Decision Support in Housing Loan Allocation: A Case Study

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Abstract. A decision support application is described in this paper that is aimed at housing loan allocation for the reconstruction of denationalised buildings in the city of Ljubljana, Slovenia. At the end of the year 1999, the Housing Fund of Ljubljana issued a float and earmarked 600 M SIT (3 M Euro) for the mentioned purpose. 256 loan applications were gathered requesting 686 M SIT. There were 215 complete and approved applications for the total amount of 551 M SIT. From the decision support perspective we developed a qualitative multi-attribute model for ranking applicants according to their priority based on the DEX methodology. This paper focuses on the lessons learned from the described real word case that can be effectively used in future decision support applications.

1 Introduction

In the last decade substantial efforts have been devoted to supporting tenders for housing loan applications in Slovenia (Bohanec, Cestnik and Rajkovic, 1996). Considerable experience has been gained since 1992 in particular with supporting management decisions for housing loan allocation together with the Housing Fund of the Republic of Slovenia. In this paper we describe one particular application for the Housing Fund of Ljubljana Municipality. This Fund had completed several floats of loans and wanted to upgrade the computer support for the given project. Their main motivation was to develop a decision support system (DSS) for supporting a tender for renovating old denationalised blocks of flats in Ljubljana.

The Housing Fund of Ljubljana Municipality earmarked 600 M Slovenian tolars (SIT), which roughly correspond to 3 M Euro, for loan consumption for the given purpose. In the first meetings with the client we had to further clarify the provisions of the tender, like for example that the main purpose was to renovate the whole blocks (shared building parts such as roof, facade, chimneys, windows, etc.). Two major categories of applicants were identified:

- A: applicants that own only one flat in which they reside (the flat must be in a denationalised block),
- B: applicants that own also some other flats (in the denationalised block) that are rented non-profitably.

The tender was published in December 1999 in daily newspapers so that the potential applicants were adequately informed. All the requirements for the application were clearly stated in the published tender.

The project was expected to comprise the following phases:

1. loan application gathering (scheduled for the first months of the year 2000),
2. (in)completeness notification and application completion,
3. decision about approved financial resources for applications,
4. notification of applicants about the outcome,
5. handling complaints.

Based on expert opinion we expected that the potential loan consumers would request about 1 000 M SIT; therefore, a DSS for ranking applications according to the approval priority was required in order to narrow the requested sum to the earmarked amount. Additionally, the development of the DSS was expected to yield some more benefits, in particular:

- clearer understanding of the problem domain (systematisation of the knowledge),
- better documentation of the decisions (transparency),
- easier and controlled adaptation to new requirements (flexibility),
- better explanation ability (what-if analysis).

2 System Development

The first step in the DSS development was to identify the parameters from a loan application that are crucial to implement two procedures:

1. to verify if a loan application satisfies the requirements of the tender,
2. to rank loan applications according to their priority to receive a loan.

Accordingly, we developed the knowledge base using DEX methodology (Bohanec, Rajkovic, 1990) as well as a supporting data base application. The knowledge base contained various evaluation and computational models related to priority ranking of loan applications and determining financial aspects of each application.

One of the major concerns in this phase was how to effectively limit the requested amount for loans. Since the earmarked amount was limited to 600 M SIT, it was reasonably to devote substantial effort to balance the demand (requested amount) to, for example, 1 000 M SIT. From our experience we knew that in such case the loan approval task (verification and ranking) could be performed effectively.

