A CASE-BASED REASONING APPROACH FOR PREDICTING BANK LENDING DECISIONS

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Abstract – This study proposes the use of a Case-Based Reasoning (CBR) approach to support the prediction of Bank Lending decisions.

The approach was applied to a survey of bank lending developed by the Eurosystem and conducted by the National Central Bank in each country. The main objective is to enhance the knowledge of credit standards and credit conditions in the euro area.

CBR is an Artificial Intelligence technique used to solve problems where human reasoning by analogy is simulated. We have created a CBR system that forecasts the future behaviour of the economic agents that offer credit. The CBR system uses the data from the Eurosystem survey for Portugal. Basically, it discovers the analogy between the current lending problem and previous lending cases and adapts the previous case decision to the new problem. This work describes the heuristic proposed to calculate the degree of similarity between past and new cases. The system takes objective and also subjective factors (Economic Sentiment) into consideration; these become the elements that lead to a decision on whether credit is granted. Pilot studies reveal that the system is capable of generating forecasts with a high level of accuracy. As a result, it clearly contributes to support monetary policy decision-making.

Keywords: Bank Lending Prediction, Case-Based Reasoning, Artificial Intelligence, Decision Support Systems.

I. INTRODUCTION

Banks play an important role in the economy, since they channel funds from households and enterprises which are net savers to those who are net borrowers [1].

Over recent years, a number of studies have in fact concluded that credit markets play an essential role in transmitting monetary policy initiatives to the real economy. There are a number of flaws in financial markets, such as in the granting of credit, which may hamper the way enterprises and households spend, to the extent that such flaws may prevent them from obtaining the financing requested [2].

Up to January 2003, the Eurosystem only had quantitative information on the credit market, that is, statistics for interest rates applied and credit granted by the banks. The European Central Bank (ECB) sought to complete these statistics and understand them better by carrying out a Bank Lending Survey (BLS) covering the private banks of member states. The survey in Portugal is being carried out by the Banco de Portugal.

In this context, it seems to be important to develop a system to help economic analysts to understand the changes in the credit standards and credit conditions applied to the approval of loans, facilitating in this way the preparation of economic studies and projections.

For this purpose, we have created a software system using a Case-Based Reasoning approach (CBR). This system forecasts the credit standards and conditions used by the banks when granting credit. It also provides an evaluation of the objective and subjective factors underlying the forecast. The CBR system developed uses the qualitative data collected through the Bank Lending Survey related to the Portuguese banks. The CBR system was developed in *Prolog* programming language.

CBR is an Artificial Intelligence technique used to solve problems where human analogy reasoning is simulated. This kind of reasoning allows us to solve a new problem through the adaptation of the way analogous problems have been solved in the past.

The choice of a CBR approach is linked to the fact that the technique provides automatic knowledge acquisition in poorly understood areas which are not easily approached through other techniques [3]. In this context, the CBR can even function as a cognitive model to forecast and analyse aspects of human thought and behaviour using past experiences [4].

The CBR system developed by us adapts past cases of credit decisions to forecast the future credit granting behaviour of economic agents. We have developed specific heuristics to compute the similarity between the current problem and previous cases during recall of similar cases, and to adapt the decision specified in the selected similar case to the new problem. In this study, the traditional CBR reasoning mechanism was extended with the possibility of representing hypotheses, which are used to capture subjective factors that influence credit decisions. In this paper, these subjective factors are called economic sentiment.

To evaluate the system, its results were compared with the answers collected from the BLS survey for the 1st and 2nd quarters of 2005.

The findings show that the system provides good quality predictions of the economic agents who are granting loans. Although quantification is somewhat

difficult, specifically for the conditions under which the credit is granted since replies here are qualitative, the system correctly predicted 90% of the approving the loan decisions. As could have been foreseen, the system's accuracy improves as its case base of previous cases becomes more comprehensive. The findings support the notion that CBR can be applied as a simple, intuitive and plausible process to cope with uncertain situations [3], capable of generating effective solutions for problems where the decision-making process is not known or when there is no deterministic model capturing the relationship between the problems and the solutions [5].

The tests also show that in both analysed segments (enterprises and households), economic sentiment has a decisive influence on standards applied to the approval of loans and the remaining conditions underlying the granting of credit.

