DOI : 10.36347/sjebm.2014.v01i11.008

Scholars Journal of Economics, Business and Management e-ISSN 2348-5302
Rofaie *et al.*; Sch J Econ Bus Manag, 2014; 1(11):580-585 p-ISSN 2348-8875

The Relative Efficiency of Investment Programs in Agriculture: Using Kourosh and Arash Model

Nina S. A. Rofaie*, Norerni Y.M. Nazal, Nurhidayyah N. N. Azlan, Dariush Khezrimotlagh
Department of Applied Statistics, Faculty of Economics and Administration, University of Malaya, 50603, Kuala Lumpur, Malaysia

*Corresponding Author
Nina S.A. Rofaie
Email: nina.rofaie@gmail.com

Abstract: The study investigates the relative efficiency of 20 investment programs in agriculture sector studied by Martic et al. (1996). The agriculture bank management is facing the tremendous problem of deciding under the constraints of limited funds and wish to maximize the economic return, which the firms to be selected for their investment portfolio. A recent model in Data Envelopment Analysis (DEA), called Kourosh and Arash Model (KAM) is applied in order to find the most efficient investment program. Although, there were 9 technically efficient investment programs by Constant Returns to Scale (CRS) technology, 10^{-6}-KAM suggests that there are only 2 efficient ones with 10^{-6} degree of freedom (DF) in the frontier. Moreover, number of technically efficient investment programs was 14 while Variable Returns to Scale (VRS) is applied. However, 10^{-6}-KAM shows there were only 4 efficient ones with 10^{-6}-DF in the frontier.
Keywords: Data envelopment analysis, Kourosh and Arash model, Technical efficiency, Agriculture sector, Investment programs, Investment loans

INTRODUCTION

Agricultural sector is always being view as a challenging and risky sector. The productions of agriculture are always changing because of weather, seasons, operating states and natural factors[1]. Agriculture is integral to the physical and economic survival of every human being[2].Report stated that over the years, global public investments in agricultural science, technology, and development have increased significantly, rising from US$16 billion (reported in 1981) to US$23 billion in 2005 purchasing power parity dollars in 2000[3]. Normally, the government is effecting its investment in agriculture sector through the banking system, by nominating one or several banks to handle the investment loans to multiple agricultural firms competing to get funds [4]. Consequently, the bank involve must select the best plan or the most efficient plan carefully to maximize profit as also to ensure repayment.

There have been several studies on efficiency of investment agriculture using Data Envelopment Analysis (DEA) [5-6]. DEA introduced by Charnes *et al.* [7] and further developed by Banker *et al.* [8]. It does not need many assumptions and easily handles multiple inputs and multiple outputs while allows direct comparisons of production possibilities without requiring additional input price data. DEA considers the frontier of a production possibility set made with available DMUs.

In this study, secondary data of 20 investment programs with 4 inputs and 3 outputs in [4] is investigated in order to find the most efficient investment programs. It is illustrated how a technically efficient agriculture investment program may not be efficient while a very small negligible error is introduced in the frontier. Since the conventional DEA models are not able to discriminate technically efficient DMUs appropriately, a recent robust DEA model, called Kourosh and Arash Model (KAM) [9] is applied to improve discrimination power of DEA.

The rest of this paper is organized into four sections. In Section 2, a short background on agriculture is presented. Data are illustrated in Section 3 and the results of applying DEA models are represented in Section 4. The paper is concluded in the last section. Simulations are also performed using Microsoft Excel Solver 2013.

Background

The productive, efficient and sustainable of agriculture activity ensure the food to become affordable and plentiful for the people around the world. The diverse, long term causes of underfeeding and malnutrition need to be address in order to combat world hunger successfully. The central task in agriculture involves producing higher amounts of food staples and providing additional healthy and affordable foodstuffs. Prognoses by the Food and Agriculture Organization (FAO) indicate that grain production alone will need to double by 2050 if everyone is to have enough to eat in the future [10]. Agricultural investment loans play a vital role for agricultural growth and sustainable development. The investment loans are used for purchasing real estate, heavy machinery for long term use and for financing the plantation of perennial crops [11]. The role in handling the investment loans and financing various agricultural firms have been traditionally played by the banks. The change in the type and characteristics of a bank's loanable funds is one of the factors that led to the fluctuations in agricultural lending [12]. The objective, standards and parameters that guide loan officers in granting loans and management of the loan portfolio have been set by commercial bank. . The lending policy provides a framework within which the credit risk arising from lending will be originate and managed in order to minimize the risk of financial loss [13].