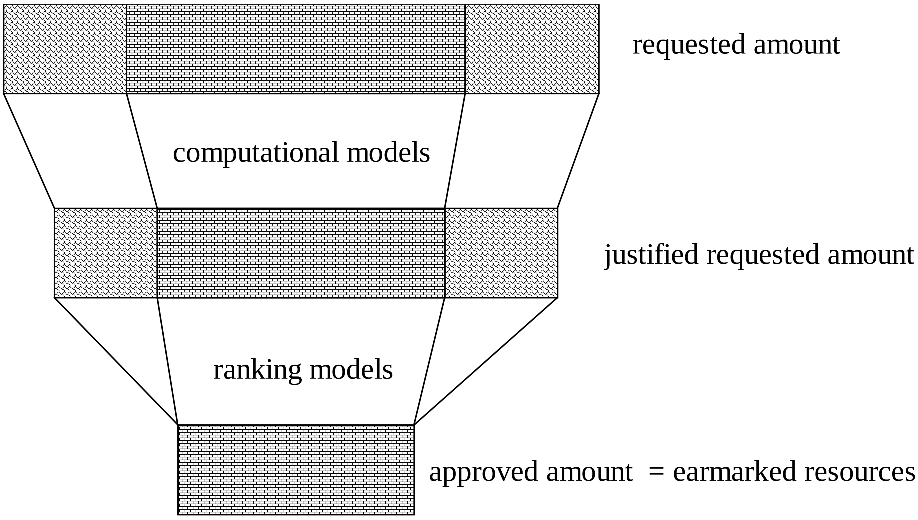

Fig. 1. From the requested amount to the approved amount

A general schema of the loan approval task when the supply is limited is shown in Fig. 1. The earmarked resources are shown at the bottom of the schema. In ideal case, at the end of the loan approval process the approved amount would be the same as the earmarked resources. The DSS should support the path from the requested amount, shown at the top of Fig. 1, using computational models to obtain the so-called justified requested amount and, finally, ranking models to obtain the approved amount. In a delicate problem domain, such as the loan approval domain, if the requested amount is substantially larger than the earmarked resources, the task turns out to be next to impossible. That is the main reason why limiting the allowed purpose of loan consumption (to roughly 150% of the earmarked amount), based on suppositions about the number of applicants, needs to be introduced.

The rest of the provisions of the tender were determined as a consequence of the discussions on the meetings with the client. Together we developed computational models and a DEX ranking model. Then, the necessary data for the models input were identified. The application form was designed so that all the required data for decision making and ranking were collected. Data definition and integrity constraints were designed based on the application form.

3 Life Cycle of a Loan Application

All the gathered loan applications had to be adequately handled by the DSS. The flowchart in Fig. 2 shows the possible application paths. First, an application has to be validated against the legal requirements and restricted the purpose of loan consumption (provisions of the tender).

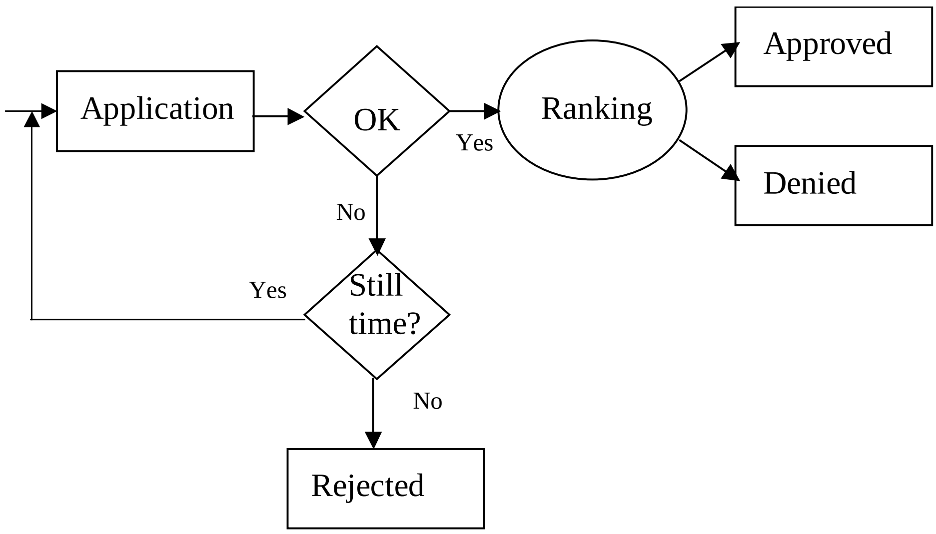

Fig. 2. Life cycle of a loan application

If there are some things missing, the applicant is notified that his/her application needs to be completed. After a reasonable amount of time, the application is rechecked and, if it remains incomplete, it is rejected. All complete loan applications then enter the DEX ranking model, where they are ranked according to their priority. Depending on application ranks, computational models and earmarked financial resources, each application is either approved or denied the requested loan.

4 Decision Models

The DSS contains two types of models: a qualitative multi-attribute model for priority ranking of applications, and computational models to perform various financial calculations.

4.1 DEX Application Ranking Model

The main role of the DEX model is to rank the applicants into five categories, where the rank 1 has the lowest priority, and the rank 5 the highest. The ranks of each application are used to determine the granted amount as a percentage of the requested amount, as well as determining the time schedule for loan consumption. In both cases loan applications with higher rank receive higher priority.

