Evaluation and Ranking of the Financial Status of the Greek Rural Cooperatives Unions by a Decision Support System

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Abstract

The Rural Cooperatives Unions (RCUs) play a significant role in the development of the Greek rural sector, but they are facing significant organizing and administrative problems. The use of methods and techniques of the operational research by the RCUs may contribute significantly in making and supporting rational decisions.

A Decision Support System (DSS) was developed that can provide very important services in the direction of evaluating the existing RCUs and forecasting their future financial performance. The system uses multicriteria analysis based on actual financial data and applies fundamental principles of fuzzy logic in order to achieve the forecasting of the future performance of the eight RCUs that are located in the region of Eastern Macedonia and Thrace (in North-Eastern Greece).

Keywords: *Multicriteria Analysis, Rural Cooperatives Unions, Decision Support Systems, Fuzzy logic, Computer Program*

Introduction

Rural cooperatives (agricultural, forest, cattle, fishing) contribute substantially in the agricultural and economic development of Greece. They provide rural supplies (fertilizers, pesticides, seeds, forages), produce and manufacture rural products (agricultural, forest, cattle, fishing) and make arrangements of the rural faith, by allowing various types of loans (cultivating) to their members. (Kamenidis, 2001).

It is a fact that the Greek RCUs are facing great difficulties, trying to adjust their marketing system according to the additional demands caused by the liberalization and globalization of markets. Moreover, in an era that is characterized by a particular uncertainty for agricultural activities and business, the cooperatives are obligated to adopt new approaches in organizing and administrating their functions (Karipidis, 2002). Therefore Greek rural cooperatives should follow new strategic planning schemes towards an effective economic behaviour and increased productivity. This paper can be a first step towards the implementation of a more rational policy.

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The main research target of this paper is the presentation and analysis of the financial factors that affect the function of the RCUs by using techniques from the area of Multicriteria Decisions Aid Methods (MCDA). This is a complicated and time-consuming task that requires expertise, knowledge and high computational skills.

More specifically, this paper describes the design, implementation and testing of a Decision Support System (DSS) that validates and ranks RCUs of the Greek Region of Eastern Macedonia and Thrace, based on their financial profile. The system also utilizes basic concepts of fuzzy algebra in order to forecast their financial performance for the following year. In 1995, Klein and Methlie defined DSS as information systems that provide information concerning complicated and badly structured problems, offering access to databases and analytical decision models. Their aim is the support of the decision maker (Zopounidis, 2001).

The DSS uses multicriteria analysis in order to carry out the evaluation and the ranking of the eight RCUs. According to Roy and Vincke (1981), before the development of the multicriteria analysis methodology, the decision challenges were well defined as problems of optimization of a financial function. This classical approach leads to very well defined questions in terms of mathematics that have nothing to do with reality. The multicriteria analysis aims in the study of problems where many views have to be taken into consideration. There are four categories of multicriteria methods (Siskos, 1984):

- The Multicriteria Mathematical Programming
- The theory of Multicriteria Usefulness
- The theory of Relevance Superiority
- The Multicriteria Regression

The method of PROMETHEE II that is used here belongs to the theory of Relevance Superiority (Brans, 1982). The basic concepts that distinguish the PROMETHEE method from other methods of the same category (ELECTRE methods) are the following: a) the extension in the concept of criteria b) the estimated relation of superiority and c) the use of the relation of superiority. There are two PROMETHEE methods, the PROMETHEE I that performs a partial ranking of the alternatives (rural investments) and the PROMETHEE II that performs a complete ranking of the actions.

Materials and Methods

The DSS performs two main tasks, namely, the annual ranking of the RCUs based on actual financial data and the forecasting of their performance for the following year. The first task is carried out by the use of the PROMETHEE II methodology. The DSS output is a pure number that is called the net flow that indicates the financial status of each Rural Cooperatives Union (RCU). Actual financial data from 1993 to 2000 is used for each RCU and its net flow is calculated till the year 2000.

The forecasting task is performed by the production of a closed interval of values, namely, the Fuzzy Expected Interval (FEI), for each RCU. The value of the net flow for each RCU is expected to be included inside the FEI (or it will be very close to its boundaries) for the following year, thus DSS produces the FEI till the year 1999. The validity of the forecasting was estimated by comparing the actual net flows for the year 2000 to the expected values of flows for the year 2000.

