Available online at http://ijdea.srbiau.ac.ir

Int. J. Data Envelopment Analysis (ISSN 2345-458X)

Vol.3, No.3, Year 2015 Article ID IJDEA-00335, 13 pages

Research Article

International Journal of Data Envelopment Analysis

Science and Research Branch (IAU)

Efficiency Evaluation of Wood Supplying Plans

Shademan. Pourmousa*

Department of wood and paper technology, Karaj Branch ,Islamic Azad University, Faculty of Agriculture & Natural Resources

Received 1 February 2016, Revised 17 April 2016, Accepted 21 May 2016

Abstract

In this research, efficiency of Iranian forest and rangeland decision making unit was assessed using non-parametric method. Inputs and outputs determined by field research and with applying a Delphi method the final input and output variables selected. Forty five wood-producing units (forestry plans) in three northern Iranian province were studied using Data Envelopment Analysis. The efficiency of wood-producing units were calculated in two forms; constant returns to scale (technical efficiency) and variable returns to scale (scale efficiency). The results indicated that 5 units out of 45 units were fully efficient by reaching to the technical efficiency of 40.38% and9 units reached to the scale efficiency of 55.47%. The result concluded that about 89% of wood producing units were not efficient technically and 80% by scale, which required forest and rangeland decision making authority to enhance inputs in the same level of outputs by suitable policies and strategies.

***Keywords**:* Efficiency, DEA, CCR/ε, BCC/ε, Wood Supplying Plans.

* Corresponding Author: sh.pourmousa@gmail.com

1. Introduction

Efficiency is mostly subject of attention in three fields of engineering, management and economics. In economics the efficiency is defined as the ratio of output to input, the quantity of which is always less than one. Hence, those institutes would be regarded as "Efficient" who use lesser inputs for the same production. In such event, if all inputs have physical properties, the result will have technical efficiency.

For calculating efficiency, two parametric and non-parametric methods are available. In parametric method, at first a special shape (such as Cab Douglass function) is considered as production function and then unknown parameters will be estimated via a usual method for estimating function which is regular in statistics and econometrics. Then efficiency of institutes will be calculated with the estimated function. In non-parametric methods, the work is based on a series of mathematical optimization which would be used for calculating the relative efficiency. In non-parametric methods, there is no need for selecting forms of functions and there would be no limit for selecting number of outputs. One of non-parametric methods is Data Envelopment Analysis (DEA) which is considered as the basis of this research (2,3).

Currently the northern forests of the country cover an approximate area of 1.9 million hectares which are enumerated as scarce ecosystems of the world and also as our national wealth. Preservation, revitalization, sustainable development and effective exploitation of them are on the top of programs of National Iranian Forests and Rangelands Organization. On the other hand, forests are among our renewal natural resources which have effective role in balanced economic growth of the country; therefore, it should be used correctly for production of wood. Therefore, increase in forest growth and supplying raw materials for wood industries will be important for meeting the basic requirements of the society to wood materials and artifacts (12).

Wood supplying plans (forestry plans) are prepared by National Iranian Forests and Rangelands Organization in ten-year periods in envisioned forests (i.e. those forest areas in which wood exploitations are carried out) for correct exploitation and observance of sustainable production of forests. These plans will be renewed and put under revision after ten years for preparing necessary grounds for sustainable management of wood producing areas (12).

It is vital for managers and decision-makers of National Iranian Forests and Rangelands Organization as well as managers of wood and papers industries to assess the plans in order to reach to macro goals and to estimate capabilities of these plans for supplying raw materials for meeting domestic needs. In the light of the foregoing and importance of efficiency increase in industries of developing countries, especially those industries which are related to natural resources such as wood and papers industries, calculation of efficiency of forestry plans as the suppliers of raw materials for the said industries will be important. If we look at the consumption of various types of wood and paper products in Iran and its role in entrepreneurship, value-added and national GDP, we will find the importance of the subject.