Each loan application is ranked into one of five priority classes based on the hierarchy of criteria shown in Fig. 3. The priority depends on three main groups of assessments: building condition, applicant status and advantages. Advantages are different for the two categories of applicants, A and B.

- **RANK**
  - **BUILDING**
    - In protected area
    - Age
  - **APPLICANT**
    - Investment part
    - Years in Ljubljana
  - **ADVANTAGES A, B**
  - **ADVANTAGES A**
    - **STATUS**
      - Earnings
      - Employed
    - **SOCIAL-HEALTH**
      - Health
    - **SOCIAL**
      - Family
      - Age
      - Children
  - **ADVANTAGES B**
    - Earnings from renting flats
    - Number of non-profit flats

Fig. 3. Criteria structure for determining loan application priority

All the criteria in the model are qualitative: their values typically express a level of priority. For example, there are four priority levels for the criterion *APPLICANT*: (1) normal, (2) priority, (3) high priority and (4) highest priority. The number of levels for a single criterion is determined according to the nature of the criterion and its desired impact. Typically, the criteria have 2 to 5 values.

The values of criteria at the bottom of the decision tree are determined from application data stored in a database. For example, the criterion *Investment part* has three values (levels of priority): (1) 40-49, (2) 50-59 and (3) over 60. The criterion *Investment part* represents the percent of applicant's own financial resources for the renovation with respect to the total cost. The actual value for a particular loan application is determined by computing its actual figures from the financial data provided by the applicant.

The values for criteria at higher levels of the tree are aggregated from the lower levels of the tree. Aggregation function is represented in the form of decision rules. For every criterion in the tree such rules are obtained in close communication with the client, since the rules represent the core DSS knowledge used in the application. For the *APPLICANT* criterion, decision rules that aggregate the values of *Investment part* and *Years in Ljubljana* are presented in Table 1.

Table 1. Decision rule for determining *APPLICANT* from *Investment part* and *Years in Ljubljana*

Investment part	***Years in Ljubljana***	***APPLICANT***
(1) 40-49	(1) less than 10	(1) normal
(2,3) 50-100	(1) less than 10	(2) priority
(1) 40-49	(2) 10-19	(2) priority
(2) 50-59	(2,3) over 10	(3) high priority
(1,2) 40-59	(3) over 20	(3) high priority
(3) over 60	(2,3) over 10	(4) highest priority

4.2 Computational Models

The application priority is just one of the factors that affect the amount of the loan granted to the applicant. There are also some other important factors, such as the amount the applicant has actually demanded, that had to be considered in determining the actual amount of approved financial resources. So, the main purpose of the computational models is to compute the granted amounts based on the predefined criteria.

In the tender it was clearly stated that the maximal approved sum for a single applicant should not exceed 60% of the applicant's owned share of the total reconstruction sum for the whole block. Namely, the applicants were encouraged to invest also at least 40% of their private funds. Moreover, in calculating the owned share in the building only the flats with non-profitable rents were accounted. For example, profitably rented flats and rented business offices were excluded from the calculations.

One additional constraint was introduced for the whole building. Namely, the sum of all approved applications for one block should not exceed 20 M SIT. Such global constraints must be accounted with particular precaution since it can only be done after the last phase as a verification and correction.

5 Results of the Application

In the first phase of the float, which was carried out in the beginning of 2000, the Housing Fund received only 109 applications requesting 286 M SIT, which corresponds to less than half of the earmarked amount. After a thorough examination of each application, only 81 complete and approved applications remained for a total amount of 188 M SIT.

Table 2. Statistics of the applicants after the first phase of the tender

	All applicants		Approved applicants	
Rank	**Number**	**Demanded (SIT)**	**Number**	**Approved (SIT)**
1	1	896 162	0	0
2	18	60 524 228	15	58 552 876
3	23	68 894 627	14	35 899 176
4	53	126 732 343	39	65 658 904
5	14	28 752 031	13	27 711 103
Total	**109**	**285 799 391**	**81**	**187 822 059**

The main reason for such low input of the applications was the limited scope of the tender with respect to the kinds of reconstruction work. So, after the completed first phase, the Fund decided to prolong the tender and extend it with additional types of reconstruction work.

