FACEPA

Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture

Application and extensions of the Operational Competitiveness Ratings Analysis (OCRA)

- Use and applicability of OCRA -

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Executive Summary

The objective of this deliverable is to offer reasons why Operational Competitiveness Ratings Analysis (OCRA) is an appropriate tool in ascertaining the relationship between production cost structure and farm performance.

OCRA is a relative performance measurement approach based on a non-parametric model. With OCRA, one can obtain ratings for a set of Decision Making Units (DMU) that gauge the performance of their operations against one another. The performance ratings obtained by OCRA are not at all sensitive to the numbers of inputs and outputs. OCRA makes direct performance comparisons between the DMUs while Data Envelopment Analysis (DEA)'s comparison is almost always indirect, through invented DMUs that define a frontier.

Several applications have been published about the applications on different field since the first publication in 1991 (*Parkan,* [1991]). As a management tool OCRA plays very important role in measuring the performance of service industry (transportation, hotel, banking, etc.). From FACEPA point of view the comparison of food industry's enterprises (USA, Hungary) are the most important applications which promotes our intention of comparing farms' performance belonging to FADN.

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Abbreviations and Acronyms

AHC	Analytic Hierarchy Process
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EU	European Union
FACEPA	Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture
FADN	Farm Accountancy Data Network
IMD	Institute for Management Development
MCDM	Multiple Criteria Decision Making
OCRA	Operational Competitiveness Ratings Analysis
TFP	Total Factor Productivity

Introduction

There are currently three broad classes of methods to measure performance, productivity and efficiency: (i) econometric models, (ii) nonparametric methods, including data envelopment analysis (DEA), and (iii) ratios, including index numbers and total factor productivity (TFP) models. Among the non-parametric productivity measurement methods, DEA is the most widely recognized one.

DEA has certain limitations that make its use to gauge the relative performance of Decision Making Units (DMUs). DEA cannot detect any relatively poorly performing DMUs with extremely low or high input/output values. This is the so-called outlier problem. Another concern with the DEA ratings is that each inefficient DMU's performance rating is computed in relation to the performance of an invented DMU that is made up of a specific set of perfectly performing DMUs called the inefficient DMU's reference set. But, the reference sets of different DMUs are usually different. Therefore, the comparison of the performances of two DMUs with different reference sets is indirect.

Operational competitiveness rating (OCRA) is a relative performance measurement approach based on a non-parametric model. With OCRA, one can obtain ratings for a set of DMUs that gauge the performance of their operations against one another. The performance ratings obtained by OCRA are not at all sensitive to the numbers of inputs and outputs or the number of industry groups.

OCRA can be applied to value data or data on quantities and unit prices, if available. Both time series and cross-industry data can be used with OCRA. OCRA identifies any performance difficulties accurately, as the ranking of the DMU in terms of their performance ratings remains consistent irrespective of the level of aggregation applied to the data. OCRA's application normally involves a set of uncomplicated ratio-type computations.

The OCRA procedure[1]

Suppose that we want to compare the operational performances of K DMUs that consume resources in M categories (the input-side) and generate revenues in H categories (the output-side). A DMU may represent the operation of an operating entity in a given year. Let vectors $u_k = (u_{k1}; \ldots ; u_{kM})$ and $v_k = (v_{k1}; \ldots ; v_{kH})$ represent the kth DMU's input values (costs) and output values (revenues), respectively. We assume that there exists a convex, at least once differentiable and increasing function E of ($\mathbf{u}$, $-\mathbf{v}$), whose value gauges the relative performance of a DMU's operation in converting the inputs of resources into the outputs of products. The kth DMU is assigned a rating to gauge its performance so that among all DMUs whose performance is inferior to the kth DMU, the kth DMU's function value, $E_k = E(\mathbf{u}_k, -\mathbf{v}_k)$ is the smallest, $k = 1; \ldots ; K$. This can be expressed as the following convex programming problem for $k = 1; \ldots ; K$:

$$E_k = E(\boldsymbol{u}_k, -\boldsymbol{v}_k) = \min_{u,v} \{E(\boldsymbol{u}_k, -\boldsymbol{v}_k):$$

$$u_m \geq u_{km},\ m = 1,\ldots,M;$$

$$v_h \leq v_{kh},\ \ h = 1,\ldots,H;\ \mathbf{u}, \mathbf{v} \geq \mathbf{0}\} \qquad (1)$$

