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Evaluation and Forecasting of the Financial Performance of the Unions of Rural Cooperatives by a Decision Support System

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The evaluation and forecasting of the performance of the Unions of Rural Cooperatives (URC) can be performed through the use of various types of financial ratios, such as ratios of efficiency, reliability and management. A computer decision support system (DSS) was designed and implemented for this purpose. The system evaluates and ranks the URC by applying principles of multicriteria analysis. Assigning various weights to the financial ratios enacts different scenarios. Actually each scenario calls for a different type of evaluation. The types of evaluation are determined by a variety of performance indicators. Actual financial data concerning the URC of north Greece for the last ten years was used as input to the DSS. The DSS applies fuzzy logic in order to forecast the future performance of each URC. The application of the system with original financial URC data and the use of a fuzzy forecasting method constitute the original contribution of the paper. The paper can be used in any country of the world without any revisions.

Key words : decision support system, fuzzy logic, multicriteria analysis, Union of Rural Cooperatives, financial scenarios, evaluation, forecasting.

1. Introduction

The Greek rural cooperatives provide rural supplies (fertilizers, pesticides, seeds, forages) and also produce and manufacture products used in the field of agriculture, forestry, animal production and fishing. They are also involved in arrangements of a financial nature, such as forwarding various types of loans (for crops) to their members. Finally, they are active in the trade of rural products in Greece and abroad [2], [12].

It is a fact that the financial assessment of rural cooperatives based on efficiency ; reliability and management performance ratios should be performed regularly. The problems that arise should be faced and new policies should be designed. The estimation of the future performance of the URC is also crucial for the design of short-term future policy. The system that was developed to perform this important task is called *URCEFDESSYS* (Unions of Rural Cooperatives Evaluation and Forecasting Decision Support System) and it should be of international interest in the global society of agribusiness managers. It can be used (as it is) on a global scale after the manual recording of the financial ratios of the URC. The paper is an original contribution because it applies actual financial ratios of eight Greek URCs located in the region of Eastern Macedonia and Thrace and because it forecasts their future performance using fuzzy algebra. It is the first time such tasks have been performed for this area and the most important aspect is that the system can be applied to any other area without any restriction. It should be clarified that the forecasting is based on the financial perfor-

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mance history of the URC.

1) Potential users of the system

The *URCEFDESSYS* is a useful supporting tool for a manager of a URC. It can provide invaluable aid towards competitiveness assurance in the agrifood sector. The managers can consider the ranking and the forecasting outcomes of the *URCEFDESSYS* in order to come to decisions about the reorganization and restructuring of the URC. This should aim at the achievement of the following strategic targets : a) capital sufficiency (at low cost), b) application of a reliable, easy-to-use DSS. The *URCEFDESSYS* gains the user's confidence by its fine explanation facility. After a consultation the DSS explains how it came to the specific conclusions. This helps the manager understand the inference mechanism of the software and gradually his confidence in the consultations grows. c) powerful management. The Ministry of Agriculture, or other state operators, or rural credit unions-organizations (investors) can also use the *URCEFDESSYS* in order to obtain a clear view of the current and future financial status of the URC. Various types of views can be considered by enacting different scenarios, changing the assigned weights. This would be useful for the investors in order to make successful plans of investment in the infrastructure, planning, staff-educational programs of the Greek URCs.

2) Characteristics and products of the evaluated URCs

The eight URCs are located in the region of Eastern Macedonia and Thrace. In this area people are mainly employed in rural activities. Almost 33.3% of the total population works in the rural sector. The contribution of this area to the GDP is more than 20 %. The main agricultural products in the area of the eight URC are cotton, cereals, corn, vineyards, and tobacco. The role of animal production is supplementary in the employment of the rural population and in the increase of their income. The region of Eastern Macedonia and Thrace also has a large forest cover and significant quantities of wood are produced annually.

Many unions of rural cooperatives are concentrated in this area. It is a fact that they are rather small (compared to the European standards) and furthermore they consist of a small number of members. Their small size does not allow the implementation of scale-economies and certainly it does not permit the application of costly competitive strategies, like the differentiation of products, advertisement or implementation of suitable distribution networks.

3) Activities of the eight URCs

It is a fact that too many credit unions are represented in the eight URCs. This means that the URCs restrict their circle of activities exclusively to the matter of cultivation-loans of the Agricultural Bank of Greece to the farmers. Both the interference of the eight URCs in the productive activity of the rural sector and their export activity are rather small.

The eight considered URCs have more or less common activities, which mainly concern the concentration and trade of corn, grain and other rural supplies (fertilizers, pesticides, seeds, agricultural machinery and equipment and tools).

2. Architecture of the *URCEFDESSYS*

The *URCEFDESSYS* was developed under the Leonardo Expert System Shell (distributed by Bezant Ltd. UK). The shell was used for three main reasons : a) It structures knowledge in the form of facts, rules and object-frames. Real, text, list, function, screen and class objects are supported in the knowledge base of a Leonardo system. The fact that class objects are supported makes the *URCEFDESSYS* partly object oriented. b) It can execute the DSS using forward chaining, backward chaining or a combination of both methods. c) It offers an excellent explanation facility. This means that the user can ask the DSS to verify its reasoning by explaining how it came to the decisions. In this way the DSS gains the user's confidence. d) It offers a friendly user interface.