In the recent decades researchers have benefitted from various methods for calculating performance of decision-making units all of which have common concepts. Data Envelopment Analysis has gained vast application practically in the light of its numerous capabilities in comparison with other methods using for performance evaluation.

In a research for studying economic planning for exploitation of northern forests of Iran in 1996 Heshmatolvaezin studied the reasons of assignment of harvesting of selected trees by exploiting companies to wood harvesting contractors and conducted a comparison between efficiency of public, private, and cooperative units for reaching to the best option of management and exploitation of northern forests. The results showed that private management has higher efficiency than public and cooperative managements (4). In an economic analysis of wood exploiting units in forest areas of Guilan province, having studied a number of sawmills, having used income and cost data, and having benefitted from prevailing economic techniques, Khorrami Moghaddam and Bakhshoudeh (2008) state that the present net value of the units under study is positive and that the ratio of profit to cost is approximately equal to 1; and the internal output rate is about to 21%(8).

Hool (1996) explained risk management in forestry decision-makings. For the first time, he applied a Markova framework for analysis of management of even-aged forests. Also he set out some plans which were succeeded to maximize the produced value of a limited period(6).

Kaya and Buongiorno (1987) studied economic exploitation of northern uneven-aged forests in risky conditions. Their approaches suggest a series of exploitation policies in risky conditions of prices and inventory growth. They used transfer probability matrix that represents changes in prices and random growth (7).

In an analysis for assessment of efficiency of exploitation and innovative activities in Spanish wood industry Luis Diaz Balteiro et al (2006) explained the relation of innovative activities and efficiency via Data Envelopment Analysis at the first step and then by using regression method. The inputs of this research include: number of personnel, representing parameter of salary; dividends of shareholders and loans in different projects, representing general condition of factories; and two other factors: research costs and expenditures, and costs and expenditures shared for research and development, representing innovative activities of factories. Such inputs were selected as outputs of the said model: the quantity of sales, pre-tax profit, as the indices for conditions of factories; the exclusive royalties, number of innovative products, and number of innovative procedures, representing factors relating to the R&D of companies. At the end, after application of CCR and BCC models, the results didn't show a significant relation between efficiency of factories and the innovative activities in Spanish wood industry(1).

Salehirad and Soulati (2006) in their analysis of dynamic efficiency of primary wood producing units in British Columbia took the following factors as inputs: number of personnel and volume of the logs used for; and took such factors as the produced lumbers and chips as outputs. The period was the years of 1990 to 2002 and they used CCR and BCC models. According to CCR model four units and according to BCC model fourteen sawmills were efficient. The results showed that the average of aggregative and technical efficiencies of sawmills were 0.68 and 0.71 respectively for the period of 1990 to 2002. These averages show that the scale efficiency of sawmills is high. However, 21% of sawmills had medium scale efficiency. Those factories which are under border of efficiency should improve their technical efficiency via improving efficiency of their sources through training of manpower, using efficient machinery and equipment and improving qualitative and managerial capacities. The results achieved from BCC model show that 61% (647 units) of factories are active with increasing outputs and 39% (416 units) are active with decreasing outputs. The average of technical efficiency of sawmills was 0.68 in 1990 which reached to 0.77 in 2002, representing an increase of 13%(13).

Nyrud and Bergseng (2002) in their studies on efficiency of sawmills in Norway within the period of 1991-1974, analyzed the relations of numerical quantity of efficiency with the size of sawmills. The results showed that in most periods the producing units with lesser production capacity had lesser efficiency in comparison with high-capacity production units. Also they studied the growth of productivities of the said mills during the same period with the index of Malmquest the result of which showed that the productivity had an increase in comparison with average of productivity and the applied technology during the said period had been improved consistently, while the changes in efficiency had gradual growth (Nyrud and Bergseng, 2003) (9,10).