E_k in Eq. (1) gauges the relative operational performance rating of the kth DMU. It has been shown in several studies that the saddle-point theorem of mathematical programming can be used to obtain the following optimality conditions for Eq. (1):

$$E_k - E_n - \sum_{m=1}^{M} \alpha_{km}(u_{nm} - u_{km})/u_{km} + \sum_{h=1}^{H} \beta_{kh}(v_{nh} - v_{kh})/v_{kh} \geq 0,$$

$$k, n = 1,\ldots,K, \qquad (2)$$

where the multipliers α_{km} and β_{kh} are such that $\alpha_{km} \geq a_{km} > 0$, $\beta_{kh} \geq b_{kh} > 0$, $k = 1,\ldots,K$, $m = 1,\ldots,M$ and $h = 1,\ldots,H$. The positive constants a_{km} and b_{kh} are called calibration constants and they reflect the relative importance that the kth DMU assigns to the mth resource category and the hth revenue category, respectively. If every DMU assigns the same relative importance to a resource consumption or revenue generation category, that is, if for $k = 1,\ldots,K$, $a_{km}=a_m$, $m = 1,\ldots,M$, and $b_{kh}=b_h$, $h = 1,\ldots,H$, then the kth DMU's performance rating, E_k , can be obtained by the following simple procedure:

(a) Compute the kth DMU's resource consumption performance rating C_k by computing first its resource consumption performance rating with respect to the mth input category

$$C_{km} = a_m \left[u_{km} - \min_{i=1,\ldots,K} \{u_{im}\}\right] / \min_{i=1,\ldots,K} \{u_{im}\},$$

$$m = 1,\ldots,M \qquad (3)$$

[1] The description of the OCRA procedure is based on *Parkan, C.,* and *Wu, Ming-Lu* [1999b]

and then linearly scaling their sum by

$$
\begin{aligned}
C_k &= \sum_{m=1}^{M} C_{km} - \min_{n=1,\dots,K} \left\{ \sum_{m=1}^{M} C_{nm} \right\} \\
&= \sum_{m=1}^{M} a_m \left[u_{km} - \min_i \left\{ u_{im} \right\} \right] / \min_i \left\{ u_{im} \right\} \\
&- \min_n \left\{ \sum_{m=1}^{M} a_m \left[u_{km} - \min_i \left\{ u_{im} \right\} \right] / \min_i \left\{ u_{im} \right\} \right\} \qquad (4)
\end{aligned}
$$

so that a value of zero is obtained for $\min_{i=1,\dots,K} \left\{ C_k \right\}$

(b) Compute the kth DMU's revenue generation performance rating R_k by first computing its revenue generation performance rating with respect to the hth output category by

$$
R_{kh} = b_h \left[\max_{i=1,\dots,K} \left\{ v_{ih} \right\} - v_{kh} \right] / \min_{i=1,\dots,K} \left\{ v_{ih} \right\}, \; h = 1,\dots,H \quad (5)
$$

and then linearly scaling their sum by

$$
\begin{aligned}
R_k &= \sum_{h=1}^{H} R_{kh} - \min_{n=1,\dots,K} \left\{ \sum_{h=1}^{H} R_{nh} \right\} \\
&= \sum_{h=1}^{H} b_h \left[\max_i \left\{ v_{ih} \right\} - v_{kh} \right] / \min_i \left\{ v_{ih} \right\} \\
&- \min_n \left\{ \sum_{h=1}^{H} b_h \left[\max_i \left\{ v_{ih} \right\} - v_{nh} \right] / \min_i \left\{ v_{ih} \right\} \right\} \\
&(6)
\end{aligned}
$$

so that a value of zero is obtained for $\min_{i=1,\dots,K} \left\{ R_k \right\}$.