The multicriteria analysis operations and the fuzzy logic methods are coded into function-objects which are called to execute from the main rule-set. The main parts of the DSS are the knowledge base and its inference engine. The knowledge base contains all of the elicited knowledge (in the form described above) and the inference engine is the mechanism that leads the system to its final goal. It is really important that the system applies

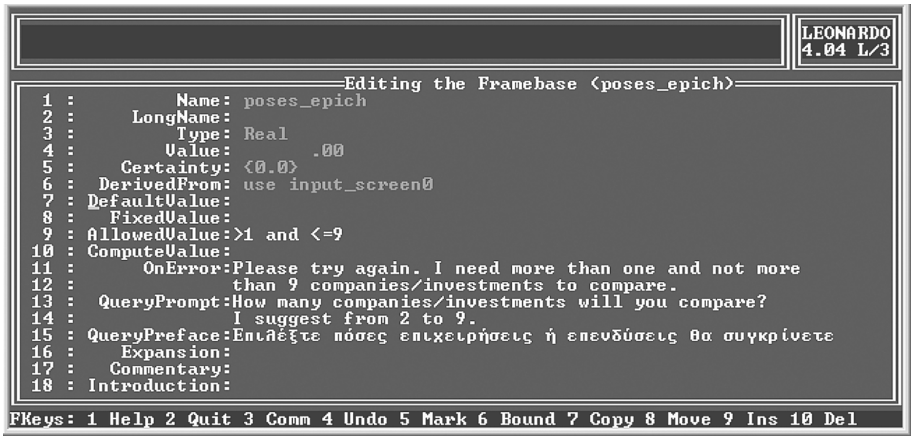

Figure 1. The frame of the object "number_of_URCs" with slots appearing to the left

a specific strategy in order to reach the goal, firing only the rules that are logically necessary. This will lead to the reduction of the runtime and to the outcome of reliable results.

1) Inference engine of the *URCEFDESSYS*

The most important part of any decision support system is the inference engine, the mechanism that leads to the desired objective [1]. The inference engine strategy that was applied was backward chaining with opportunistic forward, which means that it was designed to be a goal-driven decision support system, which used forward chaining only during the phase of data gathering for obtaining quicker results. Its reasoning is backward and it begins from the goal and only evaluates the rules necessary in reaching the final conclusion [16].

The "seek" directive sets up the goal of the rules in the main rule-set and the "ask" directive makes the DSS ask for the values of specific objects. The value of other objects has to be calculated by the program. These objects have their property Query_Prompt set to "never". An example of a rule in the main rule set follows :

Seek transaction
If data is gathered
and calculations are done
and decision is done
and results are displayed
then transaction is done

2) The knowledge base of the *URCEFDESSYS*

Knowledge is more than data. Knowledge is data plus information necessary to make inferences and reach conclusions necessary for decision making and problem solving. Once knowledge is organised and represented in a structure that can be recognised by a programming language it can be used to yield opinions often as good or better than those of a human expert [18]. The knowledge is packed in object frames, facts and rules. A text file is also used to store all the user-input data. In this way the user does not have to input data again, in the case that a new scenario is performed. The *URCEFDESSYS* was designed to be rule-based. It was designed and constructed so as to have a main rule set and local rule sets within the object-frames determining the corresponding object's value [10]. The main rule set starts with the (Leonardo) reserved word "seek". The "seek goal" command tells the system that its only target is to find a value for the object "goal". Then the system starts firing consequent rules in order to find a rule (or a combination of rules) that will give the object "goal" a value. The system either infers the values of objects or it queries the user executing "ask" commands.

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 [11]. Figure 1 presents the structure of an object-frame.

3) Systems requirements

The system runs on Win95, Win98, Win 2000, and WinXP operating systems on a Pentium Ⅲ and above PC. It is not portable to a Unix or a Mac system. It is directly executable by double clicking on its icon and it does not have special RAM memory or Hard disk Requirements.

4) The *URCEFDESSYS* user guide

The user guide of the DSS can be downloaded from the site of the Department of Forestry and Environmental Management and Natural Resources, at the following address : http://www.fmenr.duth.gr/ It is a pdf file that describes the installation and operation of the *URCEFDESSYS*.

3. Methodology Applied for the Evaluation of the URC

The decision support system was developed to use multicriteria analysis PROMETHEE methodology, which is a part of the theory of relevance superiority [4]. The above approach was applied in order to perform the evaluation and ranking tasks, for the following reasons : a) In the general form of the PROMETHEE methodology the estimated relation of superiority (of one investment over another) is less sensitive in small changes which offers an easier analysis and discussion of the results [20]. b) The use of the superiority relation in the PROMETHEE method is applied when the alternative solutions (investments) have to be ranked from the best to the worst [20]. c) The procedure of assessing and ranking complicated cases of investments is proper for the application of the above methodology in the sense that it is closer to reality [20].

