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APPLICATION OF ELECTRE III AND DEA METHODS IN THE BPR OF A BANK BRANCH NETWORK

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Abstract: Operational research methodologies are a powerful tool assisting managers in their effort to critically review business data and decide on future business actions.

This paper presents the application of Electre multi-criteria methodology and Data Envelopment Analysis, as a part of a small commercial bank's ongoing effort to reengineer its branch network. We focus on two particular problems: first, categorization of the branches so as to apply adequate equivalent organizational schemas and second the assessment of relative efficiency of human resources.

Keywords: Classification, ranking, efficiency, ELECTRE methods, Data Envelopment Analysis, banking.

1. INTRODUCTION

Political and economic changes in Eastern Europe and Balkan countries, in the recent years, have caused significant transformations in their banking systems as well. Commercial banks in these countries, faced with the pressures of deregulation, seek ways to add value to their services and resist national and international competition. Therefore, the need of process reengineering, reduction of operating expenses and, perhaps, repositioning in the local market for these banks becomes apparent.

The case presented in this paper refers to a certain phase of the reengineering plan of a Balkan bank, regarding the operations of its branches. It mainly has to do with two specific aspects of the business process reengineering (BPR) project: rearrangement of the organizational structure of branches and rationalization of human resources utilization. The methodologies applied are Electre III for ranking and categorization of the Bank branches and Data Envelopment Analysis for evaluating the personnel's productivity.

The rest of the paper unfolds as follows: In the next section, a walkthrough the Bank's current operating procedures is taken, revealing the existing problems and limitations, in the specific field of branch services and the aspects of the intervention are stated. Sections 3 and 4 are devoted to the categorization of branches: First, the theoretic background about the Electre multi-criteria methods is given and then, there are the recommendations about branch classification upon the volume in the entirety of their operations (deposits, loans, new accounts, transactions volume, sub-branches etc). Sections 5 and 6 deal with the evaluation of human resources efficiency branches. In particular, section 5 presents the basic Data Envelopment Analysis models, while in section 6 the efficiency of the accounting personnel of the branches is measured, in relevance with their activity's intensity. Finally, section 7 closes with the conclusions of the analysis and the overall assessment of the project.

2. ASPECTS OF THE INTERVENTION

The Bank is a national commercial banking institution in FYROM (Former Yugoslavian Republic of Macedonia), with a 30 years historical background, which is a leader in a quite competitive, though still highly regulated environment. Its name is not disclosed, for confidentiality reasons and hereafter we will refer to it as "the Bank".

The branch network of the Bank consists of 25 *branches*, each one in a different city. Many branches operate and administrate other service points, located in their nearby area (the suburbs of the city or small towns). These points are called *sub branches* and they mostly deal only with deposit accounts handling. The kind of the operations these sub branches perform and the way they are staffed are in the discrete authority of the branch's manager.

The operations performed by the Bank's branches cover all universal banking activities and can be separated into: Deposits acceptance in local and foreign currency; Fund transfers: Domestic and International (from and to abroad) for investments or current transactions; Credit granting to corporate clients (legal entities) and to citizens (consumer loans, mortgages, credit cards etc.); Other intermediation operations like salaries and pensions payments, utilities payments, safety boxes etc.

The whole spectrum of branches' operations and the number of the sub branches per branch, can be seen in Table 1 (columns 3, 6, 7, 9 & 10), where percentages of *items* are listed per branch. The scope of these operations may differ substantially from one branch to another, due to demographic, network structure or other reasons. For instance, it can be noted through Table 1, that B22 and B25 branches exhibit an extremely low volume of activity. The reason is that they have started operating in 2002; therefore they are in a phase of highly rated development and have not reached yet the state of maturity regarding their operations potential.

In columns 4 and 8 of Table 1, statistical data, derived from the information platform and regarding the total volume of platform transactions in the branches, are exhibited. These transactions, which will be used later in the analysis, are divided in:

- Teller Transactions (TT): including pure money handling TRNs such as deposits and withdrawals in domestic currency accounts, money transfers from teller to teller, buying and selling foreign currencies, etc.
- Fund Transfer Transactions in domestic currency (FT): including compensatory TRNs as transfers from one account to another, checks' buying and clearing, utilities bills, pensions, salaries etc.

Until recently, commercial banks of the country operated in a stable "closed" environment, where all economic activities were rigorously determined by the State or the Central Bank. In this environment, there were no financial dangers or opportunities for a banking institution and there was no room for market competition. The ongoing deregulation brought about substantial transformations in the commercial banking sector. For instance, international transactions up to the end of 2001 were realized by the Central Bank through international clearing systems and an analogous procedure was held for domestic fund transfers, which were cleared through a national settlement system. The opening of these markets added new profitable activities to the banks but it also drove massive operations to their cashiers. New ways to deal with them had to be found, in order to get a bigger portion of the market.

The Bank realized that, it was a matter of imminent priority to reengineer its processes and organization. The project started with the implementation of a new information platform, the centralization of procedures in certain critical operations, as credit granting decisions and foreign trade and the rationalization of the Head Office organization schemas. Nevertheless, it was apparent from the start that, the whole effort would remain incomplete if the knife wouldn't go as deep as the everyday branches' activity.