Pourmousa (2011) in an analysis of dynamic efficiency of wood industries in Iran, studied three production groups i.e. wood panels industry, paper and paper products industries, and production units admitted in Stock Exchange via free oriented SBM and windows analysis methods for the period of 2002-2006. In this research the financial indexes were considered as inputs and outputs: total of assets and total of costs were considered as inputs; and net profit, total income and total of sales were considered as outputs. The results showed that the most of decision-making units had many fluctuations in the period in terms of quantity of efficiency and performance and most of them had negative trends and instability in performance; and on comparison based on Hemmasi et al (2011) studies, the status of wood panel production units is much better than other industries (11,5).

The main goals of this research is evaluation of performance and efficiency of wood supplying plans through application of data envelopment analysis, which was conducted in three northern province of Iranian forest as a case study. Such cases as identification of incoming and outgoing indices in evaluation of performance of the units in accordance with the approaches of forestry and wood engineers and setting the amount of efficiency of each selected unit and ranking of them were envisioned as secondary goals of this research.

2.Materials and Methods:

At first prepared a list of the effective factors on assessment of performance of wood supplying plans after studying the resources and conducting interviews with the relevant experts and specialists. Final indices of the research were extracts in accordance with proportional important of each index via the Delphi method. Then we referred to Iranian Department General of Natural Resources and extracted the information relating to costs, incomes and productions of all wood supplying plans from the relevant booklets and used the same after final control. The inputs oriented models of CCR and BCC based on slacks were used for assessment of performances of wood supplying plans. A number of forty five primary plans (i.e. those their first 10-year periods were ended) of forestry plans were chosen for this research all of which were started in 2004 and were completed in 2014. After implementation of input-oriented CCR and BCC models, the quantity of technical and scale efficiencies of wood supplying plans were achieved within a range of zero to one. And whereas some plans were jointly reached to efficiency, virtual DMU were used for ranking of them.

Data Envelopment Analysis method considers a fraction of total of outputs to total of inputs for calculating efficiency. Farrell was the first one who suggested non-parametric method with the use of linear programming principles. He defined efficiency as the ratio of output to input; and for decision-making units that are working with one output and some inputs he tallied the bordering function with a set of outputs and inputs in such a way to achieve modular lines. Charnes, Cooper and Rhodes in 1978 presented CCR method for assessment of efficiency. This method uses efficient border curve and then indicates the location of decision-making units near to this curve; and indicates that what combination of inputs and outputs should be selected for reaching to this border. In this method, a DMU which is weakly efficient would be assessed as an inefficient one because of appearance of input and output oriented slacks. Application of ε> 0 causes the input and output weights to become positive absolutely and this will remove problem in CCR and BCC models [non-distinction of efficient and inefficient units correctly]. The input-oriented linear programming forms of CCR model is as follows:

$$min \quad \theta_p - \varepsilon\left(\sum_{i=1}^{m} p_i + \sum_{r=1}^{s} q_r\right)$$

$$s.t. \quad \sum_{j=1}^{m} \lambda_j X_{ij} + p_{i=}\theta_p X_{IP} \quad \text{i} = 1, 2, 3, 4, \dots, \text{m}$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} - q_r = Y_{rp} \qquad \text{r} = 1,2,3, \dots, \text{s}$$

$$\theta_p, , \lambda_j, p_i, q_r \geq 0$$

Table 1- Variables of selected input-oriented models

θ	The amount of estimated efficiency via using data envelopment analysis (DEA)
p	Wood supplying plan, the efficiency of which is assessed in relation to other plans
i	Input indicators' index (i= 1, 2, …., m)
j	Index indicating each plan (j=1,2, …, n)
r	Output indicators' index (r= 1, 2, …., s)
X_{ij}	Indicator of the item i of input j in wood producing plan
Y_{rj}	Indicator of the item r of input j in wood producing plan
p_i	The surplus variable for the item i of input
q_r	The surplus variable for the item r of output
λ_j	Weight of item j of reference wood producing plan

CCR model was designed based on minimizing production factors with the assumption that they are constant returns to scale. Then Banker, Charnes and Cooper (1986) added variable returns to scale to CCR model using BCC model. This method also represents the type of variable returns to scale separately for DMUs at the time of measurement of efficiency. Of course it is formed to $\sum_{j=1}^{n} \lambda_j = 1$ after adding a convexity construing to CCR model. Nowadays, efficiency calculation models are very developed and different; and currently DEA is among frequently-used models in efficiency measurement researches.