The DSS utilises the basic financial ratios that express the Profitability and Management

Performance (PMP) of the RCUs (Table 1). These financial ratios summarize the management skills applied to the business units (Longobardo, 1996) and were assessed using the Financial Reports (Balance Sheets & Profits and Losses), of the eight RCUs from the region of Eastern Macedonia and Thrace for the last eight years (1993-2000). Moreover, these ratios eliminate the differences that are due to the size variation of the productive units under study (Kantzos, 1994).

Table 1. Financial ratios used for the determination of the initial input data

Financial ratios	Financial ratios	Weights
NE / S	Net Earnings / Sales	0.125
TC / TA	Total Current / Total Assets	0.125
CA / LA	Current Assets / Current Liabilities	0.125
(CA – R) / LC	(Current Assets - Reserves) / Current Liabilities	0.125
L (L+EC)	Liabilities long – term / (Liabilities long – term + Equity Capital	0.125
R * 360 / S	Reserves * 360 / Sales	0.125
R * 360 / S	Receivable * 360 / Sales	0.125
LC * 360 / C of S	Liabilities Current * 360 / Cost of Sales	0.125

Evaluation methodology

The PROMETHEE II methods that are applied by the DSS use six types of general tests that can determine the superiority between two alternatives. In this case the aim is the determination of the superiority of a RCU X_I over RCU X_j. The type of general level test criterion was used with the corresponding criterion function, for the determination of the superiority because it has an indifferent region (Brans and Vinke 1985). This type of general criterion is the most appropriate to be used in this case, due to the fact that it does not apply a strict choice. Only pairs of RCUs are tested in the form (v_i,v_j) i=1,2,.........8, in order to determine which one v_i or v_j is superior according to the financial ratios.

There are also other methodologies for the evaluation and ranking of rural business units. For example the Data Envelopment Analysis and the Stochastic Frontier Model methods have been applied in certain cases (Rhodes, 1986; Bravo-Ureta and Rieger 1991; Battese and Coelli 1992; Kumbhakar and Hjalmarsson 1993; Psyhoudakis and Dimitriadou 1999).

The function H(d) expresses the superiority in the following way:

$$H(d) = \begin{cases} P(v_i, v_j) \text{ expresses the superiority of RCU } v_i, \text{ if } d \leq 0 \\ P(v_j, v_i) \text{ expresses the superiority of RCU } v_j, \text{ if } d \leq 0 \end{cases}$$

Where $P(v_i, v_j)$, $P(v_j, v_i)$ are the functions of preference.

Function 1: Level criterion function that uses preference functions. The value of variable d is the difference between the financial ratios of each pair of RCUs (v_i, v_j) for the criterion under evaluation.

The function H (d) can take values according to the following formula (1):

$$H(d) = \begin{cases} 0 & \text{if } |d| \leq q \\ ½ & \text{if } q < |d| \leq p \\ 1 & \text{if } p < |d| \end{cases}$$

Formula (1) the level criterion function. It should be mentioned that p and q are parameters that usually have a fixed value.

When it is examined which of the two RCUs (v_i, v_j) is the superior one, the superiority function H(d) is applied according to the value of d (positive, or negative) for each criterion. The q and p parameters are partly estimated in this project and they do not have a fixed value. The estimation of p and q is performed in the following way. First of all the annual performances of the eight RCUs is calculated for each criterion. If there is a RCU with a very high value of performance that is clearly much higher than the performance of the other seven RCUs it is excluded for the criterion under testing. This is done in order to avoid problems that might be caused in the calculation of p and q. Afterwards, all of the differences d are calculated for each pair of RCUs that is examined for each criterion. If the preference function takes into account IdI (the absolute value of d), only the positive values of d are considered. Thereafter, the range E, between the maximum and the minimum values of d is calculated using formula (2).

$$E = d_{max} - d_{min}$$

Formula (2) Calculation of the range
Finally q, p are estimated using the following formulas (3) and (4).