During the "Process diagnosis" stage of the BPR project, existing processes, on the branch level were analyzed and described, to achieve genuine understanding of their span, linkages and bottlenecks. A number of hidden pathologies were uncovered. As far as to the branch procedures, these included:

- Organizational charts surpassed by the changes in the banking environment.
- Incompatibility of the existing organization structure with the new information platform prerequisites.
- Human resources waste in non-adding-value tasks, regarding the operations' volume, the demographic and welfare conditions in the country.

Among others, the recommendations in the present phase that were agreed with the Bank management consist of the following components:

1. Initial Ranking and Classification of the Branches, according to the level and the scope of their operations and
2. Efficiency measurement of the personnel, by each branch, in relevance with the total volume of its activities.

The methods chosen as more appropriate were: the Electre III method for the sorting problem and DEA for the efficiency measurement problem.

3. THE ELECTRE FAMILY OF MULTICRITERIA METHODS

Let $F = \{1,2,3,\ldots,n\}$ be a family of criteria g_1, g_2, g_3, ……., g_n, formed for the evaluation of the alternatives of a set "A". ELECTRE (Elimination Et Choix Traduisant la REalite) methods distinguish between different types of the criteria, as following: The *true-criterion type* allows the smallest difference in performances between two alternatives to lead to a strict preference for one of the two alternatives in the comparison with the other. The *pseudo-criterion type* allows, with the use of thresholds, to take into account the imprecision and uncertainty that may affect performances [18], according to:

$$aP_jb \Leftrightarrow g_j(a) > g_j(b) + p_j$$

$$aR_jb \Leftrightarrow q_j < g_j(a) - g_j(b) \leq p_j$$

$$aI_jb \Leftrightarrow \left|g_j(a) - g_j(b)\right| \leq q_j$$

where:

- The Decision Maker's preferences are modeled through three relationships: *P* that expresses preference and it is neither symmetric, nor transitive; *I* that expresses indifference regarding the two alternatives and it is both symmetric and transitive; *R*, that expresses non-comparability, which is also both symmetric and transitive.
- The *indifference* threshold q_j is the largest difference of performances significant for indifference and the *preference* threshold p_j, is the largest difference of performances not significant for a strict preference.
- The *veto* threshold v_j is the smallest difference between the performances of two alternatives, above which the user thinks that it is not possible to support the idea that the worse of the two alternatives may be comprehensively considered as good as the better one, even if its performances on all the other criteria are better (see below).

The family of Electre multi-criteria methods belongs to the French school, which uses the rule of majority in an outranking relation [10], in opposition with the American school which uses the rule of unanimity of criteria in the idea of dominance. (Pareto optimality). The outranking relations are built on two indices, namely *the concordance index* and *the discordance index*. Based on them, an alternative is "at least as good as" another, if a sufficient majority of criteria support this appraisal (concordance principle) and the opposition of the minority of criteria is not strong enough, to prevent it (discordance principle).

In Electre III [13], [14], the comparison of alternatives in the way that has just been described leads to the building for each pair of alternatives (a, b) of a concordance index, that is expressed as (Fig. 1):

If $g_j(a) \leq g_j(b) - p_j(b)$, then $c_j(a,b) = 0$

If $g_j(b) - p_j(b) < g_j(a) \leq g_j(b) - q_j(b)$, then $0 < c_j(a,b) = \dfrac{p_j(b) - [g_j(b) - g_j(a)]}{p_j(b) - q_j(b)}) \leq 1$

If $g_j(a) > g_j(b) - q_j(b)$, then $c_j(a,b) = 1$

where: $p_j(b)$ is the preference threshold for criterion g_j and alternative b; $q_j(b)$ is the corresponding indifference threshold.