3.Results and Discussions:

All linear programming methods are based on some variables. The initial variables of this research were classified in three input and two output groups based on studying the sources, interview with experts and specialists in wood and forestry engineering as well as university instructors. Such factors as costs of road construction and relevant machinery, costs of forest preservation in line with sustainable production, socioeconomic costs of forests, personnel costs and expenditures, production and exploitation costs (all in 1000USD currency) were put in input group while the following factors were put in output group: relevant incomes resulted from sales of various types of timbers, cant, lumbers, traverses, the produced fuel woods and total value of products in cubic meter. After casting opinions via Delphi method results, five indices were selected as described in table 2. As seen, costs of road construction and related machinery performed preparing factor. Settling and preserving cost relates to preservation, inter planning, sensing, forestation, conservation, and organization of forest areas for production of woods and sustainable development that performed the dynamics factor. Production and converting costs included the total production, personnel, transportation of products and converting costs that formed the Exploitation factor.

In terms of outputs, the logging is the main value of products in cubic meter per hectare and the other products included cant, lumbers, traverses, the produced fuel woods and etc performed the byproducts income. Furthermore, for preventing of some disorders the total value of product was measured in cubic meter in accordance with opinions of some specialists. After selection of final indices, the relevant numerical quantities were extracted from the booklets of the said projects, which are listed in summary in table 3.

Table 2- Final Indices based on results of Delphi methods

Primary Indices	Road construction costs	Settling and preserving cost	Production and converting cost	value of main products	value of by products
Nature	Input	Input	Input	Output	Output
Unit	M/ha	1000USD /Ha	1000USD /Ha	M^3/Ha	M^3/Ha
Final Indices	Preparing	Dynamics	Exploitation	Main Income	Main Income
Relative importance	0.5	0.2	0.3	0.7	0.3

Table 3: Descriptive statistics of the indices and some selected information in wood supplying plans

Item	Statistical factors	Total area	Exploitable area	Preparing cost	Dynamics cost	Exploitation cost	Main Income	Others Incomes
Unit	_	Hectare	Hectare	M/ha	1000USD /Ha	1000USD /Ha	M^3/Ha	M^3/Ha
1	Average	2745.18	1785.18	22.81	0.69	2.30	8.08	10.99
2	Standard deviation	249.99	192.19	1.18	0.11	0.23	0.69	1.39
3	Range	9919.00	8160.00	34.93	3.86	6.87	18.14	42.40
4	Minimum	760.00	521.00	6.23	0.07	0.44	0.64	2.35
5	Maximum	10679.00	8681.00	41.16	3.93	7.31	18.78	44.75
6	Number higher the	20	25	23	15	18	20	16
7	Number below the	25	20	22	30	27	25	29

The total area of the twenty plans is more than the average of total areas of all plans and in this regard twenty five projects are less than the relevant average. In comparison to exploitable area, this data will be reverse. Preparing factor have been more than average only in twenty three plans out of the total number of plans at the study; and twenty two plans had such costs lesser than average .Dynamics factor were more than average only in fifteen plans, while Exploitation cost in eighteen projects had such condition in all the forty five plans.

Main Income and the others Income of twenty and sixteen plans were more than the average .However, in all variables, fluctuation ranges were very high, representing the fact that more assessments shall be conducted for more proper allocation of costs and expenditures in approving forestry plans. Whereas the total areas and the exploitable areas of each plan were very different, and this may cause ambiguity in allocation of costs, in the next step the results were become clearer after representing costs and incomes per each hectare the summary of which is presented in table 3. As indicated, about 35% of total area of plans is not exploitable in practice, because the areas within this range fall in such areas as the constructed roads, wood pulling routes, forest preservation areas (steep slopes, stony, rocky, and slider areas), and forest conservation areas (having special and scare species).

