social responsibility, service quality | Income, reputation, pollution level, satisfaction | Iranian airport       | 28          | Fuzzy Dynamic Network    |
| Cheng et al. (2016) | ✓         | ✓         | ✓              | Cost, improvement, flight procedure | Income                 | Delay, load                      | American airport       | 42          | Dynamic                  |
| You et al. (2016) | ✓         | ✓         | ✓              | Driver, vehicle, fuel, technician, managers | Kilometers traveled and network length | Number of passengers, kilometers traveled, number of accidents | Taiwan passenger bus | 20          | Multy Activity Dynamic Network CRS |
| Garcia-Palomares et al (2018) | ✓         | ✓         | ✓              | Average Time                  | -                       | Market Potential, Daily Accessibility, Respectively | Spanish Road          | 352         | VRS output-oriented      |
| Min and Ahn (2017) | ✓         | ✓         | ✓              | Population density, cost, working hours | -                       | Income, kilometers               | American transportation agency | 262         | CCR output-oriented, BCC output-oriented |
| Saxena et al. (2016) | ✓         | ✓         | ✓              | Fleet size, employees, cost   | -                       | Kilometers traveled, income     | Indian public transportation company | 37           | CCR output-oriented, BCC output-oriented |
| Wanke et al. (2016) | ✓         | ✓         | ✓              | Terminal capacity, runway     | -                       | Passengers, Aircraft movements   | Nijerian Airport       | 33          | Fuzzy DEA BCC            |
| Authors                  | √ | - | - | √   | Network length, terminal size | - | Load size | World’s best airports | 30 | BCC output-oriented |
|-------------------------|---|---|---|-----|--------------------------------|---|-----------|-----------------------|----|---------------------|
| Min and Ioo (2016)      | √ | - | - | √   | Population density, operations | - | Income, service rate | World’s airports | 60 | CCR output-oriented, BCC output-oriented |
| Hanoumapa et al. (2015) | √ | - | - | √   | Fleet size, number of employees, fuel, number of trip plans and kilometers traveled | - | Income, employees efficiency, vehicle | Indian public transportation services | - | CCR input oriented |
| Azadi et al. (2014)     | √ | - | - | √   | Number of seats, network operations, number of vehicles, cost | Maintenanc e, kilometers, environmental cost | Income, passengers, fuel saving | Iran transportation services | 24 | Two Stage Network Process |
| wanke et al. (2013)     | √ | - | - | √   | Terminal, trip plan, employees | - | Load, passengers | Brazilia n airport | 63 | Two Stage Network |
| Choi et al. (2013)      | √ | - | - | √   | Number of employees, number of seats | - | Income, service quality | American airport | 12 | CCR output-oriented |
| Lozano et al (2013)     | √ | - | - | √   | Runway, capacity, number of inputs and number of check-ins, total load belt | Plane movement | Passenger movement, load, number delays and flights | Spain airport | 39 | Two Stage Network |
| Zhao et all(2010)       | √ | - | - | √   | Fuel cost Travel time | Avg speed Vehicle miles traveled | Revenue Emission Person miles traveled | Transpo rta tion in USA | 28 | Network DEA VRS |

In past articles combining the six sigma model and data envelopment analysis, no articles were published about transportation companies’ case study and to integrate these two methods, data envelopment static method was used but in this article we used a combination of data envelopment analysis method dynamically with six sigma DMAIC cycle.

3. Model

In this section, we’ll discuss the model and different stages of the study. Integrating data envelopment analysis with six sigma framework increases six sigma usefulness and data envelopment analysis effectiveness to evaluate and improve efficiency. In order to study and perform six sigma DMAIC steps in data envelopment analysis, first we should define it. In the first phase of defining the integrated six sigma and DDEA, we must define the inputs and outputs of the model. For this purpose, by reviewing the past literature we’ll define inputs and outputs and then the model schematic. Then DDEA planning model is defined for this study. Then the model is solved and efficient and
inefficient units will be determined. Then, sensitivity analysis improvement stage is carried out to convert inefficient units to efficient ones and they’re monitored in control stage by examining the control charts of the units. In table 2, six sigma DMAIC and data envelopment analysis integration steps are discussed.

| DMAIC cycle steps | DEA executive procedure |
|-------------------|-------------------------|
| Define            | Identifying decision-making units and inputs and outputs |
| Measure           | Collecting input and output data |
| Analyze           | Applying the appropriate DEA model to gain efficiency scores for decision-making units |
| Improve           | Sensitive analysis of inputs and outputs to convert inefficient units to efficient ones |
| Control           | Providing a method to ensure proper functioning in the future |

3.1 six sigma DMAIC define and measure phase

In this phase, we’ll define inputs and outputs of the model. To determine inputs and outputs, we’ll review past literature. For this purpose, model inputs and outputs of previous articles (table 1) are displayed in figure 1.