Table 1: Operations, personnel and subbranches per Branch

BRANCH	ACCOUNTING PERSONNEL	NO. OF DEPOSITORS	TELLER TRANSACTIONS	ESTIMATION FOR NEW LOAN APPLICATIONS	TOTAL NUMBER OF LOAN ACCOUNTS	NO OF CURRENT ACCOUNTS	FUND TRANSFER TRANSACTIONS	TOTAL NO. OF TRANSFERS FROM & TO ABROAD	NO OF SUBBRANCHES
B1	2.43%	2.02%	1.90%	2.99%	0.98%	1.17%	1.42%	0.59%	1
B2	3.98%	4.30%	2.88%	2.99%	2.95%	1.98%	3.72%	2.84%	2
B3	4.17%	7.85%	4.58%	2.49%	2.48%	2.29%	4.31%	5.66%	0
B4	1.94%	2.10%	2.14%	1.49%	1.50%	0.92%	1.77%	1.29%	0
B5	2.62%	2.15%	3.12%	1.49%	0.78%	0.79%	2.46%	2.00%	1
B6	4.56%	5.40%	5.89%	7.46%	22.83%	2.41%	4.28%	2.35%	2
B7	4.37%	5.94%	3.41%	4.98%	3.36%	3.07%	4.29%	3.41%	0
B8	5.24%	3.32%	3.58%	5.97%	6.42%	3.74%	2.53%	2.16%	1
B9	1.46%	1.08%	1.09%	1.49%	1.50%	1.04%	1.25%	0.22%	0
B10	4.27%	3.40%	2.95%	4.98%	2.85%	2.09%	2.77%	1.05%	0
B11	2.14%	1.68%	1.35%	2.49%	0.88%	0.77%	1.44%	1.55%	1
B12	2.43%	1.52%	2.22%	1.49%	2.12%	2.27%	1.61%	0.12%	0
B13	9.61%	7.83%	6.57%	8.96%	4.66%	8.21%	7.23%	9.92%	3
B14	5.92%	7.16%	5.49%	9.95%	4.66%	4.06%	5.08%	2.70%	0
B15	6.31%	6.43%	6.04%	7.46%	4.76%	3.41%	5.28%	4.98%	2
B16	6.41%	6.42%	5.27%	5.97%	5.80%	6.36%	5.69%	3.15%	1
B17	1.94%	0.97%	2.30%	4.98%	0.67%	2.03%	1.66%	8.03%	0
B18	2.23%	3.14%	2.95%	7.46%	19.31%	3.15%	3.33%	5.19%	0
B19	16.50%	18.47%	25.09%	0.00%	8.59%	44.30%	32.21%	32.60%	13
B20	2.43%	1.49%	2.66%	1.49%	1.76%	2.77%	1.11%	0.00%	0
B21	1.46%	2.70%	1.81%	2.49%	0.00%	0.76%	1.76%	2.93%	0
B22	1.07%	0.26%	0.69%	2.49%	0.00%	0.02%	0.31%	0.00%	0
B23	2.91%	2.79%	3.15%	2.99%	0.36%	1.37%	2.03%	2.33%	1
B24	2.62%	1.44%	2.27%	2.99%	0.78%	1.04%	2.04%	4.87%	0
B25	0.97%	0.15%	0.62%	2.49%	0.00%	0.00%	0.45%	0.05%	0
Total	100%	100%	100%	100%	100%	100%	100%	100%	28
MAX	16.50%	18.47%	25.09%	9.95%	22.83%	44.30%	32.21%	32.60%	13
MIN	0.97%	0.15%	0.62%	0.00%	0.00%	0.00%	0.31%	0.00%	0

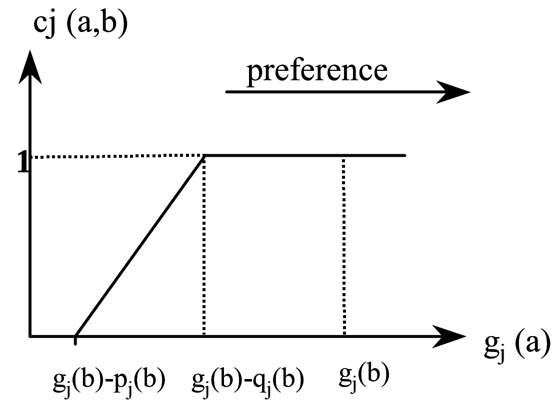

Figure 1: Values of the concordance index $c_j(a,b)$ for two alternatives *a* and *b*

Then, all the indices of an alternative are added, giving its total concordance index $C(a,b)$ for the term "alternative a is at least as good as alternative *b*, regarding the whole set of criteria" as:

$$C(a,b)=\frac{\sum_{j=1}^{n}k_j\cdot c_j(a,b)}{\sum_{j=1}^{n}k_j}$$

where k_j is the weight of criterion *j*.

The *discordance index* $D_j(a,b)$ expresses the opposition to the term "alternative a is at least as good as alternative *b*, regarding criterion *j*" and is estimated by (Fig.2):

- If $g_j(a) > g_j(b) - p_j(b)$, then $D_j(a,b) = 0$;
- If $g_j(b) - v_j(b) < g_j(a) \le g_j(b) - p_j(b)$, then $0 < D_j(a,b)=\dfrac{g_j(b)-g_j(a)-p_j(b)}{v_j(b)-p_j(b)} \le 1$;
- If $g_j(a) \le g_j(b) - v_j(b)$, then $D_j(a,b) = 1$.

where $v_j(b)$ is the veto threshold.

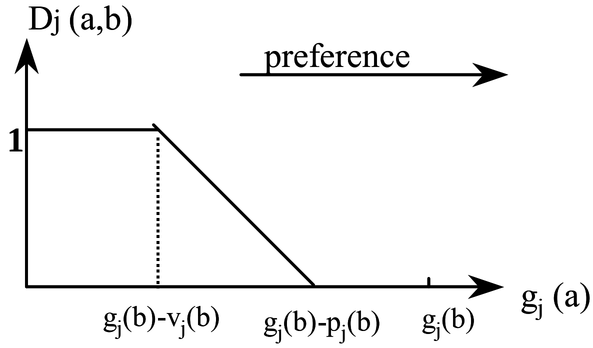

Figure 2: Values of the discordance index $c_j(a,b)$ for two alternatives a and b

For every term *"a outranks b", the creditability degree* σ_s (a,b) is estimated as following: If F is the sample of criteria, we define as:

$$\overline{F}(a,b) = \{ j \in F \,/\, D_j(a,b) > C(a,b) \}$$

and

$$\sigma_s(a,b) = \begin{cases} C(a,b) & \text{if } \overline{F}(a,b) = \varnothing \\ C(a,b) \prod_{j \in F} \dfrac{1 - D_j(a,b)}{1 - C(a,b)}, & \text{if } \overline{F}(a,b) \neq \varnothing \end{cases}$$

From this basic relation, σ_s is transformed into a "network" relation (fig. 3) testing $\sigma_s(\mathrm{a,b}) \geq \lambda$, where λ is the cut level, above which the term "*a* outranks *b*" is considered valid. The cut level λ takes values between 0.50 and 1.00 (usually 0.67).

