Contents lists available at GrowingScience

Management Science Letters

homepage: www.GrowingScience.com/msl

Ranking provinces based on development scale in agriculture sector using taxonomy technique

Shahram Rostampour*

Department of Management Science, Islamic Azad University, Central Branch, Tehran, Iran

A R T I C L E I N F O

Article history:
Received December 18, 2011
Received in Revised form February, 20, 2012
Accepted 28 March 2012
Available online April 6 2012

Keywords:
Ranking
Taxonomy
Comparative development
Data Envelopment Analysis

A B S T R A C T

The purpose of this paper is to determine comparative ranking of agricultural development in different provinces of Iran using taxonomy technique. The independent variables are amount of annual rainfall amount, the number of permanent rivers, the width of pastures and forest, cultivated level of agricultural harvests and garden harvests, the number of beehives, the number of fish farming ranches, the number of tractors and combines, the number of cooperative production societies, the number of industrial cattle breeding and aviculture. The results indicate that the maximum development coefficient value is associated with Razavi Khorasan province followed by Mazandaran, East Azarbayjan while the minimum ranking value belongs to Bushehr province.

1. Introduction

During the past few years, there has been an increasing concern on efficiently using foods in the world. From one side, we see a steady growth on the population of the world and on the other side, we see a decline on water supply, food and energy, which means we may face with serious problems of food supply within the next few decades. There is no doubt that food crises will be one of the upcoming events and human being need to invest more on optimum usage of agricultural lands and water supply. A relatively efficient land could produce more food, which reduces the risk of poverty in the world. For years, there have been tremendous efforts on proposing different methods based on multi criteria decision making (MCDM) to measure the relative efficiency of agricultural products.

Data envelopment analysis (DEA) is one of the most popular models for measuring the relative efficiency of various units. In DEA, there are normally more than one single input/output and it is possible to measure the relative efficiency of similar units based on non-financial figures. Mao and Koo (1997) used DEA method to measure productivity growth, technological progress, and efficiency

* Corresponding author. Tel: +989359821267
E-mail addresses: shahram Rostampour <shrrsp@yahoo.com (S. Rostampour)

doi: 10.5267/j.msl.2012.04.003

change in Chinese agriculture after rural economic reforms. They used 29 provinces in China and classified them into advanced-technology and low-technology categories. The Malmquist productivity measures were decomposed into two groups of technical and efficiency change index. The results indicated that total factor productivity had risen in most provinces for both technology categories during the 1984–1993 period. Technical progress was mostly attributed to Chinese agricultural productivity growth after the rural economic reforms. The deterioration in technical efficiency in many provinces indicated China had great potential to improve productivity through improved technical efficiency. Sueyoshi (1999) used DEA for meaning the ranking Japanese agriculture cooperatives.

Martić and Savić, G. (2001) presented an application of DEA for comparative analysis and ranking of regions in Serbia with regards to social-economic development. In their DEA implementation, they tried to estimate how well regions in Serbia utilize their resources. They used data for four inputs and four outputs and reported that 17 out of 30 regions were efficient. For each inefficient unit, DEA determined the sources and level of inefficiency for each input/ output. Picazo-Tadeo et al. (2011) used DEA for assessing farming eco-efficiency for both farm and environmental pressure-specific levels. The study computed for a sample of Spanish farmers operating in the rain-fed agricultural system of Campos County. The results disclosed that farmers were quite eco-inefficient, with very few differences coming from specific environmental pressures. In addition, eco-inefficiency was associated with technical inefficiencies in the management of inputs. Farmers benefiting from agri-environmental programs as well as those with university education indicated to be more eco-efficient.

Hu et al. (2006) argued that water is a limited and unevenly distributed resource in China, with the per capita amount of water resource there only about one-fourth of the world's average. As we also explained earlier, water is an essential resource for people's lives and economic development anywhere in the world including China and effective water supply is definitely important for the sustainable development of human beings. They analyzed water efficiency by using water as an input as well as using traditional inputs such as labor employment and capital stock. They used an index of a water adjustment target ratio (WATR) from the production frontier constructed by DEA including water as an input. They reported that the central area had the worst water efficiency ranking and the total adjustment amount of water used there was around three-fourths of China's total.

Chen and Song (2009) utilized a unique county-level dataset to study technology gap and technical efficiency in China's agriculture. They classified the counties into four regions based on distinctive levels of economic development, and production technologies. They reported that the eastern counties had the highest efficiency scores with respect to the regional frontier but the northeastern region led in terms of agricultural production technology nationwide. Meanwhile, the mean efficiency of the northeastern counties was relatively low, recommending technology and knowledge diffusion within region might help to improve production efficiency and agricultural output. Hoang and Rao (2010) provided sustainable efficiency in agricultural production using a cumulative exergy balance approach.