Actually, there exist two types of the PROMETHEE methodology, the PROMETHEE I, that partially ranks the URC based only on some of the considered financial ratios, and the PROMETHEE Ⅱ, which performs a full and complete ranking of the URC based on all of the input financial ratios. The PROMETHEE Ⅱ methodology was applied in this project because an overall ranking was required.

The PROMETHEE methodology fits better to the targets of the project even if it is compared to other well-established methods. For example the ELECTRE methods are methods of superiority that use the rule of majority inside a relation of superiority. The target in the ELECTRE is to determine an alternative (URC), which is relatively “good”, based on a majority of criteria without been too “bad” according to the rest of the criteria. However this is not the target of this project. The aim here is the overall and the weighted evaluation of the URC. The AHP method is also well-known and widely used. An important reason for not applying the AHP methodology is the fact that we had to deal with problems of a purely financial nature. In this project there was no need to deal with complex socioeconomic problems. According to Alphonce [3] the ability of the AHP to analyze different decision factors without the need for a common numerate, other than the decision maker’s assessments, makes it one of the favorable multicriteria decision support tools when dealing with complex socioeconomic problems in developing countries.

According to the PROMETHEE method, six types of general tests were used with the corresponding tests’ functions to determine the superiority between two alternative solutions. In this case the aim was the determination of the superiority of one, URC X_i, over another, URC X_j. The general level test criterion was selected for use in this project, corresponding to a criterion function that has an indifferent region for the determination of superiority [5]. This type of general criterion is the most appropriate in this case, due to the fact that it does not apply a strict choice. Only pairs of URC were tested using the form (V_i, V_j) $i=1, 2, \ldots\ldots 8$, in order to determine which one, V_i or V_j, was superior according to the financial ratios. The function $H(d)$ used to express superiority, is the following :

$$H(d)=\begin{cases} P(V_i, V_j)\ \text{superiority of URC } V_i, \text{ if } d \geq 0 \\ P(V_j, V_i)\ \text{superiority of URC } V_j, \text{ if } d \leq 0 \end{cases}$$

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 URC (V_i, V_j) for the criterion under evaluation.

The function 1 $H(d)$ can be assigned values according to the following formula :

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

Function 2 : The level criterion function

It should be mentioned that p and q are parameters that usually have a fixed value.

When we examine which of the two URCs (V_i, V_j) is superior, the superiority function $H(d)$ is applied according to the price of d (positive or negative) for each criterion. The q and p parameters are only partly calculated in this project and do not have a fixed value. The calculation of p and q is performed in the following way : First of all, the annual performances of the eight URCs are calculated for each criterion. If a URCs exists with a performance value that is clearly much higher than the performance of the other seven URCs, then it is excluded from the criterion under examination. This is done in order to avoid problems that might arise in relation to the calculation of p and q. Then, all the d differences are calculated for each pair of URCs that is examined for each criterion. If the preference function takes into consideration the $|d|$ (the absolute value of d) then only the positive values of d are considered.

For the next step, the range E between the maximum and minimum values of d is calculated using formula 1.

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

Formula 1. Calculation of the range

Finally, the q and p are calculated using formulas 2 and 3 below.

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

Formula 2. Calculation of the parameter *q*

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

Formula 3. Calculation of the parameter *p*

The coefficients λ and μ are considered to be threshold values used for the calculation of p and q respectively. The parameters λ and μ can be assigned specific values, depending on the type of problem and on the degree of sensitivity of the superiority control. In this case, λ has been assigned the fixed value 0.2 and μ the fixed value 0.4. This assignment has been done by the human experts (Financial Managers) that were consulted and interviewed in the design phase of the system. In this way, the q and p were calculated for each criterion and for each year [15].

The multicriteria indicator of preference Π (V_i, V_j) which is a weighted average of the preference functions $\Pi(V_i, V_j)$ with weights defined by the researcher, expresses the superiority of the URC V_i over URC V_j after all the criteria have been tested. The values of Π are calculated using formula 4 below [6].

$$\Pi(V_i, V_j) = \frac{\sum_{t=1}^{k} W_t * P_t(V_i, V_j)}{\sum_{t=1}^{k} W_t}$$

Formula 4. 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 $\Pi(V_i, V_j)$ takes values between 0 and 1. When two URCs (V_i, V_j) are compared, each one is assigned two values, the outgoing flow and the incoming flow. The outgoing flow is calculated according to formula 5 below [7].

$$\Phi^{+}(V_i) = \sum_{V_j \in A} \Pi(V_i, V_j)$$

Formula 5. Calculation of the outgoing flow

In both cases, A is defined as the set containing all remaining URC V_j (seven in this case). The outgoing flow expresses the total superiority of the URC V_i over all other URC V_j for all of the criteria. The incoming flow is determined by the following formula 6 : [7].

$$\Phi^{-}(V_i) = \sum_{V_j \in A} \Pi(V_i, V_j)$$

Formula 6. Calculation of the incoming flow

The incoming flow expresses the total superiority of all other URCs over URC V_i for the criteria. The net flow for each URC V_i is estimated by the following formula 7 :

$$\Phi(V_i) = \Phi^{+}(V_i) - \Phi^{-}(V_i)$$

Formula 7. Calculation of the net flow

The net flow is the figure that is used to compare URCs in order to obtain the final ranking. Each URC with a higher net flow is considered to be superior in the final ranking.