The ranking algorithm of ELECTRE III uses the credibility matrix (i.e. the matrix of $\sigma_s(a,b)$) to build two rankings using descending and ascending distillation: *descending distillation* selects at first the best alternatives to end the process with the worst ones. On the contrary the ascending distillation selects first the worst alternatives to end the process with the best ones. Two complete preorders are therefore found on all the alternatives. An alternative which is incomparable to a group of others will be positioned at the end of this group in the descending distillation and at the top in the ascending distillation.

The differences between the distillations, allows the decision maker to detect the alternatives that exhibit special sensitivity, regarding non-comparability and to examine them analytically. *A Median Preorder* can be built in the following manner: the alternatives are ranked following the ranks in the final (partial) preorders and two incomparable alternatives in a same rank are ranked according to the differences of their positions in the two distillations.

The use of the Electre family methods in ranking and classification problems, present the following advantages [11]:

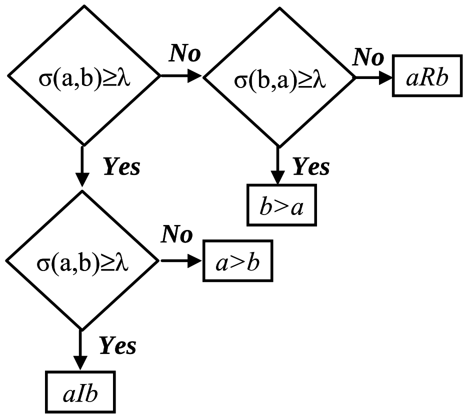

Figure 3: Outranking relations in Electre III

- Potential use of both quantitative and / or qualitative criteria.
- Acceptance and integration of the concept of non-comparability of alternatives, in the whole procedure of classification or ranking.
- Treatment of non-comparability, with two approximations, so as to focus on the alternatives that exhibit special characteristics.
- Simplicity of comparisons and consequentially understanding of the results.
- Convenience in the application of the method, manually or with a personal computer.

For an overview of multi-criteria methodology in general, the reader is addressed to [12].

4. CLASSIFICATION AND RANKING OF THE BRANCHES

The aim in classifying the branches is initially to divide them in, more or less, homogeneous categories that have the same intense of operations, in order to apply, in a second phase, adequate organizational schemas for every category.

Keeping this as the primary target, a classification system, being monitored in constant time periods (f.i. every year), can become a useful tool in: (a) updating the organizational charts of those branches that fall into another category as a result of changes in their operations' volume, and (b) appointing the most qualified and experienced managers to the appropriate branches. On the other hand, a ranking that concludes in a total score for every branch is preferred to categorization because it gives an immediate measure of the volume of their activity, compared with the whole network.

In the present case, it was decided to apply a ranking method and to divide the total grading scale with borderlines that would be the barriers between categories.