There are a number of factors affecting the agricultural loan decision-making process. The quality of the loan portfolio and its loan monitoring system determine the success or failure of the banks. The agricultural lenders evaluate the agricultural loan application by using the five C's of credit (capacity, capital, collateral, character and conditions) [14]. The lenders judge these attributes to decide whether a borrower possesses sufficient ability to repay loaned funds.

The measurement of efficiency is an integral part of management control. It is the basic for improvement and can be used as a reference in decision making. The basic of efficiency is a ratio of output over input. The four conditions: (1) increase the outputs, (2) decrease the inputs, (3) if both outputs and inputs increase, the rate of increase for outputs should be greater than the rate of increase for inputs, or (4) if both outputs and inputs are decreasing, the rate of decrease for outputs should be lower than the rate of decrease for inputs need to be considered in order to improve the efficiency [15]. Debru[16]first measured efficiency whereas Farrell [17] who defined a simple measure of firm efficiency that could account for multiple inputs within the context of technical, allocative and productive efficiency. The efficiency of any given firm consisted of two components: technical efficiency, or the ability of a firm to maximize output from a given set of inputs, and allocative efficiency, or the ability of a firm to use these inputs in optimal proportions, given the respective prices [17]. Combining the two measures provides the measure of efficiency. Recent academic research on measuring efficiency in various areas has shifted to frontier efficiency. The frontier efficiency of a firm measures how well that firm performs relative to the predicted performance of the best firms in the industry market conditions [18].

There are four methods of measuring efficiency [19]. There are the Econometric Estimation of Average Response, Index Numbers (Total Factor Productivity indices), the Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). The Econometric estimation of average response method and the Stochastic Frontier Analysis (SFA) are classified into econometric estimation of 'parametric' functions which requires econometric assumptions on the shape or parameters of the underlying production function. The accuracy of the estimated technical efficiency is sensitive to the nature of the functional form specified [20]. DEA and the TFP are classified as 'non-parametric' approaches that do not require assumptions on the form of the production function. Charnes *et al.* [7] proposed Charnes, Cooper and Rhodes (CCR) model and identified DEA as a linear programming models. Soon later, Banker *et al.* [8] extended CCR for Variable Returns to Scale (VRS) and introduced Banker, Charnes and Cooper (BCC) model. CCR in Input-Oriented (IO)/ Output-Oriented (OO) radially decreases/increases the values of inputs/outputs without worsening their outputs/inputs values. If a DMU lies on the frontier, it is called technically efficient, otherwise it is inefficient. Khezrimotlagh *et al.* [9] illustrated that a technically efficient DMU may neither be efficient nor be more efficient than all inefficient DMUs. Since the conventional DEA models are not able to discriminate between technically efficient DMUs, they proposed Kourosh and Arash Method (KAM) to improve the discrimination power of DEA significantly. KAM considers the efficient frontier as an efficient tape which is a very small negligible thicker than the efficient frontier. KAM is as follows:

$$\max \sum_{j=1}^{m} w_j^- s_j^- + \sum_{k=1}^{p} w_k^+ s_k^+$$

Subject to

$$\sum_{i=1}^{n} \lambda_i x_{ij} + s_j^- = x_{lj} + \varepsilon_j^-, \text{ for } j = 1,2,\ldots,m,$$

$$\sum_{i=1}^{n} \lambda_i y_{ik} - s_k^+ = y_{lj} - \varepsilon_k^+, \text{ for } k = 1,2,\ldots,p,$$

$$\lambda_i \geq 0, \text{ for } i = 1,2,\ldots,n,$$

$$s_j^- \geq 0, \text{ for } j = 1,2,\ldots,m,$$

$$s_k^+ \geq 0, \text{ for } k = 1,2,\ldots,p.$$

VRS:Add $\sum_{i=1}^{n} \lambda_i = 1$.
NIRS: Add $\sum_{i=1}^{n} \lambda_i \leq 1$.
NDRS: Add $\sum_{i=1}^{n} \lambda_i \geq 1$.