After reviewing the inputs and outputs of past studies (figure 1), number of drivers, cost, number of vehicles, distance traveled, number of passengers and income had the largest number of inputs and outputs assigned to them. Now, according to recent research, and Pareto 20/80 rule and considering the opinion of professors and experts, inputs and outputs are defined in this study. The inputs of the model were the number of passengers, number of manpower (drivers), and the number of public transportation services. The outputs of the defined model are the number of travels and the number of vehicles at the end of the year (total fleet renewal and past fleet). Passenger fleet or the vehicles are the system connectors that go from t-1 output stage to t input stage. And the system will be replicated for 4 years. According to Pareto 20/80 rule, Cost and income as system input and output could be selected as input and output but due to transportation companies’ information confidentiality isn’t used. The schematic figure of the defined model in this study (extracted from Chong et al 2016), is described in figure 2 by applying the changes.
related to the new model. And the inputs, outputs and the type of the model described in recent studies, is presented in table 1.

![Figure 2: dynamic model schematic](image)

3.2 DMAIC analysis phase

When selecting the model, if in the evaluation process we try to minimize the inputs by keeping the outputs constant, the nature of the pattern used is input, and if in the evaluation process, we try to increase output level by keeping the input level constant, nature of the pattern used is output. In data envelopment analysis method with input view, we’re trying to find technical inefficiency as ratio that must be reduced in inputs so the output remains unchanged and the unit is placed on the border of efficiency. In output view, we’re looking for a ratio to increase the outputs, without any changes to inputs, so the desired unit reaches efficiency. Returns to scale, expresses the link between input and output changes to a system. One of the capabilities of data envelopment analysis method is applying different patterns, corresponding to different returns to scale and also measuring returns to scale of different units. Constant returns to scale means that an increase in the input value causes an increase to output value. And variable returns to scale, is output increasing more or less than increasing ratio in input. According to the above, and also inputs and outputs of the study, and given the nature of service organizations’ work, such organizations try to increase their output, therefore the best alternative to choose a model suitable for evaluating the performance of transportation organizations is BCC output-oriented model. When evaluating public transportation performance, we typically use output pattern and variable returns to scale. the BCC output-oriented model has been changed to dynamic model. the intermediate has been used for input and output.it used in t-1 time period for input and t time period for output.

**BCC dynamic envelopment output oriented model (Parameters, Indices & Decision variables)**

| Symbol | Description |
|--------|-------------|
| \( I \) | Input index \( i = 1, \ldots, m \) |
| \( R \) | Output index \( R = 1, \ldots, s \) |
| \( T \) | Time period \( t = 1, \ldots, 4 \) |
| \( \theta \) | Efficiency rate |
| \( \lambda \) | Non-negative weights for measurement units |
| \( x^t_{ij} \) | DMU ith input vector in t time period |
| \( y^t_{ij} \) | DMU rth output vector in t time period |
| \( k^t_{ij} \) | DMU ith input vector in t-1 time period |
Given the output oriented BCC model in this study, we’re trying to increase output which is the efficiency or $\theta$. $X_{it}$ is the $i$th input in $t$ time period and $Y_{rt}$ is $r$ output value in $t$ time period. $K_{t-1}^{i}$ is the dynamic input of the model in $t-1$ time period and $K_{rt}^{i}$ is the dynamic model output that equally goes to the next step input.

3.3 Ranking efficient units using Anderson-Peterson model

Due to lack of complete ranking among efficient units in data envelopment analysis basic models, there is no possibility for comparing efficient units together. In other words, these models divide the units under review into “efficient units” and “inefficient units”. Inefficient units can be ranked by gaining efficiency score but efficient units can’t be ranked, because they have an equal efficiency rating. Therefore, some researchers suggested a few methods for rating these efficient units, and Peterson-Anderson AP model is one of the most famous. Peterson-Anderson model or supper efficiency model that enables determining the most efficient unit was proposed by Anderson and Peterson in 1993 for rating efficient units. In this method, efficient units can score more than one and in this way efficient units can be rated like inefficient units. This is how it works: decision-maker unit performs DMU from possibility of service generation set and performs DEA for other DMUs. In this model due to removing the restrictions related to the unit under evaluation (when the upper limit is one), efficiency can be more than one and therefore efficient units with a score more than one can be ranked. The objective function is the formula 8 and formulas 2 to 7 will be replicated.