Table 2: Matrix of creditability degrees

	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25
B19	0.88	0.88	0.88	0.88	0.88	0.75	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.75	1	0.88	0.88	0.88	0.88	0.88	0.88
B13	1	1	1	1	1	0.88	1	1	1	1	1	1	1	1	1	1	1	0.88	0	1	1	1	1	1	1
B15	1	1	1	1	1	0.88	1	1	1	1	1	1	0.88	1	1	1	1	0.88	0	1	1	1	1	1	1
B06	1	1	0.88	1	1	1	1	1	1	1	1	1	0.75	1	0.88	0.88	0.88	0.88	0	1	1	1	1	0.88	1
B02	1	1	1	1	1	0.66	1	0.88	1	1	1	1	0.5	0.75	0.75	0.88	0.88	0.75	0	1	1	1	1	1	1
B16	1	1	1	1	1	0.88	1	1	1	1	1	1	0.75	1	1	1	0.88	0.88	0	1	1	1	1	1	1
B08	1	1	0.75	1	1	0.88	1	1	1	1	1	1	0.38	0.86	0.75	0.88	0.88	0.75	0	1	1	1	1	0.88	1
B14	0.88	0	0.88	1	0.88	0	1	0.88	1	1	0.88	1	0	1	0	0.88	0.88	0.88	0	1	1	1	1	1	1
B18	0.88	0	0.88	1	0.88	0	1	0.88	1	1	0.88	1	0	0.88	0	0.62	1	1	0	1	1	1	1	1	1
B07	0.88	0	1	1	0.88	0	1	0.88	1	1	0.88	1	0	1	0	0.75	0.88	0.88	0	1	1	1	1	1	1
B03	0.88	0	1	1	0.88	0	1	0.62	1	1	0.88	1	0	0.88	0	0.5	1	0.75	0	1	1	1	1	1	1
B10	0.88	0	0.75	1	0.88	0	0.88	0.62	1	1	0.88	1	0	0.75	0	0.39	0.88	0.75	0	1	0.88	1	0.88	0.88	1
B05	1	0.74	0.5	1	1	0.5	0.5	0.62	1	0.62	1	0.75	0	0.39	0.25	0.38	0.62	0.5	0	0.75	1	1	1	0.88	1
B17	0.75	0	0.62	0.75	0.75	0	0.62	0.62	0.88	0.75	0.88	0.88	0	0.38	0	0.25	1	0.73	0	0.88	0.88	1	0.88	1	1
B01	1	0.5	0.38	0.88	0.88	0.12	0.38	0.62	1	0.88	0.88	0.88	0	0.12	0.12	0.25	0.88	0.38	0	0.88	0.88	1	0.88	0.88	1
B11	1	0.4	0.25	1	0.88	0.25	0.25	0.5	1	0.54	1	0.75	0	0.25	0.12	0.12	0.75	0.25	0	0.88	1	1	0.88	0.88	1
B24	0.88	0	0.47	1	0.88	0	0.5	0.5	1	0.62	0.88	0.75	0	0.25	0	0.25	1	0.5	0	0.75	1	1	1	1	1
B23	0.75	0	0.5	0.88	0.75	0	0.5	0.62	0.88	0.88	0.75	0.88	0	0.38	0	0.38	0.88	0.5	0	0.75	1	1	1	0.75	1
B12	0.75	0	0.52	0.88	0.75	0	0.5	0.38	1	0.62	0.75	1	0	0.25	0	0	0.75	0.43	0	1	0.88	1	0.88	0.88	1
B04	0.88	0	0.38	1	0.88	0	0.25	0.5	1	0.75	0.88	0.88	0	0.12	0	0	0.62	0.5	0	0.88	0.88	1	1	0.88	1
B20	0.75	0	0.62	0.88	0.62	0	0.5	0.25	0.88	0.5	0.75	0.88	0	0.26	0	0.12	0.75	0.38	0	1	0.88	1	0.88	0.88	0.88
B21	0.75	0	0.38	0.88	0.75	0	0.5	0.5	0.88	0.75	0.75	0.75	0	0.25	0	0.12	0.62	0.62	0	0.75	1	1	0.88	0.88	1
B09	0.75	0	0.38	0.88	0.62	0	0.12	0.1	1	0.25	0.75	0.85	0	0.12	0	0	0.66	0.12	0	0.75	0.75	1	0.62	0.81	1
B25	0.12	0	0.25	0.25	0.12	0	0.25	0	0.38	0.25	0.17	0.26	0	0.12	0	0	0.25	0.12	0	0.38	0.38	0.88	0.25	0.25	1
B22	0.12	0	0.25	0.25	0.12	0	0.25	0	0.38	0.25	0.25	0.25	0	0.12	0	0	0.25	0.12	0	0.38	0.38	1	0.25	0.25	0.88

Therefore, it came first to decide on the criteria that should be used, in order to embrace the whole spectrum of operations in the branch. It soon became apparent that operations' data in amounts of currency were not very accurate and panel data were not available. So, in this phase, it was more appropriate to discharge data on amounts and deal only with items. Finally, the criteria used in the present situation, were actually eight (8), as following (see Table 1):

- *DEPOSITS IN LOCAL CURRENCY*
  1. Total number of Depositors.
  2. Average sum of Teller Transactions, per month (items).
- *FUND TRANSFERS*
  3. Total number of current accounts.
  4. Average sum of Fund Transfer Transactions, per month (items).
- *FOREIGN EXCHANGE OPERATIONS*
  5. Average number of Fund Transfers from and to abroad, per month (items).
- *CREDIT OPERATIONS*
  6. Total number of loan accounts (corporate + retail).
  7. Targeted new loan applications in the current year (2002).
- *SCOPE OF ADMINISTRATION*
  8. Number of sub branches, per branch.

The important points, for which there should be some clarifications, are:

- For every major operation of a branch, two criteria were selected, so as to avoid and counterbalance any local incongruities.
- Other operations were excluded from the data set, as being of minor importance.
- Since existing loans of the Bank are not performing in a relatively high percentage, the criterion "Targeted new loan applications in the current year ", that is based on a marketing research, was chosen because it can reveal the dynamics of the local market.

It was decided to classify the branches in 5 categories, for a start, and then, in the phase of fitting the appropriate charts for each category, to select on whether it was more realistic to add or subtract a category. It was also set as a prerequisite that branch B19 (the central branch of the Bank) should be alone in the 1st category.

Although there are a number of other methodologies for ranking and classifying alternatives [20], the method applied was Electre III, as it disposes several advantages. It has a solid scientific background and it can easily administrate changes in the number of categories or in the number, the relative weight and the nature (quantitative / qualitative) of criteria. It also allows for every branch to be directly compared with every other branch of the network, without massive statistical inference needed.

All criteria were given the same weight, in this initial categorization ($k_j = 1$) and there were no indifference or preference thresholds taken into account ($q_i = 0$, $p_i = 0$). So, each branch is considered actually, ill-preferred than another, in a certain criterion, if and only if its items are more than the latter's. A veto threshold of 2 sub branches was assumed. In this way, a branch is strongly preferred than another if and only if its sub branches exceed the latter's by 2 or more (only in this criterion).

For the acceleration of the computation, the Paris-Dauphine University/Lamsade Laboratories (http://www.lamsade.dauphine.fr/software) relative software program was used.

Ranking of the branches was made in a scale of 0 to 1 and the final score of each branch B_i was derived as: $(\sum \sigma_s(B_i, B_j) + \sum \sigma_s(B_j, B_i))/2,\ j = 1.....n,\ j \neq i$. These sums, derived from the relative creditability degrees of Table 2, are shown in columns AV_LINE, AV_COL and TOTAL of Table 3.