This article is organised as follows. Section II presents an overview of the CBR approach and its advantages. Section III briefly describes the Bank Lending Survey, whose data was used in the developed system. Section IV presents the proposed CBR approach. Section V evaluates the proposed approach to forecast credit granting decisions. It provides a comparison between the system forecasts with the actual replies to the survey in the two quarters following those that have been used as input to the database. Finally, section VI presents conclusions and future research.

II. CBR OVERVIEW

CBR is an Artificial Intelligence technique used to solve problems where human analogy reasoning is simulated. Through analogy reasoning, new problems are solved by the adaptation of solutions used to solve previous similar problems. The most significant advantage of CBR is that it does not rely on knowledge / models capturing general relations in the domain. Instead, it searches, calls up, reuses and adapts past experiences (representing previous specific problems) to solve an existing situation [6].

The CBR technique has been described many times as "remember and adapt" or "remember and compare" [7]. It uses the following general methodology to generate a solution for a new problem using analogy with a previously solved problem:

- Identifying the current problem,
- Searching for similar cases in the case base,
- Generating a new solution for the current problem using solutions from similar stored problems,
- Deciding if the new case (current problem and generated solution) should be added to the case base.

This method is based on the assumption that, in the CBR application domain, similar problems with similar solutions tend to occur.

It is accepted now that CBR is made up of four components or main processes, usually referred in the literature as the four "Rs": retrieve, reuse, revise and retain, as illustrated in figure 1.

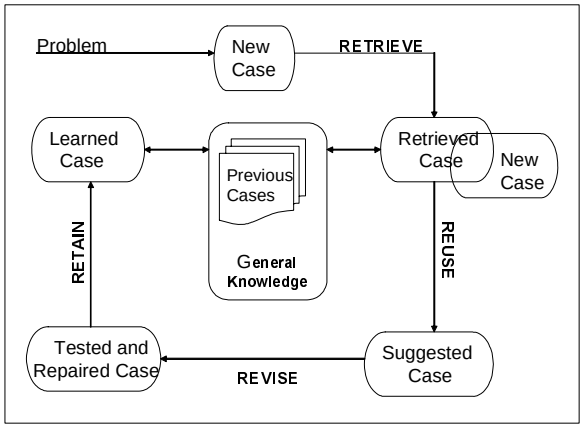

Figure 1- The CBR cycle

In ideal situations, the previous experiences which are retrieved from the case base can be reused directly to solve new problems. However, in many situations, past cases need to be revised (adapted) so as to obtain good solutions for new problems. These may in turn be retained and thus be added as new cases.

For the field of this study, the application of a rule-based system [8] is inadequate because there are no available fully understood and well structured general rules capturing the relationships between problems and credit decisions. Besides, it is believed that rule-based decision-making in the credit granting domain would not be enough since credit granting decisions depend on human intervention in situations where economic circumstances can be interpreted in a number of different ways. A rule-based system requires the acquisition of general knowledge in any given field and its conversion into a formal system, which is not currently available. A case-based system, however, does not require such acquisition of general knowledge. It is based on the use of analogies between the new problem and past specific cases (problem-solution); it does not involve the abstraction need by the rule-based approach.

Another advantage of CBR over rule-based systems is that the former is amenable to the incremental development of knowledge, which means that less initial knowledge is required [9].

There are obvious problems in choosing a single technique for solving problems in poorly understood domains, where modelling is complex or information is difficult to acquire. A variety of techniques have been used to solve the problems that arise during the CBR cycle. There has been increasing development of hybrid systems, specifically the combination of techniques such as fuzzy logic, neural networks and genetic algorithms with CBR [10, 11, 12]. Some authors even maintain that CBR is not a technique but a methodology, combining a number of the techniques mentioned above [9].

Bearing in mind the characteristics of the problem (lack of knowledge, not fully understood) it was decided to choose a pure CBR approach to better understand and control the experiments phase.

A system based on CBR also has great potential when it comes to learning. This is because its learning process is relatively simple: existing problems can be stored as new cases in the system case base, improving the process of finding good solutions to new problems. Stored cases may represent successful or unsuccessful solutions to previous problems, and thus contribute to prevent repetition of wrong decisions.

There are no specific references in CBR research relating to the problem of forecasting credit granting decisions, maybe due to the fact that this is a very specific emerging area. Indeed, only in 2002 did the European National Central Banks (NCBs) begin to come to grips with understanding what leads commercial banks to grant credit. Up to that point, credit market analysis in Europe's NCBs was made on an *ad-hoc* basis using statistics on interest rates and the amount of credit granted.