The average of harvested wood stands at 19.07m^3 per hectare out of total area within a decade (10-year period). The interesting point is that the achieved average is very lesser than the average of production in northern forests of Iran (with 2.50m^3 per hectare a year), but we are witness that northern forest areas of the country are decreasing day to day. This reveals that the decision-making organization should follow and control such subjects as preservation, organization, forestation, and surrounding of forest areas for conservation and preservation. Meanwhile, more proper actions should be taken into account for pulling out the cattle and traditional shepherds of forest areas and for fighting against wood trafficking. It is obvious that the said quantity of harvest is only the share of decision-making organization; and no quantity is considered in this calculation as harvest by traditional farmers and animal breeders and wood traffickers.

With implementation of CCR/ε, it was revealed that only five plans have been technically efficient. Such proportion includes about 11% of statistical population in comparison to the entirety of plans under study; and therefore 89% of plans were inefficient. The average of technical efficiency of the plans stands at 40.38. Only fourteen plans were in proper condition in relation to the average and thirty one ones were on undesirable ranks. Therefore, the decision-making organization should take necessary action for scheduling more proper programs in order to use inputs (manpower, machinery, and production and exploitation costs) more efficient via more effective methods. The respective organization should apply better ways for lessening the inputs for the same area of exploitation.

Nine wood supplying plans were efficient in terms of scale efficiency via using input-oriented BCC/ε. This portion includes 20% of statistical plans, therefore 80% of were inefficient. The average of scale efficiency of the plans subject matter of this study was 55.47; and only eighteen plans had been occurred in more proper condition in relation to this average. In comparison to technical efficiency, scale efficiency of wood supplying plans is in a more proper stand. The result of CCR/ε, BCC/ε and the comparison of them fallowed at table of 4, 5 and 6.

Table 4- The amount in relative technical efficiency and final ranking in wood supplying plans

Code of plan	CCR/ε	Virtual DMU	Ranking	Code of plan	CCR/ε	Virtual DMU	Ranking
WFP1	24.27		32	WFP24	16.52		38
WFP2	100.00	35.33	4	WFP25	32.83		22
WFP3	28.94		25	WFP26	13.68		41
WFP4	63.10		8	WFP27	10.10		45
WFP5	100.00	25.16	5	WFP28	39.40		16
WFP6	100.00	50.20	2	WFP29	13.78		42
WFP7	100.00	95.24	1	WFP30	27.08		29
WFP8	100.00	39.08	3	WFP31	27.87		28
WFP9	26.52		30	WFP32	36.11		18
WFP10	99.19		6	WFP33	33.48		20
WFP11	16.66		37	WFP34	19.13		35
WFP12	50.08		10	WFP35	15.01		39
WFP13	94.18		7	WFP36	28.53		26
WFP14	47.77		11	WFP37	25.25		31
WFP15	31.68		24	WFP38	20.20		34
WFP16	39.63		15	WFP39	28.09		27
WFP17	42.04		13	WFP40	12.62		43
WFP18	18.19		36	WFP41	11.79		44
WFP19	37.58		17	WFP42	24.15		33
WFP20	46.76		12	WFP43	14.00		40
WFP21	60.41		9	WFP44	34.15		19
WFP22	33.45		21	WFP45	32.48		23
WFP23	40.47		14				

Table 5- The amount in relative scale efficiency and final ranking in wood supplying plans