The KAM best technical efficient target and score with ε degree of freedom (ε-DF) are as follows, respectively:

$$\begin{cases} x_{ij}^{*} = x_{ij} - s_{ij}^{-*} + \varepsilon_j^{-}, \text{for } j = 1,2, \dots m, \\ y_{ik}^{*} = y_{ik} + s_k^{+*} - \varepsilon_k^{+}, \text{for } k = 1,2, \dots p. \end{cases}$$

$$KA_{\varepsilon}^{*i} = \frac{\sum_{k=1}^{p} w_k^{+} y_{ik} \,/\, \sum_{k=1}^{p} w_j^{-} x_{ij}}{\sum_{k=1}^{p} w_k^{+} y_{ik}^{*} \,/\, \sum_{k=1}^{p} w_j^{-} x_{ij}^{*}}$$

The weights are defined as $w_j^- = 1/x_{lj}$ and $w_k^+ = 1/y_{lk}$, where $x_{lj} > 0$ and $y_{lk} > 0$, and if $x_{lj} = 0$ or $y_{lk} = 0$, the weights are defined as 1. Moreover, the components of epsilon vector, ε_j^- and ε_k^+, are defined as $\varepsilon \times \min\{x_{ij}: x_{ij} \neq 0, i = 1,2, \dots, n\}$ and $\varepsilon \times \min\{y_{ik}: y_{ik} \neq 0, i = 1,2, \dots, n\}$, respectively, where ε is a nonnegative real number[23-24]. The value of ε is considered as a very small positive real number in order to have a negligible thickness in the frontier. A technically efficient DMU is called efficient with ε-DF if $1 - KA_{\varepsilon}^{*} < \delta$, otherwise, it is called inefficient with ε-DF. The value of δ depends on the aim of measuring the efficiency scores of DMUs and would be defined by $\varepsilon/(m+p)$ or $\varepsilon/10$ or less/greater value to have at least one efficient DMU with ε-DF in the sample.If the value of epsilon is 0, KAM is the same as the weighted Additive DEA model (ADD) [7], and is almost completely the same as the non-linear Slack-Based Measure (SBM)[21].

EXPERIMENTAL SECTION

For the successful application of DEA, careful identification of inputs and outputs is important. This study illustrates the application of the proposed approach to assess the relative efficiency of 20 investment programs in agriculture and their ranking. The chosen of input and output on this study are based on the previous study by Martic *et al.*[4].

Table 1: The 20 DMUs with four inputs and three outputs.

DMUs	Input 1	Input 2	Input 3	Input 4	Output 1	Output 2	Output 3
P01	250	50	50	30	200	100	90
P02	1500	150	150	125	600	250	60
P03	800	300	300	85	600	450	40
P04	500	200	200	75	500	360	60
P05	200	120	120	60	330	250	50
P06	600	50	50	35	180	75	80
P07	1500	90	90	40	500	200	100
P08	1000	300	300	90	750	500	65
P09	500	100	100	60	350	180	50
P10	300	80	80	50	440	230	80
P11	700	60	60	30	300	130	100
P12	500	50	50	20	200	80	85
P13	200	50	50	40	160	90	100
P14	100	20	20	15	125	50	80
P15	800	200	200	100	700	400	90
P16	1200	250	250	115	750	400	55
P17	250	20	20	25	180	70	100
P18	400	30	30	10	130	60	90
P19	1000	130	130	100	600	270	95
P20	300	60	60	45	225	100	40

Inputs identified are the required loan amount, labour costs, production costs and energy consumption. Three outputs will be selected, including the expected value of domestic sales, expected value of exports, social justifiability and environmental acceptability. The definitions and corresponding units of measure are obvious for all inputs and first two output, but for social justifiability and environmental acceptability deserve further explanation. The term socially justifiable encompasses a number of factor such us the unemployment level, regional level of development and similar. Each of the investment programs proposed has assigned social justifiability and environmental acceptability level using the scale from 0 to 100. An investment program that is assigned level of 100 is acceptable and 0 levels cannot be justified at all. The sets of inputs and outputs are clearly stated as follows:

Input1: Required amount of loan which is the certain amount that borrower want to borrow.