One of the issues on the implementation of DEA is that there may be more than one single efficient units in a particular province and we need to use so called super efficiency techniques to repeat measuring the relative efficiency among efficient ones. Sadjadi et al. (2011) used DEA for measuring the relative efficiency of different gas distribution companies operating in various provinces of Iran. In their method, they developed an interactive super-efficiency DEA, which made it possible to better handling the supper-efficiency issue.

Murshed-E-Jahan and Pemsl (2011) presented an empirical study on the impact of integrated aquaculture–agriculture on small-scale farm sustainability and farmers' livelihoods in Bangladesh. They reported that the training had a significant positive impact on farmers' technical efficiency, net incomes and total factor productivity.

Sultana and Kumar (2012) developed an MCDM technique to rank various biomass feedstock-based pellets, in terms of their suitability for use in large heat and power generation plants and demonstrated the relative importance of economical, environmental and technical factors in making decision about various pellets. Five pellet alternatives of wood, straw, switchgrass, alfalfa and poultry litter were ranked according to eleven criteria, using the Preference Ranking Organization Method for Enrichment and Evaluation (PROMETHEE). Both quantitative and qualitative criteria were used including technical, environmental and economic factors. Three scenarios, namely base case, environmental and economic, were developed by changing the weight assigned to various criteria. Based on the PROMETHEE rankings, wood pellets were the best source of energy for all scenarios followed by switchgrass, straw, poultry litter and alfalfa pellets except economic scenario, where straw pellets represented higher position than switchgrass pellets. Reith and Guidry (2003) tried to integrate piecemeal environmental improvements into a farm-wide program of systematic improvement and reported that eco-efficiency defined as 'the efficiency with which receivables could be converted into deliverables', was a suitable way to apply the lessons of industry to the agricultural sector.

In this paper, we present an empirical study to rank different provinces of Iran in terms of agricultural factors using Taxonomy method, which is an MCDM technique. The organization of this paper first presents details of the implementation of the proposed model in section 2. Section 3 presents the results of our survey and finally section 4 summarize the contribution of this paper.

2. Problem statement

Taxonomy is one of the most popular MCDM techniques used for ranking existing alternatives based on development level by using matrix of alternatives and attributes relationship.

In this approach, first a data matrix is formed which consists of *n* alternatives and *m* attributes, which contrast with each such that X_{ij} indicates value of *j*th feature in *i*th attribute, and then by calculating mean and standard deviation (SD), we proceed to data normalization and compute compound distances between alternatives as follows,

$$D_{ab} = \sqrt{\sum_{j=1}^{m} (Z_{aj} - Z_{bj})^2}. \quad (1)$$

We also determine upper and lower acceptance limits and remove out of range alternatives, and finally specify development level of any alternative as follows,

$$C_{io} = \sqrt{\sum_{j=1}^{m} (Z_{ij} - D_{oj})^2}, \quad (2)$$

$$F_i = \frac{C_{io}}{C_o}, \quad (3)$$

Where

D_{ab}: compound distance between alternatives,

D_{oj}: positive ideal value,

Z_{ij}: normalized feature,

C_{io}: development pattern of any alternative,

C_o: upper limit of development,

F_i is development level of any alternative.

3. Case study

The purpose of this study is to determine the provinces' development ranking by using indices including annual rainfall amount, the number of permanent rivers, the width of pastures and forest, cultivated level of agricultural and garden harvests, the number of beehives, fish farming ranches. We also consider the number of tractors and combines, the number of cooperative production societies and industrial cattle breeding and aviculture. It is worthy of mention that all country's provinces have been considered as dependent variables. Table 1 shows the summary of primary data for entering to model (data source: statistics of agriculture jihad ministry, 2010).

Based on the accomplished modeling after implementing cited technique and doing computations to determine comparative development level, the rank of any province has been calculated, which is summarized in Table 2.