Code of plan	BCC/ε	Virtual DMU	Ranking	Code of plan	BCC/ε	Virtual DMU	Ranking
WFP1	92.78	-	10	WFP24	20.67		45
WFP2	100.00	91.52	3	WFP25	43.69		21
WFP3	58.92	-	15	WFP26	24.41		44
WFP4	100.00	82.67	5	WFP27	35.90		33
WFP5	100.00	97.44	4	WFP28	39.71		27
WFP6	100.00	53.31	7	WFP29	37.82		31
WFP7	100.00	34.81	8	WFP30	34.23		38
WFP8	100.00	98.10	2	WFP31	34.52		36
WFP9	43.01		23	WFP32	47.71		20
WFP10	100.00	57.95	6	WFP33	36.65		32
WFP11	39.29		28	WFP34	33.15		41
WFP12	55.54		17	WFP35	38.64		30
WFP13	100.00	27.00	9	WFP36	35.66		34
WFP14	100.00	98.17	1	WFP37	40.44		26
WFP15	53.93		18	WFP38	35.55		35
WFP16	55.96		16	WFP39	42.85		24
WFP17	43.53		22	WFP40	34.16		39
WFP18	60.56		14	WFP41	26.41		42
WFP19	39.13		29	WFP42	64.88		13
WFP20	53.55		19	WFP43	24.47		43
WFP21	91.10		11	WFP44	42.27		25
WFP22	34.29		37	WFP45	33.74		40
WFP23	67.02		12	-	-	-	-

Table 6- The abbreviation of Technical and Scale efficiency results in wood supplying plans

Parameters	Average	Minimum	Maximum	Standard deviation	Range
CCR	40.38	10.10	100.00	28.21	89.90
BCC	55.47	20.67	100.00	26.74	79.33

4.Conclusion

A concern of specialists in relative efficiency of forestry and the relevant sciences is lacking a reliable mechanism in decision-making unit for proper evaluation of performance and efficiency of wood supplying plans. Without applying modern and innovative methods we would not evaluate the efficiency of management factor in forestry and forest areas with exploitation plans. It is obvious that performance evaluation would at least indicate the status of a DMU in comparison with similar units. Man can take necessary action for going toward efficiency and optimization of his enterprise through considering efficient organizations as a model.

In all managerial models we could benefit from gaining more outputs from a fixed amount of inputs, or via using lesser inputs for reaching to a fixed amount of outputs, or via using simultaneous mixed models (decreasing inputs and increasing outputs). Hence, some models have been designed for minimizing inputs i.e. input-oriented models, or for maximizing outputs i.e. output-oriented models, or for minimizing inputs and maximizing outputs simultaneously i.e. free orientation models. These models will help organizations for adopting necessary decisions. For reaching to a successful management in forestry, we should not have income-oriented approach and should not consider wood production as evaluation measure. Therefore, we cannot use output-oriented models. With implementation of input-oriented models, we would take action for decreasing costs or inputs and drive the organization toward more productivity. Therefore, the executable strategy for dynamic production in a DMU should be input-oriented. Perhaps adopting output-oriented models in harvesting and exploitation methods such as strip harvesting or clear-cutting methods etc. itself indicates that the said methods are not efficient and that they are not in line with such issues as sustainable development and/or nature-oriented exploitation of forests. Although in management of nature few factors are in control of manager or organization, we can decrease effects of the uncontrolled factors on productivity through using more suitable decision-making techniques. Therefore, with a glance to the variables of this research it will be indicated that the selected factors are fluctuating within a wide range. After implementation of model for all wood supplying plans and achieving relative efficiency for each plan, the comparison between efficiencies indicated that in selected plans on which CCR/εmodel was implemented, the minimum technical efficiency with the rate of 10.10 and the maximum one belonged to five Plans with the common quantity of one; while with implementation of BCC/ε, the minimum relative scale efficiency with the rate of 20.67 and the maximum one belonged to nine Plans.

As seen, in implementation of CCR/ε a number of thirty-one plans out of the total forty five plans under study had the efficiency amount lesser than the average of all plans, and fourteen plans had this amount more than the average, while these amounts reached to twenty seven and eighteen plans out of the total number of forty five plans when we implemented BCC/εmodel.