Input2: Labour costs which is the cost of wages paid to workers during an accounting period.

Input3: Production costs which is the costs related to making a goods and service that generates revenue.

Input4: Energy consumption which is amount of energy consumed in an organization.

DOI : 10.36347/sjebm.2014.v01i11.008

Outpu1: Expected value of domestic sales refer to the expected value or service sold in origin country.
Output2: Expected value of exports refer to the expected value goods or service sold to foreign countries
Output3: Social justifiability and environmental acceptability which is a number of factors such as the unemployment level, regional level of development and similar.

Martic *et al.*[4]used Banker-Gifford modified model [22]and suggested that investment program P13 is relatively more efficient that other efficient program and that essentially program P07 and P08 are on the boundary of efficient. In the next section the results of KAM are illustrated to find the most efficient DMU.

RESULTS AND DISCUSSION

There is no zero in data, thus the weights in KAM when DMU_l is evaluated are defined as $w_j^- = 1/x_{lj}$and $w_k^+ = 1/y_{lk}$.

The components of epsilon vector, ε_j^- and ε_k^+, are defined as $\varepsilon \times \min\{x_{ij}: x_{ij} \neq 0, i = 1,2,\ldots,n\}$ and $\varepsilon \times \min\{y_{ik}: y_{ik} \neq 0, i = 1,2,\ldots,n\}$, respectively, where ε is a nonnegative real number. Indeed, the minimum values of non-zero inputs and output values are 100, 20, 20, 10, 125, 50, and 40, respectively. Therefore, in order to apply KAM the positive real number is defined as ε=0.000001=10^{-6}, to introduce the components of epsilon vector which means considering a very small negligible thickness for the estimated frontier. The components of epsilon vector are ε_1^- =0.000100, ε_2^- =0.000020, ε_3^- =0.000020, ε_4^- =0.000010, ε_1^+ =0.000125, ε_2^+ =0.000050 and ε_3^+ =0.000040, which are completely negligible according to each factor. Even if the positive real number is defined as 10^{-3}, the thickness of the frontier is still negligible, however, 10^{-6} is considered to depict the robustness of KAM to find the most efficient DMU.

Table 2 illustrates the results of applying CCR IO, CCR OO, BCC IO, BCC OO, ADD CRS, ADD VRS as well as the results of 10^{-6} KAM [25]. The inverse of CCR OO and BCC OO scores are written in Table 2 to have the score between 0 and 1. The results obtained using the Microsoft Excel Solver 2013.

The number of technically efficient DMUs, those lie on the frontier, in CRS are 9 while in VRS are 14. As can be seen, the last four columns of Table 2 clearly show how KAM with 10^{-6}-DF ranks all DMUs appropriately. The value of δ is defined as 10^{-7}, thus KAM CRS suggests there are only 2 efficient DMUs (P14 and P17) with 10^{-6}-DF and other technically efficient DMUs are inefficient with 10^{-6}-DF. KAM VRS also suggests there are only 4 DMUs (P14, P17, P10 and P15) which are efficient with 10^{-6}-DF. Table 3 illustrates the KAM decision in CRS and VRS as well as the reference sets for each inefficient and technically efficient DMU.P14 are the reference set for almost all DMUs in CRS. As KAM appropriately suggests, P14 and P17 are most efficient DMUs in the sample.

Table 2: The results of DEA models in CRS and VRS.