$$\text{MAX} \: Z_{p} = \theta$$

4. Computational results

In this section we’re going to analyze DMAIC data. In fact, the model, inputs and outputs are imported to MATLAB so the results are obtained and efficient and inefficient units are determined. After determining efficient and inefficient units, we have the improvement DMAIC stage and by analyzing the sensitivity of increasing or decreasing the variables in order to improve efficiency, each unit is identified. And at the end we’ll perform DMAIC cycle control system. And then we’ll rank efficient units by Anderson-Peterson model.

4.1 organizing data and information

After determining the inputs and outputs, data was collected from passenger transportation statistical yearbook (31 provinces) and was expressed according to the following table (table 3).
Table 3: table of inputs and outputs information

| input          | Link (input and output)                                                                 | output          |
|----------------|----------------------------------------------------------------------------------------|-----------------|
| Number of drivers | The number of passenger fleets at the beginning of the year are considered as the input for that year and passenger fleet renewal with fleet form the beginning of that year (total passenger fleets at the end of the year) is the output for that year and used as the input for the next year. | Number of travels | Number of passenger fleets |
| Number of passengers |                                                                                       |                 |
| Number of passenger fleets |                                                                                      |                 |

4.2 Computational result

After inserting the inputs and the outputs and coding in MATLAB software, we observed that efficiency ratio is obtained from the results of inputs and outputs. Efficiency (θ) is always a possible solution for DEA model. If θ = 1, that unit is efficient, so there are no hypothetical units that can produce more output with no reduction in inputs. If 0 < θ < 1, it means the model has found a default unit more efficient than zero. In other words, DMU is inefficient. Higher values of θ indicate lower efficiency of this unit. DMU efficiency is calculated as 1/θ. Table 4 indicates the efficiency of DMUs.

Table 4 – the efficiency ratio of provinces.

| DMUS  | Province                  | Efficiency | Type Of Efficiency |
|-------|---------------------------|------------|--------------------|
| DMU1  | East Azarbaijan           | 0.9629     | Inefficient        |
| DMU2  | Western Azarbaijan        | 0.9818     | Inefficient        |
| DMU3  | Ardabil                   | 0.9836     | Inefficient        |
| DMU4  | Isfahan                   | 0.9803     | Inefficient        |
| DMU5  | Alborz                    | 1.0000     | Efficient          |
| DMU6  | Ilam                      | 0.9630     | Inefficient        |
| DMU7  | Bushahr                   | 0.9325     | Inefficient        |
| DMU8  | Tehran                    | 1.0000     | Efficient          |
| DMU9  | Chahar Nahal & Bakhtiari  | 0.9326     | Inefficient        |
| DMU10 | South Khorasan            | 1.0000     | Efficient          |
| DMU11 | Razavi Khorasan           | 1.0000     | Efficient          |
| DMU12 | North Khorasan            | 1.0000     | Efficient          |
| DMU13 | Khuzestan                 | 1.0000     | Efficient          |
| DMU14 | Zanjan                    | 0.9599     | Inefficient        |
| DMU15 | Semnan                    | 1.0000     | Efficient          |
| DMU16 | Sistan & Baluchestan      | 1.0000     | Efficient          |
| DMU17 | Fars                      | 0.9935     | Inefficient        |
| DMU18 | Qazvin                    | 0.9398     | Inefficient        |
| DMU19 | Qom                       | 0.9343     | Inefficient        |
| DMU20 | Kurdistan                 | 0.9801     | Inefficient        |
| DMU21 | Kerman                    | 1.0000     | Efficient          |
| DMU22 | Kermanshah                | 0.9684     | Inefficient        |
| DMU23 | Kohgiluyeh & Boyer-Ahmad  | 1.0000     | Efficient          |
| DMU24 | Golestan                  | 0.9273     | Inefficient        |
| DMU25 | Gilan                     | 0.9941     | Inefficient        |
| DMU26 | Lorestan                  | 0.9520     | Inefficient        |
| DMU27 | Mazandaran                | 1.0000     | Efficient          |
| DMU28 | Markazi                   | 0.9335     | Inefficient        |
| DMU29 | Hormozgan                 | 1.0000     | Efficient          |
| DMU30 | Hamedan                   | 0.9887     | Inefficient        |
| DMU31 | Yazed                     | 0.9902     | Inefficient        |
4.3 six sigma DMAIC cycle improvement phase