Table 3. Statistics of the applicants after the second phase of the tender

	All applicants		Approved applicants	
Rank	**Number**	**Demanded (SIT)**	**Number**	**Approved (SIT)**
1	3	2 389 767	1	1 493 605
2	49	111 001 508	43	103 764 299
3	72	156 011 221	54	120 647 602
4	116	376 203 328	100	287 270 070
5	18	36 935 681	17	37 792 206
Total	**258**	**682 541 505**	**215**	**550 967 782**

6 Extending the Tender with Additional Purposes

Since only a third of the earmarked amount was consumed, the Fund's management decided to prolong the tender and additionally extend the purposes. While the first phase covered only roof renovation, facade renovation, chimneys renovation and windows renovation, the second phase includes also renovation of electrical, water, gas and central heating installments and renovation of lifts, boilers, etc.

In the second phase, 147 applications were additionally gathered requesting about 400 M SIT. Among them, 134 of the complete applications were approved with the total sum of 364 M SIT. Every applicant was notified about the decision and the complaints were also handled. New the total results are shown in the Table 3; almost all of the available money was consumed; therefore the Fund declared the tender completed and closed.

7 Lessons Learned

First, the employed DSS approach offers substantial degree of flexibility and robustness that is usually missing in more traditional approaches. In our case, the flexibility turned out to be the most important critical success factor for the whole practical application. When a new, unexpected condition occurs, such systems are supposed to offer a well-controlled pattern to resolve the intricate situation (Klein, Methlie, 1995).

Second, in order to reduce the complexity of the loan approval task when the supply is limited, it is wise to find a means to adequately limit the demand. However, this can be very delicate task, as it turned out in our practical application. Namely, all the decisions about the demand limitations had to be based on expert's suppositions that may eventually turn out not to be accurate enough. There might be the cases where such approaches yield relatively good results; however, it is impossible to completely rule out such anomalies. Consequently, the developing team should be prepared to react accordingly when such situations occur.

Last but not least, we found out that the explanation facilities of the developed approach contributed substantially to its overall success (Rajkovic, Bohanec, 1991). This was particularly important in the design stage of the system, when an intensive communication between the designers and managers is required. It turned out that the models provide an effective framework for the articulation of management's requirements. Additionally, in the loan approval state, the transparency facilitates the explanation of the process and its results to the loan applicants.

8 Conclusion

The primary goal of the described DSS application was to support the process of housing loan allocation for the reconstruction of denationalised buildings in the city of Ljubljana, Slovenia. The goal was successfully achieved and the customer (the Housing Fund of Ljubljana Municipality) was very pleased with the result. Usually, when we describe the basics of our DSS approach, we particularly stress two important features, flexibility and robustness. In this application, both features were challenged by some unexpected events that occurred during the process, such as low demand for loans in the first phase. Eventually, we managed to demonstrate that these features present a substantial ingredient of the described knowledge-based approach.

The most important part of our approach is a model for ranking applicants according to their priority. The model is based on DEX methodology (Bohanec, Rajkovic, 1990). The main role of the DEX model is to rank the applicants into five priority categories. The major benefits of having such model incorporated in the system (in contrast to traditionally 'manual' decision making) are:

- increased objectivity of the decision making process,
- improved effectiveness of decisions,
- high explanation power.

The ranks of each application are used to determine the granted amount as a percentage of the requested amount, as well as determining the time schedule for loan consumption. In both cases, loan applications with higher rank receive higher priority. In our case it turned out that the sum of requested amounts did not outgrow the earmarked financial resources; consequently, all complete applications were granted the requested loans. However, in our experience this is rather a special case than regularity. In most practical cases concerning loan approval applications it is reasonably to expect that the demand would outgrow the supply. From this perspective, the effort to develop the DEX model can be justified. In addition, as it turned out in our practical case, the approved applications had to be scheduled for loan consumption. The applicants were divided into two groups, where ranks 4 and 5 were allowed to consume the loans in the first month, and the rest in the second month. In summary, the development of the model was justified even in this somewhat unusual case.

From the fund's management perspective, the main benefits of having the tender supported with the developed application are the following:

- Clearer and well documented framework (defined purpose) of a tender,
- Established common grounds for the future fund's floats,
- Clearer and more focused communication between the fund's officers and applicants.

In our view, all these strong features represent a firm basis for future DSS applications of the similar kind.

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