The superiority of URC V_i over URC V_j can be expressed in the following way :

Table 1. List of evaluated URCs

Name of URC	Number of staffs in 2000	Number of Rural Cooperatives members (Agricultural and Forest)	Sales in Euro	Total assets in Euro
Orestiada	87	43	18, 052, 033	32, 161, 581
Didimoteicho	46	39	8, 625, 409	8, 068, 110
Evros	102	86	5, 125, 608	8, 192, 751
Rodopi	230	91	43, 155, 660	39, 153, 299
Xanthi	72	80	8, 268, 388	28, 418, 159
Kavala	90	48	17, 365, 534	26, 093, 686
Pangaio	37	38	3, 911, 041	19, 514, 742
Drama	55	126	12, 538, 941	21, 114, 618

Table 2. Financial ratios used for the determination of the initial input data

Index	Formula	Linguistic formula	Category
D1	NE/S	Net earnings/Sales	Efficiency
D2	TC/TA	Total current/Total assets	Reliability
D3	CA/CL	Curent assets/Curent liabilities	Reliability
D4	(CA−R)/CL	(Curent assets-reserves)/Curent liabiities	Reliability
D5	L(L+EC)	Long-term liabilities/(Long-term liabiities+Equity capital)	Reliability
D6	R*360/S	Reserves*360/Sales	Management
D7	R*360/S	Receivables*360/Sales	Management
D8	CL*360/C of S	Current liabilities*360/Cost of sales	Management

Table 3. Weights assigned to the ratios in each scenario

Scenario	Weights							
	D1	D2	D3	D4	D5	D6	D7	D8
Scenario 1	0. 125	0. 125	0. 125	0. 125	0. 125	0. 125	0. 125	0. 125
Scenario 2	0. 116	0. 116	0. 116	0. 116	0. 116	0. 140	0. 140	0. 140
Scenario 3	0. 140	0. 123	0. 123	0. 123	0. 123	0. 123	0. 123	0. 122
Scenario 4	0. 110	0. 140	0. 140	0. 140	0. 140	0. 110	0. 110	0. 110

V_iPV_j(V_i is superior to V_j) or $V_i \rightarrow V_j$ when $\Phi(V_i) \succ \Phi(V_j)$

When $\Phi(V_i) = \Phi(V_j)$ the superiority relation is written as follows : V_iIV_j(this means that the relation between V_i and V_j is neutral).

4. Testing the System for the URC of Northern Greec

The system can be applied in every country of the world without any changes or limitations. Actual financial data concerning the URCs of northern Greece was available and the system was tested for them.

The first Greek Rural Cooperative was established in 1780 in the region of Ambelakia of Thessaly and is considered to be one of the first Rural Cooperatives in the world. The first act concerning the establishment, organization and function of Rural cooperatives was introduced in 1915 (Act 602/1915). Since then, several others acts have followed (Act 921/1979, Act 1541/1985, Act 1667/1986, Act 2169/1993 and Act 2810/2000) [12].

The eight secondary cooperative organizations (Unions of Rural Cooperatives), which were evaluated by the DSS, are located in the eastern Macedonia—Thrace region of northern Greece and can be seen in Table 1. The data used as input for the decision support system came from URC balance sheets for the period 1993‐2000. As regards the balance sheets, eight financial ratios were calculated. These financial ratios have already been used (in past research projects) for the evaluation of investments [8] and are divided into the following three main categories : a) efficiency ratios, b) reliability ratios and c) management performance ratios. All of the scenarios use the same ratios and are acted out when we assign different weights to the ratios in question.

The sum of the weights equals 1. $\sum_{i=1}^{8} W_i=1$ $i=1, 2, \ldots\ldots 8$. The eight ratios that were used in all of the scenarios and their respective categories can be seen in Table 2.

The weights that were assigned to the ratios in each scenario can be seen in Table 3.

In the first scenario, all of the weights are equal to 0.125. This means that the evaluation of the URCs is based equally on efficiency, reliability and management performance. It is obvious that in this case the URCs are evaluated according to their average performance in all three categories.

In the second scenario a weight of 0.116 is assigned to all of the efficiency and reliability ratios and a higher value of 0.140 to the management ratios. It is obvious that, in this case, the evaluation of the URCs is mainly performed according to their management performance. The ratios in Table 3 highlight that the third scenario is mainly based on efficiency performance and the fourth scenario mainly depends on the reliability performance of the URCs.

5. Discussion on the Results

The rural cooperatives constitute a "financial system with social targets". It is a fact that "satisfaction" of members and member-cooperatives is the most important in their activities. There are two kinds of URC member's satisfaction. The first asks for high net earnings with competitive prices and the second asks for a supply of goods and services at low margins and low prices. However the competitive situation in the market of rural-products imposes the application of development strategies similar to the ones used by companies of the private sector. It is obvious that a compromise should be made between the two opposite views. The URC should not only sell in reasonable prices to their members but they also have to survive in a competitive market. From this point of view the financial and management situation of the URC is really important for their members and for the government. This means that the evaluation, ranking and forecasting of the ***URCEFDESSYS*** interests members of both sides. During the first stage, the computer system performed a calculation of the net flows of the eight URCs belonging to the Eastern Macedonia—Thrace region. The calculation of the net flows was performed according to the financial ratios that were mentioned in Table 2 for the period 1993-2000.