(c) Compute the kth DMU's overall operational performance rating by linearly scaling the weighted sum of C_k and R_k by

$$E_k = w_c C_k + w_r R_k - \min_{n=1,\ldots,K} \{ w_c C_n + w_r R_n \}$$

$$= w_c \sum_{m=1}^{M} a_m \left[u_{km} - \min_i \{u_{im}\} \right] / \min_i \{u_{im}\}$$

$$+ w_r \sum_{h=1}^{H} b_h \left[\max_i \{v_{ih}\} - v_{kh} \right] / \min_i \{v_{ih}\}$$

$$- \min_n \Big\{ w_c \sum_{m=1}^{M} a_m \left[u_{km} - \min_i \{u_{im}\} \right] / \min_i \{u_{im}\}$$

$$+ w_r \sum_{h=1}^{H} b_h \left[\max_i \{v_{ih}\} - v_{nh} \right] / \min_i \{v_{ih}\} \Big\} \quad (7)$$

so that a value of zero is obtained for $\min_{i=1,\ldots,K} \{E_k\}$. In Eq. (7), w_c and w_r are calibration constants reflecting the relative importance of the input and output categories.

OCRA's assessment criterion is such that the smaller the rating E_k , the better the kth DMU's relative operational performance. The DMU with the best operational performance receives an operational performance rating of zero.

The calibration constants

The calibration constants in the models of the previous section represent the relative importance of the input and output categories they are associated with. Operational performance ratings obtained using different calibration constant values would be comparable if they are normalized so that their sum is a constant. Thus, we make sure that

$$\sum_{m=1}^{M} a_m = \sum_{h=1}^{H} b_h = w_c + w_r = 1 \quad (8)$$

We use an intuitive procedure to obtain sensible initial values for the calibration constants. In our approach, an input category is assigned a calibration constant value that is in proportion to the costs incurred in that category. A revenue category is assigned a calibration constant value in a similar manner. Since the values of the calibration constants should reflect the relative importance of the various input and output categories, an input category whose costs are higher than those of another category is assigned a relatively larger cost calibration. This approach has some similarity to the entropy method of assigning weights to attributes in the context of multiple criteria decision making (MCDM) where an attribute with relatively large variation receives a larger weight. The procedure consists of the following steps:

(a) Define w_c and w_r as the average total cost and revenue shares, respectively, which are computed by

$$w_c = \sum_{k=1}^{K} \left[\sum_{m=1}^{M} u_{km} \Big/ \left(\sum_{m=1}^{M} u_{km} + \sum_{h=1}^{H} v_{kh}\right)\right] \Big/ K,$$

$$w_r = \sum_{k=1}^{K} \left[\sum_{h=1}^{H} v_{kh} \Big/ \left(\sum_{m=1}^{M} u_{km} + \sum_{h=1}^{H} v_{kh}\right)\right] \Big/ K$$

$$= 1 - w_c \qquad (9)$$

(b) Compute the calibration constants a_m and b_h by

$$a_m = \sum_{k=1}^{K} \left[u_{km} \Big/ \sum_{m=1}^{M} u_{km}\right] \Big/ K, \qquad m = 1,\ldots,M,$$

$$b_h = \sum_{k=1}^{K} \left[v_{kh} \Big/ \sum_{h=1}^{H} v_{kh}\right] \Big/ K, \qquad h = 1,\ldots,H$$

(10)

The first expression in Eq. (10) defines a_m as the average cost share of the *m*th cost category and the second expression defines b_h as the average revenue share of the *h*th revenue category. Eqs. (9) and (10) satisfy Eq. (8).