Data envelopment analysis provides further information besides determining performance ratings which can be used in six sigma improvement stage. This information includes a reference set of efficient companies for each of inefficient companies and input and output sensitivity analysis is used for determining effective inputs and outputs in companies’ performance. Defining target values for inputs and outputs also enables inefficient companies to obtain efficiency. Therefore, we can provide some measures to improve their performance. By creating a virtual unit and comparing the inputs and outputs of the virtual unit and the inefficient unit, the desired inputs and outputs are determined so that inefficient units reach the efficiency border (table 5).

| Province                | Input2-91 | Output 1-91 | Input1-92 | Input2-92 | Output 2-92 | Input1-93 | Input2-93 | Output 12-93 | Input1-94 | Input2-94 | Output 12-94 |
|-------------------------|-----------|-------------|-----------|-----------|-------------|-----------|-----------|--------------|-----------|-----------|-------------|
| East Azarbaijan         | -         | -           | -         | -         | -           | 1401.459  | -         | -            | -         | -         | 950.4049    |
| Western Azarbaijan      | -         | -           | -         | -         | -           | 530.762   | -         | -            | -         | -         | -            |
| Ardabil                 | 605.5732  | -           | -         | -         | -           | 755.018   | -         | -            | -         | -         | 701.3800    |
| Isfahan                 | 1117.0752 | -           | -         | 1087.1641 | -           | -         | -         | 50.2391      | 2438.8640 | -         | -            |
| Ilam                    | 1491.4852 | -           | -         | -         | -           | 268.5167  | -         | 408.1546      | 241.1055  | -         | -            |
| Bushehr                 | -         | 26.5630     | -         | -         | -           | 42.4563   | 246.5518  | -            | -         | -         | -            |
| Chahar Sahik & Gilan    | -         | -           | -         | -         | -           | 658.1611  | -         | 2041.2790     | -         | -         | 1422.0776   |
| Zanjan                  | -         | -           | -         | -         | -           | 327.5424  | -         | 219.5592      | -         | -         | -            |
| Fars                    | -         | -           | -         | -         | -           | 361.562   | -         | -            | -         | -         | -            |
| Qazvin                  | -         | -           | -         | -         | -           | 34.6157   | 465.9288  | -            | -         | -         | 171.6684    |
| Qom                     | -         | 78.1571     | -         | 101.3805  | -           | 141.0357  | 5.4554    | -            | 10.0733   | 106.1851  |
| Kurdistan               | -         | -           | -         | -         | -           | 172.597   | -         | 604.5385      | -         | -         | -            |
| Kermanshah             | -         | -           | -         | -         | -           | 1465.7712 | -         | -            | 15.2408   | 604.5385  | 105.9044    |
| Golestan               | -         | -           | -         | 190.1252  | -           | 355.2309  | -         | 853.2845      | 255.7465  | -         | -            |
| Gilan                  | -         | -           | -         | -         | -           | -         | -         | -            | -         | -         | -            |
| Lorestan                | -         | -           | -         | -         | -           | -         | -         | -            | -         | -         | -            |
| Markazi                | -         | -           | -         | -         | -           | 345.2647  | -         | 10.0733       | -         | -         | 106.1851    |
| Hamadan               | -         | 1484.0281   | -         | -         | -           | -         | -         | -            | -         | -         | -            |
| Yazd                  | 68.9784   | 126.0668    | -         | -         | -           | -         | -         | -            | -         | -         | -            |

4.4 six sigma DMAIC cycle control phase

According to the performance standards that are determined by DEA model, the efficiency of each unit (province) is controllable. According to the sensitivity analysis performed in improvement phase, we can determine what changes to be made to input and output values for inefficient units to become efficient. Therefore, by monthly controlling the statistical control charts we can monitor and supervise input and output values so they don’t get far from efficiency border.

4.5 ranking efficient units using Anderson-Peterson method

Data envelopment analysis basic models don’t provide the possibility to compare efficient units due to lack of complete ranking. In other words, these models divide the units under review into “efficient units” and “inefficient units”. Inefficient units can be ranked by gaining efficiency scores. But because efficient units have an equal
efficiency score (unit efficiency), they can’t be ranked. Therefore, some of the researchers suggested some methods for ranking these efficient units and Anderson-Peterson AP model is one of them. Anderson-Peterson or super efficiency method makes it possible for us to determine the most efficient unit. In this method, ratings of efficient units can be more than one and in this case efficient units can also be ranked. How it works is that decision-making unit performs DMU from possibility of service generation set and DEA model for other DMUs. In this model, due to the removal of restrictions related to the unit under evaluation, efficiency can be more than 1 and therefore efficient units with a score more than 1 can be ranked. Therefore, transportation companies in 31 provinces can be ranked by Anderson-Peterson model. How we do it is, efficient provinces will be ranked so the most efficient province is selected and then inefficient provinces are also ranked so the province with the lowest efficiency and productivity is determined so that improvement and control measures are taken to convert inefficient units to efficient ones.