After that, all of the URCs were ranked according to their annual net flows for the entire period 1993-2000. The net annual flows of all eight URCs according to the first scenario are presented in Table 4.

1) The first position approach

A first attempt towards evaluating the performance of the URCs took into account the frequency of first position from 1993 to 2000. According to this approach, the above-mentioned results of the first scenario show that the URCs of Kavala and Drama (which are located in capitals of prefectures) have the best overall performance. It is a fact that the URCs of Kavala and Drama have qualified first in five out of eight cases. The URCs of Evros, Pangaio and Didimoteicho have been ranked in the first position only once (in 1995, 1997 and 1998 respectively).

The annual rankings of each URC for the

Table 4. Annual evaluation of the URCs according to the first scenario (overall performance)

First scenario URC	Flow1993	Flow1994	Flow1995	Flow1996	Flow1997	Flow1998	Flow1999	Flow2000
Kavala	**0.875**	**2.875**	−0.375	0.375	−0.250	0.125	−0.125	**1.375**
Pangaio	−0.125	−1.880	0.125	0.063	**0.875**	−0.250	0.375	−0.375
Drama	−0.125	0.500	−0.125	**1.375**	0.188	0	**2.125**	1.375
Xanthi	−0.125	−1.380	0.250	−1.630	−0.063	−1.880	0.375	1.125
Evros	−0.125	−1.630	**0.750**	−1.190	−0.260	−0.875	−1.630	−0.375
Didimoteicho	−0.125	0.625	0.625	1.250	0.188	**1.875**	0.375	1.125
Orestiada	−0.125	0.125	−1.880	−0.063	−0.125	0.375	1.125	0
Rodopi	−0.130	0.750	0.625	−0.188	−0.250	0.625	−2.630	−0.375

Table 5. Annual position of each URC for the period 1993-2000 according to the first scenario (overall performance)

URC	1993	1994	1995	1996	1997	1998	1999	2000
Kavala	**1**	**1**	7	3	6	4	6	**1**
Pangaio	2	8	5	4	**1**	6	3	5
Drama	3	4	6	**1**	2	5	**1**	2
Xanthi	4	6	4	8	4	8	4	3
Evros	5	7	**1**	7	8	7	7	6
Didimoteicho	6	3	2	2	3	**1**	5	4
Orestiada	7	5	8	5	5	3	2	—
Rodopi	8	2	3	6	7	2	8	7

Table 6. Annual evaluation of the URCs according to the second scenario (management performance)

Scenario 2 URC	Flow1993	Flow1994	Flow1995	Flow1996	Flow1997	Flow1998	Flow1999	Flow2000
Didimoteicho	−0.140	0.556	0.652	1.280	0.210	**1.812**	0.324	0.370
Drama	−0.140	0.632	−0.188	**1.444**	0.210	−0.120	**2.092**	**0.700**
Evros	−0.140	−1.630	0.528	−1.260	−0.630	−0.748	−1.630	−0.650
Kavala	**0.980**	**2.692**	−0.468	0.276	−0.280	0.044	−0.188	0.650
Orestiada	−0.140	0.236	−1.760	0.002	−0.140	0.236	1.116	−0.550
Pangaio	−0.140	−1.910	0.236	0.094	**0.982**	−0.640	0.516	−1.070
Rodopi	−0.140	0.768	**0.748**	−0.282	−0.280	0.556	−2.600	0.560
Xanthi	−0.140	−1.350	0.256	−1.560	−0.070	−1.720	0.372	—

total period 1993-2000 are shown in Table 5.

The net annual flows of all eight URCs according the second scenario are presented in Table 6.

Using the same approach, the results of the second scenario have also shown that the URCs of Kavala and Drama (capitals of prefectures) have qualified first in five out

Table 7. Annual evaluation of the URCs according to the third scenario (efficiency performance)

Scenario 3 URC	Flow1993	Flow1994	Flow1995	Flow1996	Flow1997	Flow1998	Flow1999	Flow2000
Didimoteicho	−0.122	0.531	0.493	1.199	0.183	−0.287	0.344	0.564
Drama	−0.122	0.502	−0.171	**1.355**	0.183	**1.893**	−0.047	0.704
Evros	−0.122	−1.713	**0.728**	−1.170	−0.549	−0.029	−0.561	−1.054
Kavala	**0.854**	**2.913**	−0.313	0.415	−0.244	−0.523	−0.059	0.774
Orestiada	−0.122	0.101	−1.929	−0.107	−0.122	0.143	**0.760**	−0.846
Pangaio	−0.122	−1.889	0.135	0.086	**0.854**	−0.001	0.651	−0.978
Rodopi	−0.122	0.786	0.693	−0.121	−0.244	0.735	−1.698	**0.836**
Xanthi	−0.122	−1.231	0.364	−1.657	−0.061	−1.931	0.609	—

Table 8. Annual evaluation of the URCs according to the fourth scenario (reliability performance)