Table 1
Primal data problem

Row	province	1	2	3	4	5	6	7	8	9	10	11	12	13
1	East Azarbayjan	285	78	2473440	188075	737126	114610	607443	359	25485	424	45	512	268
2	West Azarbayjan	364.4	13	2516584	174000	722893	108239	527762	342	36360	675	21	450	26
3	Esfahan	210	28	6270213	446380	280923	79134.72	511994	434	17773	381	42	2389	140
4	Ilam	257.6	21	1112358	641667	251123	4555	24218	128	3999	106	72	74	2
5	Ardebil	257	20	1015000	53193	685491	33123	144080	163	17020	951	19	208	22
6	Bushehr	110	3	1211525	257069	222023	40986.1	17257	80	3619	43	33	169	1
7	Tehran	185	36	1256400	76420	194154	82041	85410	151	4605	476	59	3329	230
8	Bakhtiari	479	20	1093000	335000	147473	46612	91599	220	6267	40	26	329	6
9	North Khorasan	165.5	47	1025941	408915	249452	37767.8	37242	74	8096	177	104	198	1
10	Razavi Khorasan	225.1	42	6566029	996156	652925	237470	75303	543	22966	569	151	2314	226
11	South Khorasan	134	3	6214464	606176	173800	53718	5798	222	4212	79	27	283	15
12	Khozestan	393	6	2488608	947842	1212975	63787	52052	294	13826	372	47	345	6
13	Zanjan	300	9	1137060	97553	431932	39024	73923	183	11097	304	21	141	16
14	Semnan	135	5	3741386	352245	113479	34571	23146	142	2176	54	18	1000	23
15	Sistan	101	4	10565100	1000000	150702	69903	939	554	6370	49	25	74	1
16	Fars	5382.2	72	7309242	2215689	710477	354461	225076	297	6320	510	160	1442	28
17	Qazvin	272.8	6	853485	28000	220634	75443	39195	166	1560	142	11	405	35
18	Qom	177.3	2	72319	13275	49994	17045	15000	203	1767	86	25	574	113
19	Kordestan	422	50	1361660	373326.2	74168	346360.063	103310	162	20516	834	96	96	7
20	Kerman	126	41	9275049	2531247	261946.6	482615.2	66284	235	14831	104	154	642	17
21	Kermanshah	5526.5	38	1250323	678648	758710	51136	129644	290	18567	502	5	108	15
22	Boyerahmad	323.5	18	478000	874000	199631	37360	55639	154	1853	42	14	59	1
23	Golestan	497	64	862825	426476	606354	31947.548	55948	234	23325	2552	63	363	14
24	Gilan	1330	77	244986	564712	304778	115926.2	156426	2028	3612	37	58	158	3
25	Lorestan	266	31	884355	1217313	357314	41196	120412	328	12217	180	18	214	6
26	Mazandaran	624	66	585022	1107256	425585	150684	324404	1332	17790	1963	15	348	21
27	Markazi	275	4	2030203	23639	379831	47200	66405	248	11969	227	22	1564	69
28	Hormozgan	153.4	12	4059900	1075894.887	76312	73498	6646	66	2740	17	21	53	1
29	Hamedan	344	17	822000	37704	634433	60555	126044	113	19839	672	69	276	34
30	Yazd	104	5	6518007	183922	52391	75818.7	39923	280	3025	44	62	1311	33

1. Annual rainfall amount, 2. Number of permanent rivers, 3. The width of pastures, 4. The width of forest, 5. Cultivated level of agricultural harvests, 6. Cultivated level of garden harvests, 7. Number of beehives, 8. Number of fish farming ranches, 9. Number of tractors, 10. Number of combine, 11. Number of cooperative production societies, 12. Number of industrial cattle breeding, 13. Number of industrial aviculture

Table 2
Provinces comparative development rank based on taxonomy method

Row	Province	Coi	CO	Fi	RANK	Row	Province	Coi	CO	Fi	RANK
1	East Azarbayjan	10.21804	14.61816	0.698997	4	16	Fars	9.170925	14.61816	0.627365	2
2	West Azarbayjan	10.90294	14.61816	0.745849	7	17	Qazvin	13.46422	14.61816	0.921061	28
3	Esfahan	10.2752	14.61816	0.702906	5	18	Qom	13.61951	14.61816	0.931685	29
4	Ilam	13.15879	14.61816	0.900167	24	19	Kordestan	11.48525	14.61816	0.785683	11
5	Ardebil	12.18851	14.61816	0.833792	15	20	Kerman	10.46646	14.61816	0.71599	6
6	Bushehr	13.65732	14.61816	0.934271	30	21	Kermanshah	11.20745	14.61816	0.76668	9
7	Tehran	11.69665	14.61816	0.800145	12	22	Boyerahmad	13.40442	14.61816	0.91697	27
8	Bakhtiari	13.10611	14.61816	0.896563	23	23	Golestan	11.1328	14.61816	0.761574	8
9	North Khorasan	12.77264	14.61816	0.873751	21	24	Gilan	11.37584	14.61816	0.778199	10
10	Razavi khorasan	8.763117	14.61816	0.599468	1	25	Lorestan	12.2891	14.61816	0.840674	16
11	South Khorasan	13.00196	14.61816	0.889439	22	26	Mazandaran	9.783058	14.61816	0.66924	3
12	Khozestan	11.7396	14.61816	0.803083	13	27	Markazi	12.35867	14.61816	0.845433	18
13	Zanjan	12.34191	14.61816	0.844286	17	28	Hormozgan	13.30432	14.61816	0.910123	26
14	Semnan	13.24903	14.61816	0.90634	25	29	Hamedan	11.99258	14.61816	0.820389	14
15	Sistan	12.58127	14.61816	0.86066	19	30	Yazd	12.64795	14.61816	0.865221	20