Table 3: Final scores and rankings

	AV_ LINE	AV_ COL	TOTAL	RANK
B19	0.869	1.000	0.935	1
B13	0.948	0.828	0.888	2
B15	0.943	0.760	0.852	3
B06	0.918	0.758	0.838	4
B02	0.877	0.687	0.782	5
B16	0.933	0.561	0.747	6
B08	0.875	0.381	0.628	7
B14	0.752	0.458	0.605	8
B18	0.746	0.409	0.578	9
B07	0.751	0.338	0.545	10
B03	0.725	0.353	0.539	11
B10	0.679	0.228	0.453	12
B05	0.667	0.197	0.432	13
B17	0.604	0.205	0.405	14
B01	0.611	0.176	0.394	15
B11	0.581	0.168	0.375	16
B24	0.593	0.136	0.364	17
B23	0.585	0.118	0.351	18
B12	0.551	0.140	0.345	19
B04	0.553	0.108	0.331	20
B20	0.528	0.129	0.328	21
B21	0.542	0.097	0.320	22
B09	0.439	0.077	0.258	23
B25	0.195	0.015	0.105	24
B22	0.198	0.010	0.104	25

So it looks, as B19 branch is the best scoring 0.935, when taking into account all the criteria, while B13 is the second, with a relative score of 0.888. Meanwhile, B25 and B22 (scores 0.105 and 0.104 respectively) are ranked as the last and this fact is accounted as reasonable as the have launched their operation very recently.

Finally, the categorization proposed consists of the following levels:

i. <u>*Category "1"*</u> (best): Score $0.90 \leq x \leq 1.00$,
ii. <u>*Category "2":*</u> Score $0.80 \leq x < 0.90$,
iii. <u>*Category "3":*</u> Score $0.60 \leq x < 0.80$,
iv. <u>*Category "4":*</u> Score $0.40 \leq x < 0.60$,
v. <u>*Category "5":*</u> Score $0.00 \leq x < 0.40$.

Of course, these scores do not have the meaning of showing absolute distances, but rather of being relative indicators. For example, it would be much easier for B18 (scoring 0.578) to increase its activity so as to reach the limit of 0.60, than for B02 (scoring 0.782) to reach the limit of 0.80.

The bounds for each category were, of course, arbitrarily set, as "round" numbers that are easy to remember. The only effort was to keep in mind the prerequisites mentioned in a previous paragraph, about 5 categories and B19 being in the 1st category. Also, another logical suggestion of the bank's management was to have more branches as we move to lower categories (i.e. more branches in Categ. "4", than in Categ. "3").

It must be emphasized that this initial ranking, although tested by the project team and the results seem to agree with the Bank's prevailing ideas, it was suggested to be carefully re-examined in a future categorization (when more accurate data were available, the data-set would consist of yearly figures or if amounts were taken into account), in order to avoid significant differences.

5. DATA ENVELOPMENT ANALYSIS

Under the *production approach*, a bank is defined as a producer of services for account holders performing transactions on deposit accounts and processing documents such as loans. Thus, it uses as input mainly capital (premises and labor) to produce outputs (loans, deposits, referrals to auxiliary services and so forth) and the total number of accounts or their related transactions best measure outputs. In this framework, deposits are included among the latter, in contrast with the *intermediation approach* that considers deposits as an input [16]. Since staff expenses represent about 70% of the total branch costs, internationally [15], the most usual input is the personnel (tellers, officers, and supervisors). As outputs most of the existing applications use the total number of transactions, the number of accounts or funds of loans and deposits, sales of new products, profits and commissions [5].

Efficiency is defined as the degree to which the observed use of inputs to produce outputs of a certain quality matches the optimal. Assuming a given level of outputs, overall input inefficiency implies that the bank or branch is not optimally using the factors of production, so it is not operating at the least possible cost. Input inefficiency can be divided into *technical* inefficiency and *allocative* inefficiency. Technical inefficiency refers to the conversion of inputs to outputs and is determined by the difference between the observed ratio of combined quantities of a bank's output to input and the ratio achieved by best practice. It is affected by the size of operations (scale efficiency) and by managerial practices. It is also defined independent of prices and costs. Allocative inefficiency occurs when, for any level of production, inputs are not used in the proportion that minimizes the cost of production, given the input prices [2].

An optimal output level is possible if *variable returns to scale* exist at different output levels. A scale-efficient entity (bank-branch in our case) will produce where there are *constant returns to scale*; that is, changes in output result in proportional changes in costs [4].

5.1. The DEA method

DEA is a linear programming-based method for assessing the efficiency of homogeneous organizational units by creating a segmental empirical external production surface, interpreted in economic terms as the best production frontier (envelope) in practice [8]. A DEA model is resulting to a branch's relative efficiency, regarding the other branches in the network. By applying interpolation and inefficiency assumptions, the *Production Possibility Set*

$$T = \{(y, x) \in R^{m+s} : \text{input } x \in R^m \text{ can produce output } y \in R^s\} \text{ is created,}$$

this corresponds to the space containing all feasible combinations of inputs and outputs. *Efficient Targets* of not efficient units are expressed as linear combinations of a subset of the efficient frontier that lies near the DMU under examination and is called *Efficient Reference Set (Peer Group)*.