Scenario 4 URC	Flow1993	Flow1994	Flow1995	Flow1996	Flow1997	Flow1998	Flow1999	Flow2000
Kavala	**0.770**	**3.040**	**3.040**	0.435	−0.220	0.200	0.160	0.840
Pangaio	−0.110	−1.800	−1.800	−0.020	**0.770**	−0.430	0.060	−0.840
Drama	−0.110	0.320	0.320	**1.315**	0.165	0.210	**2.200**	**0.900**
Xanthi	−0.110	−1.660	−1.660	−1.655	−0.055	−1.980	0.180	0.260
Evros	−0.110	−1.460	−1.460	−1.120	−0.495	−0.860	−1.360	−0.780
Didimoteicho	−0.110	0.880	0.880	1.295	0.165	**2.140**	0.600	0.560
Orestiada	−0.110	0.020	0.020	−0.070	−0.110	0.200	0.800	0
Rodopi	−0.110	0.660	0.660	−0.180	−0.220	0.520	−2.640	−0.940

Table 9. Total net flows of the three best URCs

URC	Total flows 1st scenario	Total flows 2nd scenario	Total flows 3rd scenario	Total flows 4th scenario
Didimoteicho	**5.938**	**5.064**	**5.085**	6.410
Drama	4.075	4.630	2.375	5.320
Kavala	4.875	3.706	4.483	**8.265**

of eight cases. This means that these URCs have not only the best overall performance but the best management performance as well. The URCs of Rodopi, Pangaio and Didimoteicho have qualified first in only one case (for the years 1995, 1997 and 1998 respectively) and they are competitive from a management performance point of view for these years.

The net annual flows of all eight URCs according to the third scenario are presented in Table 7. In the third scenario, once again the URCs of Kavala and Drama have qualified first in four out of eight cases. The URCs of Evros, Pangaio, Orestiada and Rodopi have been ranked first (in 1995, 1997, 1999 and 2000) and they are competitive for these years. Once more the URCs of Kavala and Drama have proven to be in first place and they share the best efficiency, management and overall performance.

The net annual flows of all eight URCs according to the fourth scenario are presented in Table 8. In the fourth scenario, the URCs of Kavala and Drama are again ranked in first place in six out of eight cases. The URCs of Pangaio and Didimoteicho qualified first only once, in 1997 and 1998 respectively.

If we analyze the number of first positions of each URC we are led to the following conclusions :

i) The URCs of Kavala and Drama have the best overall, management, efficiency and reliability performance.

ii) The URCs of Evros, Pangaio and Didimoteicho have the second best overall performance and the URCs of Rodopi, Pangaio and Didimoteicho have the second best management performance.

iii) The URCs of Evros, Pangaio, Orestiada and Rodopi have the second best efficiency performance and the URCs of Pangaio and Didimoteicho have the second best reliability performance.

2) The total net flow approach

The results of the first position approach are indicative of the best URCs in efficiency, reliability and management performance. However, it is the total net flow that characterizes the performance of each URC from 1993 to 2000 much more clearly. It is a better long-term measure because it includes the annual differentiations in the performance of each URC. It also takes into account the second, third and all other positions of the URC (all of its history). Consequently, the net flows from 1993 to 2000 were summed up for each URC in order to obtain the total net flows. Looking at the total net flows, the three URCs of Kavala, Drama and Didimoteicho always appear to be in the top three positions, regardless of the scenario. The total net flows of the three best URC can be seen in Table 9.

It is very important to note that the total net flow of the URC in the fourth position is always extremely low compared to the total net flows of the first three URCs.

For example, in the second scenario, the URC of Orestiada is in the fourth position with a negative total flow of −0.45, i.e. far below the third flow, which is 3.706.

In the third scenario, Rodopi is in fourth position with a negative total flow of −0.948. This is also very low compared to the third flow, which is 2.375.

Finally, in the fourth scenario, the URC of Orestiada is in the fourth position with a total flow of 0.75. This is 7 times lower than the third flow, which equals 5.32.

It is obvious therefore that the URCs of Kavala, Drama and Didimoteicho belong to the top group with the best average performance in all four cases and that there is a very large difference between them and the remaining URCs. Consequently, the new result emerging from this approach is that Didimoteicho should be added to the group of best URCs. This is due to the fact that, although Didimoteicho has few first positions, it constantly shows a very good performance in all categories.

3) Testing the consistency of the URC annual rankings

The consistency of the URC annual rankings was tested using Kendall's weights. A separate Kendall's weight W was calculated for each annual analysis. This weight is a statistical measure of the agreement of all the partial rankings that were obtained using the four scenarios. It is clearly shown by the high values of Kendall's weights that, except for 1995, the annual evaluation results are consistent with one another.

4) Discussing the nature of the problem

The testing has revealed that the problems of the Greek URCs are structural and operational and that their low performance (in a competitive environment) is not due to their aim of keeping the farmers satisfied. All of them face serious financial problems, which (combined to their high level of debts) restrict their chances for profits. These problems are mainly due to the lack of capital, and to the lack of organized networks for fast product-distribution. The lack of a long-term business plan has put them in a position where they cannot develop competitive marketing strategies or export policies. As a result of these, the URCs have become vulnerable to the changes of the international food trade and to the frequent changes in the Common Agricultural Policy of the European Union.