DMUs	CCR-IO (OO)	BBC-IO	BBC-OO	ADD CRS	ADD VRS	10^{-6} KAM CRS	Rank	10^{-6} KAM VRS	Rank
P01	0.8089	0.9129	0.9566	0.6331	0.7559	0.6331034	12	0.7559124	15
P02	0.5786	0.8667	0.9546	0.1985	0.6226	0.1985395	19	0.6225846	17
P03	1	1	1	1	1	0.999987	9	0.9999963	14
P04	1	1	1	1	1	0.9999901	8	0.9999997	8
P05	1	1	1	1	1	0.9999989	5	0.9999995	9
P06	0.5678	0.574	0.8	0.4432	0.5333	0.4431933	14	0.5332883	18
P07	1	1	1	1	1	0.9999974	7	0.9999998	6
P08	1	1	1	1	1	0.9999982	6	0.9999999	5
P09	0.644	0.647	0.7138	0.3002	0.4994	0.3001906	18	0.4993749	19
P10	1	1	1	1	1	0.9999989	4	0.9999999	3
P11	0.9287	1	1	0.705	1	0.7050331	10	0.9999989	11
P12	0.8971	0.8991	0.9266	0.678	0.7532	0.6780343	11	0.7532425	16
P13	0.7369	1	1	0.5879	1	0.5879103	13	0.9999982	13
P14	1	1	1	1	1	1	1	1	1
P15	0.8268	1	1	0.3999	1	0.3999344	15	0.9999999	4
P16	0.7104	1	1	0.1768	1	0.1768151	20	0.9999986	12
P17	1	1	1	1	1	1	1	1	1
P18	1	1	1	1	1	0.9999997	3	0.9999998	7
P19	0.7156	1	1	0.3404	1	0.3403586	16	0.9999995	10
P20	0.6118	0.6177	0.6364	0.3273	0.4351	0.3272727	17	0.4351153	20

Table 3: KAM decision and reference sets.

DMUs	KAM CRS Decision and Reference Sets		KAM VRS Decision and Reference Sets	
P01	Inefficient	P14	Inefficient	P10,P14,P17
P02	Inefficient	P14, P17	Inefficient	P10,P15,P19
P03	Inefficient with 10^{-6}-DF	P03,P04,P08	Inefficient with 10^{-6}-DF	P03,P04,P08
P04	Inefficient with 10^{-6}-DF	P04,P08,P10	Inefficient with 10^{-6}-DF	P04,P10,P15
P05	Inefficient with 10^{-6}-DF	P05,P14	Inefficient with 10^{-6}-DF	P05,P10,P15
P06	Inefficient	P14	Inefficient	P10,P17
P07	Inefficient with 10^{-6}-DF	P07,P17,P18	Inefficient with 10^{-6}-DF	P07,P10, P17
P08	Inefficient with 10^{-6}-DF	P08,P10,P18	Inefficient with 10^{-6}-DF	P08,P15
P09	Inefficient	P14,P18	Inefficient	P10,P17
P10	Inefficient with 10^{-6}-DF	P05,P10,P14	Efficient with 10^{-6}-DF	P10,P14
P11	Inefficient	P14,P18	Inefficient with 10^{-6}-DF	P07,P10,P11,P17,P18
P12	Inefficient	P14,P18	Inefficient	P10,P14,P18
P13	Inefficient	P14	Inefficient with 10^{-6}-DF	P10,P13,P14,P17
P14	Efficient with 10^{-6}-DF	P14	Efficient with 10^{-6}-DF	P14
P15	Inefficient	P10,P14,P18	Efficient with 10^{-6}-DF	P10,P15
P16	Inefficient	P14,P18	Inefficient with 10^{-6}-DF	P08,P15,P16
P17	Efficient with 10^{-6}-DF	P14, P17	Efficient with 10^{-6}-DF	P14,P17
P18	Inefficient with 10^{-6}-DF	P14,P18	Inefficient with 10^{-6}-DF	P14,P18
P19	Inefficient	P14,P17	Inefficient with 10^{-6}-DF	P10,P15,P19
P20	Inefficient	P14	Inefficient	P10,P17

As can be seen P13 is inefficient in CRS and it is completely dominated by P14. Although, P13 is a technically efficient DMU in VRS, P10, P14 and P17 can be reference sets for it with 10^{-6}-DF which shows the weak efficiency of P13. Both KAM CRS and VRS rank P13 into 13th level, whereas the previous study mentioned it as more efficient compared to other technically efficient programs.

CONCLUSION

This study reviews an application of DEA for a real-life numerical example proposed by Martic et al.[4],and shows how badly using a methodology may suggest a worse performer as a most efficient DMU.