It should be noted that, partly due to the fact that the calibration constants in Eqs. (9) and (10) are scale dependent, the OCRA procedure as described in Eqs. (3) - (7) may have the rank reversal problem. Rank-reversal relates to the change of performance rank order of the DMUs when one or more DMUs are removed from the list and is, in fact, associated with many MCDM and performance measurement techniques. For example, the analytic hierarchy process (AHP), a popular MCDM method, has a serious rank reversal problem that has been the topic of many discussions. Even in IMD's simple additive weighting approach, since a standard deviation transformation is employed to convert the original data into a comparable scale for each criterion, there may be rank reversals when some of the nations are removed from or new ones are added to the competitiveness analysis. OCRA's rank reversal problem is less serious than AHP's. For example, for a given set of calibration constant values, the rank order of the DMUs' performance ratings obtained by the OCRA procedure in Eqs. (3) - (7) will remain unchanged if DMUs that do not contain the maximum and minimum cost/revenue values for all resource and revenue categories are removed. OCRA's rank reversal problem has a simple solution: introduce one positive and one negative benchmark DMU that outperforms every DMU and is outperformed by every DMU in all resource and revenue categories, respectively.

OCRA applications

Several applications have been published since the first publication in 1991 (*Parkan,* [1991]).

Among them we mention the measuring the service performance of a subway system. That study demonstrates the application of OCRA to gauge a company's service performance from customers' (passengers') perspective. The company in question operates one of the two subway lines in Hong Kong that has an average weekday ridership of 2.5 million. The company conducts a customer satisfaction survey in March and September of each year to monitor the passengers' perception of service performance. (*Parkan,* [1996a])

Next is the analysis of another managerial problem. This is a case study of a 100 room hotel that caters primarily to business travelers. The OCRA procedure is provided to obtain the hotel's operational competitiveness profile based on its observed performance over several months. (*Parkan,* [1996b])

The next application shows again the importance of managerial aspects during the utilization of the procedure. The Hong Kong branch of an international investment bank hired additional staff in anticipation of increased business activity that eventually did not quite materialize and management was concerned about the effect of that decision on the bank's overall performance profile. The paper summarizes a study carried out to address two related questions: (1) what is the direction of the overall performance trend and (2) how serious has the impact of the incremental costs of hiring additional staff been on the bank's overall performance? The discussion focuses on the construction of the bank's performance profile using OCRA performance measurement method. (*Parkan, C.,* and *Wu, Ming-Lu* [1999a])

Another example is the examination of the introduction effect of a POS system. A new electronic point of sale (POS) system was deployed by a Hong Kong drugstore-chain in eight of its drugstores as the first stage of a company-wide introduction of POS automation. The management wanted to know if the new system had a significant impact on the performances of the drugstores where the new POS system was deployed. (*Parkan,* [2003])

The relative operational performance of Hong Kong's manufacturing industries is measured and analyzed for the period from 1987 to 1993. The measurement technique used is the OCRA procedure. The comparison of the overall operational performance of Hong Kong's nine manufacturing industry groups is based on the OCRA computations of relative resource consumption and revenue generation performance. The implications of OCRA results in terms of industry performance trends are discussed and strategic issues are reviewed. (*Parkan, C.,* and *Wu, Ming-Lu* [1999b])

From our point of view the next applications seem to be very important. *Jayanthi, Sh., Kocha, B., Sinha, K. K.* [1999] present a model-based approach for competitive analysis of manufacturing plants. They propose the application of OCRA to measure the competitiveness of plants in terms of their relative inefficiency. The authors present a conceptual framework to classify and identify the drivers of plant competitiveness in terms of decisions related to plant structure and infrastructure. They demonstrate the application of this model-based approach to conduct competitive analysis of plants in the US processed food industry.

Tóth [2005] has also utilized the industry-level approach in his study. He has analyzed the performance of the Hungarian food industry based on OCRA and further on the effect of regionality on operational competitiveness of the meet industry's enterprises.

Conclusions

OCRA as analyzing tool has got some new features compared to the most accepted and used non-parametric evaluation procedure, the DEA. As a new approach it can be used especially in cases when data in FADN database are missing or we have to face to extremely low or high input/output values (the outlier problem). This sometimes happens, especially with the new member states, when the FADN system includes relatively low performing and small scale farms. These difficulties can be well treated with the help of OCRA.

After having calculated the appropriate performance measurements we can analyze the relationship between production cost structure and farm performance, as well as to analyze the efficiency (with special attention to the effect of economies of scale) and competitiveness of the crop and dairy sectors in the participant countries. It is also a possible outcome of OCRA analysis that we assess the differences between the economic performance of individual and corporate farms in the New Member States.

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