The CCR model of Charnes, Cooper & Rhodes (1978), for n DMUs, m inputs and s outputs, in an environment with constant returns to scale, estimates the efficiency measure of each DMU_0, as:

<u>CCR Input Primal Model (CCR$_P$-I)</u>

$$\min_{\theta,\lambda,s^+,s^-} z_0 = \theta - \varepsilon\vec{1}s^+ - \varepsilon\vec{1}s^-$$

s.t. $\text{Y}\lambda - s^+ = Y_0$ (s constraints)

$\theta \text{X}_0 - X\lambda - s^- = 0$ (m constraints)

$\lambda, s^+, s^- \geq 0$

<u>CCR Output Primal Model (CCR$_P$-O)</u>

$$\max_{\phi,\lambda,s^+,s^-} z_0 = \phi + \varepsilon\vec{1}s^+ + \varepsilon\vec{1}s^-$$

s.t $\phi \text{Y}_0 - \text{Y}\lambda + s^+ = 0$ (s constraints)

$X\lambda + s^- = X_0$ (m constraints)

$\lambda, s^+, s^- \geq 0$

Where:

- X, Y are the ($m\times n$) and ($s\times n$) input and output matrices (x_{ik} the i input of DMU_k, y_{jk} the j output of DMU_k).
- $\lambda = (\lambda_1, \lambda_2, ...\lambda_n)^T$: λ_k the weight of DMU_k in its attempt to dominate DMU_0.
- $s^+ = [s_1^+, s_2^+, ..., s_s^+], s^- = [s_1^-, s_2^-, ..., s_m^-], s_i^-, s_r^+$: are slack variables that indicate superfluous economy in input i and superfluous production in output r, respectively.
- $0 < \varepsilon \leq 1$, a non- Archimedean constant, that impedes the DMU under examination give zero weights to the components $\mu_i \in \mu$ and $v_i \in v$, that it does not control absolutely.

It holds that $0 \leq \theta \leq 1$ ($\varphi \geq 1$) and DMU_0 lies on the efficient frontier if and only if $w_0{*}=z_0{*}=1$, *or equivalently if* $\theta{*}=1$ and all slacks are 0 ($X\lambda = x_0 \wedge Y\lambda = y_0$). The CCR model imposes two assumptions: (1) that the frontier is concave or equivalently that the production set is convex and (2) it assumes linear homogeneity.

In 1984, Banker, Charnes & Cooper extended the CCR formulations, to account for variable returns on scale, by adding the constraints $\vec{1}\lambda = 1$. Their BCC model, compared to the CCR, imposes only the assumption of concavity of the frontier.

Every DEA model is solved separately for each DMU (n formulations for n DMUs) resulting to its relative efficiency score θ or φ. In an extension of standard DEA modeling, that allows the ranking of all DMUs, Andersen & Petersen [3] compute the maximal feasible radial change of an efficient DMU's outputs (in input orientation) or inputs (in output orientation), such that the DMU remains efficient. Formally, this is achieved if the DMU under consideration is excluded from the above mentioned constraints (i.e. the definition of the technology set). Then, the computed score of the DMU (θ >1 in input orientation) is called *super efficiency* score and the DMU is called *super efficient*.

There are a number of other DEA models referred to in the recent literature. For a further analysis and discussion of these models and their applications, useful directions are given for the reader in [6] and [7].

A typical methodology in using DEA is the following:

i. Evaluation of the data, location of outliers and DMUs that perform unique activities.
ii. Pre-assessment clustering of the units to identify and isolate potential performance differences that might be attributed to group associations.
iii. Selection of the appropriate model.
iv. Selection of inputs and outputs (discretional and non-discretional), that reflect the management's objective criteria.
v. Evaluation of the results.

The *strengths of DEA* are mainly:

- There are no restrictions imposed on the functional form of the production response relating inputs and outputs.
- Each DMU is directly compared to an Efficient Reference Set, which leads straight through to the sources of its inefficiencies.
- It can handle multiple inputs and outputs stated in different measurement units.
- Elasticity in the choice of the weights.

6. EVALUATION OF THE PERSONNEL'S PRODUCTIVITY

Perhaps the best potential use of DEA in improving managerial efficiency comes from the analysis of the branches of an individual financial institution. The "best" and "worst" practices that are discovered can be used to rewrite policies and procedures for the branches. In addition upper management may use frontier efficiency rankings to determine which branches are in most need of reform, local management replacement or closure.

A significant question arising when trying to re-organize a branch network is that of measuring the efficiency of a branch that is its degree of productive transformation of inputs (staff, premises equipment etc) into outputs (transactions, sales of products, new accounts etc). There is a number of relevant articles in bibliography, like [9], [15], [17], [19] etc. Of course, as mentioned before, the kind of inputs and outputs, or their measurement units are depended on the chosen approach of the application.

In the present situation, it was more important to realize the level of efficiency of the branches' *accounting staff*, for several reasons:

i. From the beginning of the BPR project it was obvious that branches were over-staffed, regarding the demographic and welfare size of the country.
ii. This fact was amplified by the launching of the new information platform that computerized a serious amount of everyday operations.
iii. The new organizational schemes in the branch should be in accordance with the total range of supervision within it.