From the research that was conducted locally, it was found that the eight URCs do not employ expert and experienced staff in their managerial positions. In addition, the managerial staff has not been allocated specific tasks and responsibilities and the result is that they often interfere in each other's work. Most of the URCs work with non-specialized personnel and they employ many more people than they really need. The problems of their internal organization and quality of staff have not been solved. Finally it is a fact that most of their personnel are not familiar with new technologies. Till recently there was a lack of the strict and continuous quality control and the necessary systems of quality assurance that are suggested by the international standards (ISO, HACCP). As a result of this, the rural cooperative products can not obtain the quality assurance certificates.

Finally the frequent changes in their constructive frame the interference of political parties and governments in their management and the performance of social policy (for the governments) have led them to lose their economic stability and strength.

6. Forecasting the Expected Intervals of Net Flows for the URCs

Fuzzy logic was introduced by Zadeh [19]. The expanding popularity of fuzzy systems appears to be related to their ability to deal with complex systems using a linguistic approach [17]. Many applications have appeared in systems science, especially in modeling and control while other fuzzy systems have being developed to perform forecasting [9]. One of the main features of the DSS is the calculation of the Fuzzy Expected Interval (FEI) for each URC in Greece. This means that it can produce a narrow characteristic interval of values. The net flow of the examined URC is expected to be included this interval for the following years.

For example the FEI could be (1.200, 1.480). This would mean that the net flow for the URC would fall between 1.200 and 1.480 in most of the cases. In this way the FEI can be used to forecast the future flow of each Union of Rural Cooperatives of Greece. Thus, a classification of all Unions of Rural Cooperatives in the country can be achieved, in relation to their expected flow. It is important to note that the system manages to produce

Table 10. Kendall's weights

Year	Kendall's weight	Year	Kendall's weight
1993	1.000	1997	1.000
1994	0.970	1998	0.946
1995	0.580	1999	0.845
1996	1.000	2000	0.888

Table 11. Types of linguistics

Type	Keywords	Lower bound	Upper bound
1st Type	Almost	$X-20\%$	$X-1$
2nd Type	More or less	$X-20\%$	$X+20\%$
3rd Type	Over	$X+1$	$X+20\%$
4th Type	Much more than	$2X$	∞

an interval that is as narrow as possible.

The basic idea is that, statistically and practically, there is no interest in forecasting the exact size 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 whether it will drop to 0.600 and not to estimate the precise figure as regards the past flows of the URC [19].

This means that data can be grouped in an imprecise way (using various keywords) and thus fuzzy logic can be applied [18]. For example, if the data on net flows is 0.980, 1.010, 1.090 and 9.99 for the past four years, these can be grouped in the following way :

On four occasions the net flow was almost 1.000.

In this way the data can be grouped imprecisely. Table 11 presents the four types of linguistics that can be used for the classification of the data.

In a hypothetical situation using this approach, the net flows can be classified imprecisely into groups in the following way :

On 5 occasions the flow was almost 0.600.

On 8 occasions the flow was more or less 0.850.

On 3 occasions the flow was over 1.100.

On 2 occasions the flow was much more

Table 12. Comparison of the fuzzy expected intervals of flows to the actual flows and to the average flows according to the first scenario

URC	Actual value of flows for the year 2000	Forecasted FEI of flows for the year 2000	Average flow 1993-1999
Kavala	1.375	0.900-0.999	0.500
Pangaio	−0.375	0.400-0.500	0.116
Drama	1.375	0.600-0.625	0.560
Xanthi	1.125	0.320-0.350	−0.630
Evros	−0.375	0.100-0.110	−0.708
Didimoteicho	1.125	0.625-0.625	0.600
Orestiada	0	0.110-0.120	−0.241
Rodopi	−0.375	0.625-0.625	−0.171

Table 13. Comparison of actual ranking to the two forecasted rankings for the year 2000 according to the first scenario

Actual classification for the year 2000	Forecasted classification based on average values of flows	Forecasted classification based on FEI
Kavala	Didimoteicho	Kavala
Drama	Drama	Didimoteicho
Didimoteicho	Kavala	Rodopi
Xanthi	Pangaio	Drama
Pangaio	Rodopi	Pangaio
Rodopi	Orestiada	Xanthi
Evros	Xanthi	Evros
Orestiada	Evros	Orestiada

than 1.500.

Kandel described all of the theorems that are used in the following section [13].

After the initial imprecise classification, there are the following four actions which should be taken according to Kandel [14]:

A. The first action is to input data from the imprecise classification into the characteristic function $C(X)$ and find all Cs [14].

The characteristic function is the following:

$$C(X) = \begin{cases} 0 \text{ IF } X \leq 0 \\ \dfrac{X}{100} \text{ IF } X \leq 100 \\ 1 \text{ otherwise} \end{cases}$$

Where 100 is used to portray the maximum flow that was ever calculated according to existing data (this is the most extreme case according to the designers' judgment). This function is used for the forecast of the total flow.