As observed from the results of Table 2, Razavi Khorasan comes first in terms of ranking followed by Mazandaran, East Azarbayjan while Bushehr received the lowest development level. It is surprising to see that the province of Semnan, which is located on the right side of the capital city of Iran maintains a low priority.

4. Conclusion

In this paper, we have presented a mathematical model to measure the relative efficiency of different provinces based on agricultural features. The primary concern was to determine the ranking based on taxonomy approach as an MCDM technique. Along with this, data related to annual rainfall amount, the number of permanent rivers, the width of pastures and forest, cultivated level of agricultural and garden harvests, the number of beehives, fish farming ranches, tractors, and combines, the number of cooperative production societies and industrial cattle breeding and aviculture have considered as input indices. The Results of our survey indicated that that Razavi Khorasan maintained the highest development level and Bushehr had the lowest development level.

We have used taxonomy technique in this study. However, we can profit from other existing methods like Data Envelopment Analysis (DEA), Deterministic Frontier Analysis (DFA), Stochastic Frontier Analysis (SFA), and Topsis, which can be applied as a basis for doing future researches.

Acknowledgement

The author thinks it necessary to acknowledge all people who help accomplishing this study and compiling paper.

References

Chen, Z., & Song, S. (2009). Efficiency and technology gap in China's agriculture: A regional meta-frontier analysis. *China Economic Review*, 19(2), 287-296.

Hoang, V.N., & Rao, D.S.P. (2010). Measuring and decomposing sustainable efficiency in agricultural production: A cumulative exergy balance approach. *Ecological Economics*, 69(9), 1765-1776

Hu, J.L., Wang, S.C., & Yeh, F.Y. (2006). Total-factor water efficiency of regions in China. *Resources Policy*, 31(4), 217-230.

Judd, W.S., Campbell, C.S., Kellog, E.A., Stevens, P.F., & Donoghue, M.J. (2007). *Taxonomy. In Plant Systematics - A Phylogenetic Approach*, 3rd Ed. Sinauer Associates, Sunderland.

Mao, W., & Koo, W.W. (1997). Productivity growth, technological progress, and efficiency change in chinese agriculture after rural economic reforms: A DEA approach. *China Economic Review*, 8(2), 157-174.

Martić, M., & Savić, G. (2001). An application of DEA for comparative analysis and ranking of regions in Serbia with regards to social-economic development. *European Journal of Operational Research*, 132(2), 343-356.

Murshed-E-Jahan, K., & Pemsl, D.E. (2011). The impact of integrated aquaculture–agriculture on small-scale farm sustainability and farmers' livelihoods: Experience from Bangladesh. *Agricultural Systems*, 104(5), 392-402.

Picazo-Tadeo, A.J., Gómez-Limón, J.A., & Reig-Martínez, E. (2011). Assessing farming eco-efficiency: A Data Envelopment Analysis approach. *Journal of Environmental Management*, 92(4), 1154-1164.

Reith, C.C., & Guidry, M.J. (2003). Eco-efficiency analysis of an agricultural research complex. *Journal of Environmental Management*, 68(3), 219-229

Sadjadi, S.J., Omrani, H., Abdollahzadeh, S., Alinaghian, M., & Mohammadi,H. (2011). A robust super-efficiency data envelopment analysis model for ranking of provincial gas companies in Iran. *Expert Systems with Applications*, 38(9), 10875-10881.

Sueyoshi, T. (1999). DEA non-parametric ranking test and index measurement: slack-adjusted DEA and an application to Japanese agriculture cooperatives. *Omega*, 27(3), 315-326.

Sultana, A., & Kumar, A. (2012). Ranking of biomass pellets by integration of economic, environmental and technical factors. *Biomass and Bioenergy*, 39, 344-355.