Table 4: Human Resources' efficiency evaluation

BR.	Score	Benchmarks	Personnel in excess
B1	55.92%	6 (0.2924) 19 (0.0070)	44.12%
B2	50.53%	19 (0.1166)	49.47%
B3	75.48%	6 (0.4058) 19 (0.0874)	24.52%
B4	73.42%	6 (0.2971) 19 (0.0157)	26.62%
B5	80.95%	6 (0.4633) 19 (0.0156)	19.03%
B6	104.31%	21	0.00%
B7	59.18%	19 (0.1366)	40.81%
B8	61.28%	6 (0.4919) 19 (0.0272)	38.71%
B9	60.38%	6 (0.0418) 19 (0.0335)	39.58%
B10	52.41%	6 (0.3024) 19 (0.0467)	47.61%
B11	47.18%	6 (0.0795) 19 (0.0352)	52.79%
B12	65.78%	6 (0.3040) 19 (0.0173)	34.20%
B13	53.35%	6 (0.2886) 19 (0.1940)	46.64%
B14	70.63%	6 (0.5714) 19 (0.0846)	29.39%
B15	68.04%	6 (0.7249) 19 (0.0705)	31.96%
B16	59.28%	6 (0.3016) 19 (0.1391)	40.73%
B17	79.25%	6 (0.2755) 19 (0.0271)	20.80%
B18	85.82%	6 (0.0831) 19 (0.0981)	14.19%
B19	134.03%	20	-43.22%
B20	81.65%	6 (0.4512)	18.35%
B21	79.74%	6 (0.1382) 19 (0.0397)	20.26%
B22	40.36%	6 (0.1168)	59.65%
B23	72.66%	6 (0.5354)	27.34%
B24	71.15%	6 (0.2177) 19 (0.0395)	28.82%
B25	44.63%	6 (0.1049) 19 (0.0002)	55.33%
Avrg.	69.10%		27,77%

It should be stated here that, in the Bank, there did not exist any formal hierarchy in the units of a branch (there did not exist a chief executive of the unit). All employees, theoretically, referred directly to the branch manager or sub managers, and only their employment maturity, expressed as the resultant of education & years of employment, was the yardstick of their position in the branch.

Therefore, the total number of *accounting employees* per branch was regarded as the one and only input. On the other hand, the outputs were the same as in the ranking of branches process, excluding the number of sub branches, because this criterion does not have to do with the productivity of the branch's staff. So, seven outputs were taken into account. Also, 10 weight restrictions of the form $q_i \succ q_j$ (where q_i is TT or FTT and q_j are the other five outputs) have been added, in order to ensure that the criteria "Teller Transactions" and "Fund Transfer Transactions" are relatively higher rated, as they are the most overwhelming components in a branch's operation. Finally, the constant returns to scale environment was chosen, as the most appropriate in the situation.

The CCR input model with super efficiency was used, with no pre-assessment clustering imposed, since there was no evidence about any group associations. The computation was aided by the Dortmund University EMS software package (http://www.wiso.uni-dortmund.de/lsfg/or/scheel/ems) and gave the results of Table 4.

According to the results:

1. The average efficiency of the network is 69%, which is considered as comparatively low.
2. B19 and B6 are the only efficient branches.
3. Benchmarks of inefficient branches are derived as linear combinations of the efficient branches' inputs.
4. Estimation of the efficient targets, for the inefficient branches, results to a potential total cost decrease, in accounting staff, up to 27.77%.
5. Branch B19 is aroused as super-efficient by 34%, meaning that it uses less than optimal employees to achieve the tasks it must handle.
6. Efficiency scores of the branches are not related to the categorization scores. In this manner, certain branches like B20 and B21, that were ranked low in categorization (low volume of operations), achieve a relatively better score in efficiency measurement (this volume of operations is achieved with proportionally less staff), than other branches like B2, that show the opposite results.

It was a pleasant surprise, when presenting these results to the upper management executives of the Bank, to realize that they were, more or less, analogous with the results of a parallel project of the Human Resources Division, which used only empirical data on branch operations. This was a convincing guide both for the BPR team and the Bank executives that the method used was in the right direction.

7. EPILOGUE

Applying business process reengineering (BPR) on an organization includes the rearrangement of organizational structures, processes and tasks, as well as the relocation of individuals and changes of work positions.

The aim of the study is to show how certain operational research methods can be applied in order to back up managerial decisions about new organizational schemas based on undisputed "countable" proofs. The results that are discovered can be used to reanalyze procedures for the branches. In addition, they are useful for the determination of the branches that are in most need of reform or relocation.

In this paper, two specific aspects of the Bank's branch network reorganization are addressed and the operational research tools used are presented. The initial ranking and classification of the branches was achieved with the use of Electre III and the efficiency of the personnel, by each branch, was measured with DEA. There is no doubt, that the reader might suggest of other methodologies, perhaps equally or more appropriate, but this comes beyond the main point of this article.

Since organizations are, more or less, stable systems that have to be disturbed for change, the explicit request and/or acceptance of proposed alterations by the upper management team has to be ensured, in advance. In this specific occasion, the recommendations presented here seemed to agree with the upper management's prevailing ideas or other relevant in-house studies. So they were positively accepted, and easily embodied in the Bank's short-term planning.

Finally, an intriguing perspective for future work in the framework of the present study would be to use results of other authors who work with similar methodologies (see e.g. [1], [12]) and apply them to categorization and ranking of bank branches.

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