Table 6 – ranking provinces

| DMU   | Province                  | Efficiency | Ranking |
|-------|---------------------------|------------|---------|
| DMU1  | East Azarbaijan           | 0.9629     | 23      |
| DMU2  | Western Azarbaijan        | 0.9818     | 18      |
| DMU3  | Ardabil                   | 0.9836     | 17      |
| DMU4  | Isfahan                   | 0.9803     | 19      |
| DMU5  | Alborz                    | 1.3025     | 4       |
| DMU6  | Ilam                      | 0.9630     | 22      |
| DMU7  | Bushehr                   | 0.9325     | 30      |
| DMU8  | Tehran                    | 1.2379     | 5       |
| DMU9  | Chahar Nahal & Bakhtiar   | 0.9326     | 29      |
| DMU10 | South Khorasan            | 1.0600     | 11      |
| DMU11 | Razavi Khorasan           | 1.1165     | 7       |
| DMU12 | North Khorasan            | 1.4571     | 2       |
| DMU13 | Khuzestan                 | 1.0831     | 9       |
| DMU14 | Zanjan                    | 0.9599     | 24      |
| DMU15 | Semnan                    | 1.0518     | 12      |
| DMU16 | Sistan & Baluchestan      | 1.1470     | 6       |
| DMU17 | Fars                      | 0.9935     | 14      |
| DMU18 | Qazvin                    | 0.9398     | 26      |
| DMU19 | Qom                       | 0.9343     | 27      |
| DMU20 | Kurdistan                 | 0.9801     | 20      |
| DMU21 | Kerman                    | 1.1127     | 8       |
| DMU22 | Kermanshah                | 0.9684     | 21      |
| DMU23 | Kohgiluyeh & Boyer-Ahmad  | 1.4287     | 3       |
| DMU24 | Golestan                  | 0.9273     | 31      |
| DMU25 | Gilan                     | 0.9941     | 13      |
| DMU26 | Lorestan                  | 0.9520     | 25      |
| DMU27 | Mazandaran                | 2.2054     | 1       |
| DMU28 | Markazi                   | 0.9335     | 28      |
| DMU29 | Hormozgan                 | 1.0763     | 10      |
| DMU30 | Hamedan                   | 0.9887     | 16      |
| DMU31 | Yazd                      | 0.9902     | 15      |

5. conclusion

In this study we demonstrated different phases of six sigma DMAIC cycle, integrated with data envelopment analysis. Input and output definition phase and decision-making units were identified. Data related to maintenance and road transportation organization were determined for inputs and outputs in the measurement phase, and real data were used. In the analysis phase, we designed the dynamic output oriented envelopment BCC model and the data related to the corresponding formula were implemented in MATLAB software and efficiency or inefficiency of different units were determined and in the improvement phase with sensitivity analysis it was determined what changes should be made to inefficient units to become efficient. In control phase, monitoring and control of inputs
and outputs of each unit was performed based on standard operators. Ranking efficient units was performed by Anderson-Peterson model and it was determined which unit has the highest efficiency based on ranking. Integrating these two methods is done by combining six sigma DIAMIC cycle and data envelopment analysis in different phases of DMAIC cycle. In the synthesis analysis phase of DMAIC cycle and data envelopment analysis, efficient and inefficient units are determined and in the phase of improving inefficient units by applying some changes to the inputs and outputs they can improve the performance of their units. Outputs obtained from integrating these two methods are recognizing efficient and inefficient units. In static environment, only at a specified time and with unit data we can determine the efficiency boundary, but for better recognition and using more reliable results, we used a dynamic environment. In fact, the data are not just for a specified time and are extracted for a 4-year period so that more confidence is obtained given the changes inside or outside the organization and community culture. In a period of 1391 to 1394, 19 provinces were inefficient and 12 provinces were efficient. Using network and multi stage models for data envelopment analysis is one of the suggestions for future studies. We can benefit from six sigma implementation and belt definition methods to obtain more relevant indicators. In this study we used definitive data, in future studies we can use fuzzy and qualitative data for inputs and outputs.

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