$$q = d_{min} + \lambda * E$$

Formula (3) The calculation of p

$$p = d_{min} + \mu * E$$

Formula (4) The calculation of q

The coefficients λ and μ are considered to be the threshold values that will be used for the estimation of p and q, respectively. The parameters λ and μ can be assigned specific values depending on the type of the problem and on the degree of sensitivity of the superiority control. In this case, λ has been assigned the value of 0.2 and μ the value of 0.4. In this way the q, p were calculated for each criterion and for each year (Koutroumanidis et al. 2001). The multicriteria indicator of preference Π (v_i, v_j) which is a weighted mean of the preference functions Π (v_i, v_j) with weights defined by the researcher, expresses the superiority of the RCU v_i against RCU v_j after all the criteria are tested. The values of Π are calculated using the following formula (5) (Brans et al. 1986).

$$\Pi(v_i, v_j) = \frac{\sum_{t=1}^{k} w_w * Pt(v_i, v_j)}{\sum_{t=1}^{k} w_t}$$

Formula (5) Calculation of the multicriteria indicator.

It should be mentioned that k is defined to be the number of criteria (k=8) and P_t (v_i, v_j) the preference functions for the k criteria. The multicriteria preference indicator Π (v_i, v_j) takes values between 0 and 1. When two RCUs (v_i,v_j) are compared to each other, each one is assigned two values of flows, namely, the outgoing flow and the incoming flow. The outgoing flow is calculated that by the following formula (6) (Baourakis et al. 2001)

$$\varphi^+(v_i) = \Sigma\, \Pi\, (v_i, v_j) \text{ where } v_j \in A$$

Formula (6) Calculation of the outgoing flow.

In both cases, A is defined to be the number of the alternative solutions RCU v_j. (which in this case are seven). The outgoing flow expresses the total superiority of the RCU v_i against all the other RCUs v_j for all the criteria. The incoming flow is determined by the following formula (7) (Baourakis et al. 2001).

$$\varphi^-(v_i) = \Sigma\, \Pi\, (v_j, v_i) \text{ where } v_j \in A$$

Formula (7) Calculation of the incoming flow.

The incoming flow expresses the total superiority of all the other RCUs against RCU v_i for the criteria. The net flow v_i for each RCU is estimated by the difference between the outgoing and the incoming flow. $\varphi(v_i) = \varphi^+(v_i) - \varphi^-(v_i)$. The net flow is the number that is used for the comparison between the RCUs in order to obtain the final ranking.

Forecasting methodology

One of the main features of the DSS is the calculation of the FEI for each one of the RCUs. This means that it can produce a narrow characteristic interval of values (Zadeh, 1965).

In this way, the FEI can be used to forecast the future flow of each RCU. Thus, a classification of all RCUs of the country, according to their expected flow, can be achieved. It is important that the system manages to produce an interval that is as narrow as possible.

Practically, there is no interest in forecasting the exact number of the future flow, but rather in finding the general tendency and its direction. The main point is to know if the flow will increase from 1.200 to 1.900, or if it will drop to 0.600 and not to estimate the precise number concerning the past flows of the RCUs. This means that data can be grouped in an imprecise way (using various keywords) and thus, fuzzy logic can be applied. (Patridge and Hussain, 1995)

There are four types of sentences that can be used during classification of the data:

keywords	Lower Bound	Upper Bound
1st type almost	x-20%	x-1
2nd type more or less	x-20%	x+20%
3rd type over	x+1	x+20%
4rth type much more than	2x	∞

Fuzzy logic was introduced by Zadeh in 1965. All the theorems that are used in the following section were described by Kandel and Byatt (1978). After the classification, there are four steps that should be followed according to Kandel (1992). The first step is to input data from the imprecise classification, into the characteristic function C (X) and find all C' s (Kandel, 1992).