REFERENCES

1. Mugera AW; Measuring Technical Efficiency of Dairy Farms with Imprecise Data: A Fuzzy Data Envelopment Analysis Approach. Agriculture & Applied Economics Association’s 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 2011; 24-26.
2. Organisation for Economic Co-operation and Development (OECD) Annual Report 2009, 2009. Available from www.oecd.org/newsroom/43125523.pdf
3. The World Bank; Agricultural Innovation Systems: An Investment Sourcebook. Washington DC, 2012.
4. Martic M, Krcevinac S, Petric J; An Application of Data Envelopment Analysis to Assess Relative Efficiency of Investments in Agriculture. Studies in Regional and Urban Planning, 1996; 4: 141-152.
5. Salgado Junior AP, Carlucci FV, Bonacim CAG, Novi JC, Pacagnella Junior AC; Investment Potential for New Sugarcane Plants in Brazil Based on Assessment of Operational Efficiency. International Food and Agribusiness Management Review, 2014; 17(2):41-64.
6. Melgarejo L, Figueiredo JN, Fries CE; A decision support methodology for increasing public investment efficiency in Brazilian agrarian reform. International Transactions in Operational Research, 2009; 16: 25-48.
7. Charnes A, Cooper WW, Rhodes E; Measuring the efficiency of decision making units. European Journal Operational Research, 1978; 2(6): 429-444
8. Banker RD, Maindiratta A; Nonparametric analysis of technical and allocative efficiencies in production. Econometrica, 1988; 56(6): 1315-1332
9. Khezrimotlagh D, Mohsenpour Z, Salleh S; A new method for evaluating decision making units in DEA. Journal of the Operational Reseatch Society, 2014; 65: 694-707.
10. Deuische Bank AG, Frankfurt am Main; Agricultural investments for more productivity and sustainability. 2014; Available from https://www.db.com/cr/en/concrete-Agricultural investments-for%20more-productivity-and-sustainability%20.htm
11. Becerra N, Fiebig,M, Wisniwski S; Agricultural Production Lending: A Toolkit for Loan Officers and Loan PortfolioManagers, Eschborn, GTZ, 2010.
12. Eustacius NB, David JL; Factors affecting commercial bank lending to agriculture. Journal of

Agricultural And Applied Economics, 1995; 27: 112-126.
13. Centenary Bank; Centenary Bank Credit Policy & Procedures Manual, 2005.
14. Gustafson CR; Credit Evaluation: Monitoring the Financial Health of Agriculture. American Journal of Agricultural Economics, 1989; 71: 1145-1151.
15. Adel Asgari Safdar; Measure Efficiency by DEA Model. Journal of Mathematics and Computer Science, 2014; 10:253-257.
16. Debru G; The Coefficient of Resource utilization. Econometrica, 1951; 19: 273-292.
17. Farrel MJ.; The measurement of productivity. Journal of the Royal Statistical Society, 1957; 3: 253-290.
18. Cummins JD, Zi H; Comparison of Frontier Efficiency Methods: An Application to the U.S. Life Insurance Industry. Journal of Productivity Analysis, 1998; 10(2): 131-152.
19. Coelli TJ, Rao DSP, O'Donnell CJ, Battese GE; An Introduction to Efficiency and Productivity Analysis. 2nd edition, Springer, New York, 2005.
20. Frimpong JM; Investigating Efficiency of Ghana Banks: A Non-Parametric Approach. American Journal of Scientific Research, 2010; 7: 64 -76.
21. Tone K; A slacks-based measure of efficiency in data envelopment analysis. European Journal of Operational Research, 2001; 120(3): 498-509.
22. Banker RD, Gifford JL; A Relative Efficiency Model for The Evaluation of Public Health Nurse Productivity. Pittsburgh: School of Urban and Public Affairs, Carnegie Mellon University, 1988.
23. Khezrimotlagh D; How to Select an Epsilon in Kourosh and Arash Model, Emrouznejad, A., R. Banker R., S. M. Doraisamy and B. Arabi. Recent Developments in Data Envelopment Analysis and its Applications, Proceedings of the 12th International Conference of DEA, April 2014, Kuala Lumpur, Malaysia.
24. Khezrimotlagh D, Salleh S, Mohsenpour Z; A New Robust Mixed Integer Valued Model in DEA, Applied Mathematical Modelling, 2013; 37(24):9885-9897.
25. Khezrimotlagh D, Salleh S, Mohsenpour Z; Nonlinear Arash Model in DEA, Research Journal of Applied Sciences, Engineering and Technology, 2013; 5(17): 4268-4273.