B. The second action is to find all the μ_s which are the candidates' fuzzy expected intervals [14]. The μ_s are intervals of the form [LB, UB] and can be calculated using the following equations:

$$UB_j = \frac{\sum_{i=j}^{n} MAX(p_{i_1}, p_{i_2})}{\sum_{i=j}^{n} MAX(p_{i_1}, p_{i_2}) + \sum_{i=1}^{j-1} MIN(p_{i_1}, p_{i_2})}$$

Equation 1. This equation is used to find the upper bound of every interval μ_i

Where p_{i_1} is the lowest bound of group i and p_{i_2} is the upper bound of group i.

$$LB_j = \frac{\sum_{i=j}^{n} MIN(p_{i_1}, p_{i_2})}{\sum_{i=j}^{n} MIN(p_{i_1}, p_{i_2}) + \sum_{i=j}^{j-1} MAX(p_{i_1}, p_{i_2})}$$

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

Where p_{i_1} is the lowest bound of group i and p_{i_2} is the upper bound of group i.

C. The third action is to find the minimum interval of each line using Theorems 1, 2 and 3 according to Kandel [14]. The theorems 1 to 6 are used to compare pairs of intervals of values and to determine which interval is larger and which smaller.

Theorem 1 : $MAX(S, R) = \begin{cases} R \text{ if } r_m > s_l \\ S \text{ if } s_n > r_l \end{cases}$

Where $S = \{S_l, \ldots\ldots S_n\}$ $R = \{r_l, \ldots\ldots r_m\}$ and $R \cap S = \phi$

Theorem 2 : $MAX(S, R) = \begin{cases} R \text{ if } r_m > s_l \\ S \text{ if } s_n > r_m \end{cases}$

Where $R = \{r_l, \ldots\ldots r_m\}$ $S = \{S_l, \ldots\ldots S_n\}$ $R \cap S \neq \phi,\ S \notin R,\ R \notin S$

Theorem 3 : If $R = \{r_l, \ldots\ldots r_m\}$ $S = \{S_l, \ldots\ldots S_n\}$ and $R \subseteq S$ then $MIN(S, R) = [S_l, \ldots\ldots r_m]$

D. The final task is to find the maximum interval over the minimal using theorems 4, 5 and 6 according to Kandel [14].

Theorem 4 :
If $R = \{r_l, \ldots\ldots r_m\}$ $S = \{S_l, \ldots\ldots S_n\}$ and $R \cap S = \phi$ then $MAX\ (S,\ R) = R$ if $r_l > S_n$ and $MAX\ (S,\ R) = S$ if $S_l > r_m$

Theorem 5 :
If $R = \{r_l, \ldots\ldots r_m\}$ $S = \{S_l, \ldots\ldots S_n\}$ and $R \cap S \neq \phi$ $S \notin R,\ R \notin S$ then $MAX\ (S, R) = R$ if $r_m > S_n$ and $MAX\ (S, R) = S$ if $S_n > r_m$

Theorem 6 :
If $R = \{r_l, \ldots\ldots r_m\}$ $S = \{S_l, \ldots\ldots S_n\}$ and $R \subseteq S$ then $MAX\ (S, R) = [r_l, \ldots\ldots S_n]$

The maximum interval found is the preliminary fuzzy expected interval. The maximum flow (which in this case is 100) should be multiplied with the bounds of the preliminary fuzzy expected interval in order to produce the real fuzzy expected interval. This interval could indicate the expected situation for that specific Union of Rural Cooperatives. It is obvious that the narrower the interval, 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 effectively carried out. After the FEI is calculated for each URC of Greece, the intervals are compared to each other using the above equations and a classification of the Union of Rural Cooperatives is performed according to their fuzzy expected intervals of flow.

7. Discussion of the Forecasting Process for the Overall Performance

The forecasting was actually done for the eight Unions of Rural Cooperatives of northeast Greece using the first scenario, in which the average performance of all types of ratios is taken into consideration. The initial knowledge base of the system included financial data on URCs from 1993 to 1999. The decision support system carried out a forecast of the fuzzy expected interval of the net flow (using the first scenario) for each URC 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 were very impressive and are described in Tables 12 and 13.

In Table 12, it is clearly shown that in 7 out of 8 cases the FEI are closer to the actual flows than the average values and only in one case is the average value closer. All of the actual flows are included within the closed interval [MaxFEI - 1, MaxFEI + 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.

In Table 13 it is clearly shown that the forecasted ranking of the URC for the year 2000 is absolutely correct in 4 out of 8 cases and at the same time, the other 4 URC that were not ranked in their correct position, have a very small divergence from their actual ranking position for the year 2000. This means that the forecasted ranking is totally correct in 50% of the cases when FEI are used. This is a very satisfying percentage, if we take into account that unpredictable factors can emerge from year to year, such as investments or damage to 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 URCs from

1993-2000, only in 1 out of 8 cases is the ranking correct. This means that the ranking is correct in only 12% of cases, if the average values of the net flows are used.

Finally, the classification of Table 12 (using the average position of each URC in the rankings that were performed from 1993 to 2000) has no correct rankings of URCs compared to the one that is based on actual data for the year 2000.

The decision support system will be used and tested again with future data. This means that the task of evaluating URCs will continue and the system's credibility will also be evaluated.

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