The characteristic function is the following:

$$C(X)=\begin{cases}0 & \text{if } \quad X\le 0\\ \dfrac{X}{100} & \text{if } \quad X\le 100\\ 1 & \text{otherwise}\end{cases}$$

The number 100 is used as the maximum number of flow that was ever calculated according to the data existing so far (it is the most extreme case according to the designers' judgment). This function is used for the forecasting of the total flow. The second step, Kandel (1992), is to find all μ's, which are the candidate Fuzzy Expected Intervals. The μ' s are intervals of the form [LB, UB] and they can be calculated from the following equations:

$$UB_j=\frac{\sum_{i=j}^{n} MAX(pi_1,pi_2)}{\sum_{i=j}^{n} MAX(pi_1,pi_2)+\sum_{i=1}^{j-1} MIN(pi_1,pi_2)}$$

Equation (1) This equation is used to find the upper bound of every interval μi.
Where pi_1 is the lowest bound of group i and pi_2 is the upper bound of group i.

$$LB_j=\frac{\sum_{i=j}^{n} MIN(pi_1,pi_2)}{\sum_{i=j}^{n} MIN(pi_1,pi_2)+\sum_{i=1}^{j-1} MAX(pi_1,pi_2)}$$

Equation (2) This equation is used to find the lower bound of every interval μ_i.

Where pi_1 is the lowest bound of group i and pi_2 is the upper bound of group i. The third task is to find the minimum interval of each line using theorems (1), (2) and (3) according to Kandel (1992). The theorems (1) to (6) are used to compare pairs of intervals of values and to determine which interval is larger and which is smaller.

Theorem 1:

$$MAX(S,R)=\begin{cases}R, & \text{if } \ r_1>s_n\\ S, & \text{if } \ s_1>r_m\end{cases}$$

where $S=\{s_1,\dots,s_n\}$, $R=\{r_1,\dots,r_m\}$ and $R\cap S=\varnothing$.

Theorem 2:

$$MIN(S,R)=\begin{cases}R, & \text{if } \ r_m<s_1\\ S, & \text{if } \ s_n<r_1\end{cases}$$

where $S=\{s_1,\dots,s_n\}$, $R=\{r_1,\dots,r_m\}$, $R\cap S=\varnothing$

Theorem 3:

$$MAX(S,R)=\begin{cases}R, & \text{if } r_m>s_n\\ S, & \text{if } s_n>r_m\end{cases}$$

where $S=\{s_1,\dots,s_n\}$, $R=\{r_1,\dots,r_m\}$ and $R\cap S\neq\varnothing$ and $S\not\subseteq R$ and $R\not\subseteq S$

Theorem 4:

$$MIN(S,R)=\begin{cases}R, & \text{if } r_m < s_n\\ S, & \text{if } s_n < r_m\end{cases}$$

where $S = \{s_1,\ldots,s_n\}$, $R = \{r_1,\ldots,r_m\}$ and $R \cap S \neq \varnothing$ and $S \not\subseteq R$ and $R \not\subseteq S$

Theorem 5:
In the case when $S = \{s_1,\ldots,s_n\}$, $R = \{r_1,\ldots,r_m\}$ and $R \subseteq S$,

$$MAX(S, R) = [r_1 \ldots\ldots s_n]$$

Theorem 6:
In the case when $S = \{s_1,\ldots,s_n\}$, $R = \{r_1,\ldots,r_m\}$ and $R \subseteq S$,

$$MIN(S, R) = [s_1 \ldots\ldots r_m]$$

The forth task is to find the maximum interval over the minima using the theorems (1), (3) and (5) according to Kandel (1992).

The maximum interval found is the Preliminary Fuzzy Expected Interval. The maximum number of flow (which in this case is 100) should be multiplied to the bounds of the preliminary fuzzy expected in order to produce the real fuzzy expected interval. This interval could indicate the expected situation for the specific RCU. It is obvious that the narrower this interval is, the more useful it is. To achieve a narrower interval, for example, [1.500-1.700] for the net flow of the following year, the classification of the groups of frequencies should be successful.

After the FEI is constructed for each RCU the intervals are compared to each other using the above equations and a classification of the RCU is performed according to their fuzzy expected intervals of flow.