While the performance in forest industry is assessed more efficient than other industrial groups relating to forest industry such as wood panels or paper-making industries, it seems that the decision-making organization should put those plans with lesser exploitable areas as conservative and preservative areas and forbid exploitation thereat. The decision-making organization should reassess the performance and efficiency of the forest areas which have renewed forestry plans via optimal and proper methods so that it may have successful and sustainable management on them. The comparison of five efficient plans with five inefficient as fallowed. As the result showed in

Table 7 -The comparison of five efficient plans (Type A) with five inefficient (Type B) and average.

	Indices	Preparing cost	Dynamics cost	Exploitation cost	Main income	Other incomes
	unit	M/ha	1000USD /Ha	1000USD /Ha	M^3/Ha	M^3/Ha
Type A	mean	16.78	0.14	0.78	8.02	24.65
Type B	mean	26.81	0.68	2.98	5.06	4.06
Total average	mean	22.81	0.69	2.30	8.080	10.99

table -7, at inefficient plans preparing, dynamics and exploitation cost increased 60%, 385%, and 282% respectively while the main income and other incomes decreased 37% and 83 % respectively. It is better to conduct more proper analyses by decision-making units for decreasing the whole of inputs through more developed methods at a same of outputs level. With a glance to the share of the selected factors it is revealed that road construction costs (preparing costs) is the most important of them. In case it is financed by annual developmental budgets of the country, the system will gain better results.

5. Acknowledgements:

The financial support for this study was provided by Karaj Branch, Islamic Azad University, Iran. The authors gratefully acknowledge the support of this university.

References

[1] Balteiro, L. D., H. A.Casimiro., M. Martinez and Gonzalez-Pachon .2006. An analysis of productive efficiency and activity using DEA: An application to Spanish wood – based industry. Forest Policy and economics, 8: 762-773.

[2] Banker, R.D., A. Charnes and W.W .Cooper. Some models for estimating technical & scale inefficiencies in Data Envelopment Analysis, Management science 30(9) , pp, 1078-1092

[3] Charnes, A., W.W. Cooper and E .Rhodes.1978. Measuring the efficiency of decision making units. European Journal of Operational Research, 2: 429-444

[4] Heshamtolvaezin, S. M., 1996, Economic Planning for Exploitation of Iranian Northern Forests, M.Sc. thesis, Tehran University. (in Persian)

[5] Hemmasi,A., Talaeipour, M., Khademi-Eslam, H., Farzipour Saen,R and Pourmousa,Sh., 2011. Using DEA Window analysis for performance evaluation of Iranian wood panels, African Journal of Agricultural Research Vol. 6(7), pp. 1802-1806.

[6] Hool, N. 1996. A dynamic programming-Markova chain approach to forest control, forest sciences, monograph, 12-26p

[7] Kaya, I and J. Buongiorno. 1987. Economic harvesting of uneven aged northern

hardwood stands under risk: a Markova decision model, forest science, 33: 889-906

[8] KhorramiMoghaddam, S and Bakhsoudeh, M. 2007. Journal of the 6th Conference on Iranian Agricultural Economics, Pages 189-196. (In Persian)

[9] Nyrud ,A .Q and E.R. Bergseng. 2002.Production efficiency and size in Norwegian sawmilling, Scand J Forest Res, 17(6):566-575.

[10] Nyrud ,A. Q and E.R. Bergseng.2003. Production efficiency and productivity growth in Norwegian sawmilling, For. Sc, 49(1):89-97

[11] Pourmousa, Sh. 2011. The evaluation of relative efficiency for Iranian wood industries using DEA and Window Analysis, Ph.D. dissertation, Islamic Azad University, Sciences & Research Branch , Tehran.(In Persian)

[12] Pourmousa, Sh and B.Bakhshandeh. 2015. The evaluation of relative efficiency for Iranian Forestry Plan using DEA, Research plan, Islamic Azad University, Karaj Branch. (In Persian)

[13] Salehirad, N and T,Sowlati. 2007. Dynamic efficiency analysis of primary wood producers in British Columbia. Mathematical & Computer modeling. 45 : 1179-1188.