Input Data

The actual data that were used as input to the DSS come from balance sheets of the RCUs for the period 1993 -2000. According to these balance sheets, the financial ratios were calculated. These financial ratios used for the determination of the initial input data are presented in table 1. The ratios express the efficiency and the performance of the management of the RCUs and they were used (in past research projects) for the evaluation of investments, using multicriteria analysis. (Evrard and Zisswiller, 1982). The weights assigned to the financial ratios have a sum equal to one:

$$w_i = 0.125 \quad i = 1,2, \ldots 8 \quad \text{with} \quad \sum_{i=1}^{8} w_i = 1 \quad \text{(Table 1).}$$

Architecture of the DSS

Description of the inference engine

The DSS is rule-based and it consists of facts, rules and object-frames. It has a main rule set and local rule sets within the object frames (Jackson, 1992). The inference engine strategy is backward chaining with opportunistic forward. This means that it is goal driven, and it uses forward chaining only for the phase of data gathering in order to make it faster. It starts from the goal and it evaluates only the necessary rules in order to reach the final conclusion (Leonardo User Guide, 1992). Knowledge about real world objects is stored in the object frames that contain various types of slots. Each slot describes the properties and the characteristics of the associated object (Jackson, 1993).

Results

Initially, the DSS performed the calculation of the net flows of the eight RCUs of Eastern Macedonia - Thrace for the period 1993-2000. Then, all RCUs were ranked in proportion to their annual net flows and for the entire period of 1993-2000. The calculated flows are shown in Table 2.
The annual and average ranking of each RCU for the total period 1993-2000 is shown in the following Table 3.

Table 2. Selective presentation of the net annual flows of the eight RCUs

PNet Annual Flows									
	RCUs	‘93	‘94	‘95	‘96	‘97	‘98	‘99	2000
Φ(K)	Kavala	**0.875**	**2.875**	-0.375	0.375	-0.25	0.125	-0.125	**1.375**
Φ(P)	Paggaio	-0.125	-1.88	0.125	0.0625	**0.875**	-0.25	0.375	-0.375
Φ(D)	Drama	-0.125	0.500	-0.125	**1.375**	0.1875	0	**2.125**	**1.375**
Φ(X)	Xanthi	-0.125	-1.38	0.25	-1.63	-0.0625	-1.88	0.375	1.125
Φ(E)	Evrou	-0.125	-1.63	**0.75**	-1.19	-0.26	-0.875	-1.63	-0.375
Φ(Did)	Didimoticho	-0.125	0.625	0.625	1.25	0.1875	**1.875**	0.375	1.125
Φ(O)	Orestiada	-0.125	0.125	-1.88	-0.0625	-0.125	0.375	1.125	0
Φ(R)	Rodopi	-0.13	0.75	0.625	-0.1875	-0.25	0.625	-2.63	-0.375

Table 3. Annual position for each one of the RCUs in the rankings of the period 1993 – 2000 and the average position of each RCU in the same rankings

RCUs	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Average ranking for the period 1993-2000**
Kavala	1	1	7	3	6	4	6	1	3rd
Paggaio	2	8	5	4	1	6	3	5	4th
Drama	3	4	6	1	2	5	1	2	1st
Xanthi	4	6	4	8	4	8	4	3	6th
Evros	5	7	1	7	8	7	7	6	8th
Didimoticho	6	3	2	2	3	1	5	4	2nd
Orestiada	7	5	8	5	5	3	2	-	5th
Rodopi	8	2	3	6	7	2	8	7	7th

The initial knowledge base included financial data of RCUs from 1993 to 1999. The DSS was tested to forecast the fuzzy expected interval of the net flow, for each RCU for the year 2000. Finally the forecasted intervals for the year 2000 were compared to the actual values of net flows for 2000 and to the average values of flows from 1993 to 2000. The results produced are described in Tables 4 and 5.

Table 4. Comparison of the fuzzy expected intervals of flows to the actual flows and to the average flows

RCUs	Actual values of flows for the year 2000	Forecasted FEI of flows for the year 2000	Average flow 1993-1999
Kavala	1.375	0.9 – 0.999	0.5
Paggaio	-0.375	0.4 – 0.5	0.116
Drama	1.375	0.6 – 0.625	0.56
Xanthi	1.125	0.32 – 0.35	-0.63
Evros	-0.375	0.10 – 0.11	-0.708
Didimoticho	1.125	0.625 – 0.625	0.600
Orestiada	0	0.11 – 0.12	-0.241
Rodopi	-0.375	0.625 – 0.625	-0.171

Table 5. Comparison of actual ranking to the two forecasted rankings for the year 2000

Actual classification for year 2000	Forecasted classification based on average values of flows	Forecasted classification based on FEI
Kavala	Didimoticho	Kavala
Drama	Drama	Didimoticho
Didimoticho	Kavala	Rodopi
Xanthi	Paggaio	Drama
Paggaio	Rodopi	Paggaio
Rodopi	Orestiada	Xanthi
Evros	Xanthi	Evros
Orestiada	Evros	Orestiada

Discussion

The evaluation and ranking process has revealed that the RCUs of Drama, Kavala and Didimoticho have much better performance than the rest. The RCU of Drama has qualified first in three cases, in 1996 in 1999 and in 2000 with high values of net flows. It should be mentioned that it has a very high performance that equal 2.125 in 1999. Considering the average ranking for the period 1993 to 2000 the RCU of Drama is ranked in the first position. The RCU of Drama had only two bad years in 1993 and 1995 with negative net flows, but it has improved its performance since then. The RCU of Didimoticho has the second best average performance from 1993 to 2000 and it has a very high net flow for 1999 that is equal to 1.875. It also has high net flows for 1996 and for 2000. Except for 1993, it has positive flows for all the other years. Finally, the RCU of Kavala has high net flows for 1993 and 1994, but for the following years it has very bad performances with negative results. Things seem to improve for 2000 where its average performance is ranked in the third place.

All of the other RCUs have very bad annual net flows, either negative or very close to zero. They surely have to improve the way they operate.

The forecasting process has proven to operate quite satisfactory. It is clearly shown in table 4, that in 7 out of 8 cases the FEIs are closer to the actual flows than the average values and only in one case the average is closer. All of the actual flows are included inside the close interval [Max(FEI)-1, Max(FEI)+1] which is [0.375, 1625]. This means that the threshold value for the acceptable error is 1. This error is much higher if the average flow is used.

Table 5 clearly shows that the forecasted ranking of the RCUs for the year 2000 is correct in 4 out of 8 cases and at the same time the other four RCUs that were not ranked in their correct position, have a very small difference from their actual ranking position for the year 2000. This means that the forecasted ranking is correct in 50% of the cases when FEI are used. This is a very satisfying percentage if we take into account that unpredictable factors are involved every year, like investments or damages in the rural production. These factors cause a huge variance in the values of the net flows. On the other hand, by using the average value of the net flows of the RCUs from 1993 – 2000, only in 1 case out of eight the ranking is correct. This means that only in 12% of the cases the ranking is correct if the average values of the net flows are used. Finally the classification (that uses the average position of each RCU in the rankings from 1993 to 2000) provides zero correct rankings.

The DSS will be used and tested again with future data. This means that the task of the evaluation of RCUs will continue and the system's credibility will also be evaluated.

Conclusions

The DSS could play a very important role not only in evaluating each RCU separately, but ranking many of them as well. With its application it can evaluate the RCUs from many different aspects and provide useful information for the decision making process. This is a very difficult task for humans due to the heavy amount of calculations required and due to the cognition and storage problems of the human brain. All classical methods of financial ranking and evaluation use a vast amount of data and thus, are time consuming and perform a long series of calculations bringing the human capabilities of reasoning and inferring to their limits.

Alternatively, in the testing phase, the system has been proven very effective tool. This is a very important attitude because of its excellent human machine interaction and its fine and operational explanation facility. The explanation mechanism of the DSS justifies the final outcome and in this way the end-user feels confident that the obtained result is accurate. This is really important for the system to gain acceptance in the business and scientific community. Something really important is that the system could be applied not only in the cooperatives, but also in other sectors of rural sector. Managers should realize that we are moving towards an information and strongly competitive economic society (e.g. globalization) where the appropriate software tools could be very important for effective decision-making.

Obviously the DSS is one of the major keys that RCUs should use in the scheduling of a more rational and effective management policy. What adds more value to the system is that it produces results faster and more reliably than the classical methods used by human experts. Another important matter is that human experts are very costly, difficult to find, very slow and error prone. The system eliminates all of these problems and limitations and it starts a new era for the management of cooperatives and farms.

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