Be that as it may, reference can be made to the positive work in the application of CBR in application domains close to the present study [13] [14] [15].

III. CREDIT MARKET SURVEY

The credit market is extremely relevant for an assessment of how economies work. With this in mind, in 2003, the Eurosystem created a quarterly survey of the credit market in the euro area. This is carried out in Portugal by the Banco de Portugal. The aim is to gather information on the factors, criteria and conditions applied to credit granting, beyond the cost of credit (the interest rate).

This survey on the credit market will boost the available information and will help in the interpretation of European Central Bank (ECB) statistics on the criteria and conditions used for granting credit, along with the factors underlying the decision. The statistics show, for instance, how the amount of loans evolves but not the reasons for such evolution. Apart from this, the information obtained from the credit market survey should provide a clearer view of future economic developments and simplify the task of forecasting. This is above all true in changes anticipated in the patterns of credit and the demand for loans [2].

Other central banks (such as the US Federal Reserve and the Bank of Japan) have for some time been analysing qualitative information on the credit market. Their experience shows that this kind of information can provide important data for assessing past and future economic developments [16].

The survey takes the form of a questionnaire sent to those in charge of the banks' credit policy. This is normally a member of the board or the chairperson on the bank's credit committee. There are 18 questions on the credit market trend up to the present and the forecast for the future. These are the questions which are relevant for the two classes of borrowers analysed in this study, that is, enterprises and households. The questions are all qualitative. The value of the information gathered from this questionnaire is that it is obtained directly from the lenders (the banks). These institutions are in the best position to assess whether a loan is approved in specific circumstances on the basis of criteria not related to price and, if so, why this is the case.

The aim is of course to obtain information on the array of factors which have a bearing on the criterion used for the approval of loans, along with the conditions pertaining to the credit which is granted.

IV. THE APPROACH

It is difficult for economists to interpret the results and forecast the future behaviour of economic agents who grant credit, given the fact that information gathering on the factors underlying the granting of credit only began in January 2003.

The credit market is extremely relevant for an assessment of how economies work as the conditions prevailing in this market may affect the process of transmission of the monetary policy to economic activity. It is particularly important for the ECB Council to assess monetary and economic developments in the euro area, and understanding the way monetary policy relates with the decision-making process relating to credit granting decisions [2].

Bearing this in mind, a software system using a CBR approach is proposed as an application developed specifically as a tool for the economic analyst for forecasting the behaviour of economic agents in the credit conditions and credit standards applied to the approval of loans. In particular, the system aims at finding answers to the following questions:

- Decision-making – foresee the decisions of economic agents relating to the criterion for loan approval and the conditions inherent to credit granting (spread, length of the contract and guarantees requested),
- Decision factors – foresee what factors determine changes in the behaviour of economic agents when granting credit. For example, to what extent an increase in pressure from competition among banks will ease or tighten credit,
- The economic sentiment – to what extent this sentiment (expectations regarding economic activity in general, sectors or the risks attached to guarantees) conditions decisions.

The proposed system extends the traditional CBR approach with hypotheses that are used to capture the economic sentiment of the policy makers regarding the general economic evolution. This new mechanism allows the system to predict the decisions that would be made if the specified hypotheses were satisfied. That is, the answer is X if the hypothesis H is holds. The hypothesis may also be used as an additional condition of the problem. The introduction of this hypotheses mechanism in the CBR system developed provides the means to represent the economic sentiment of the economic agents regarding their subjective perception of state and evolution of the economy. The aim here is to assess the importance of subjective economic expecta-

tions in the decisions of economic agents who grant credit. A further contribution is the heuristic used to compute the similarity between the new problem and previous stored cases of credit granting decisions.

The generic case structure takes the following form:

- The problem is specified as a set of objective factors relating to a given situation in which the credit granting decision is to be made,
- The hypothesis is a single condition representing the economic sentiment of the decision-maker,
- The solution is the decision regarding credit granting. It specifies a set of actions relative to credit granting.

The CBR system developed describes each case with the following structure:

Case (Condition, Economic Sentiment, Decision)

The *Condition* component is made up of a series of literals: $[C_1, C_2, \ldots, C_n]$. Each literal C_i has the following structure:

Factor (bank, factor tendency)

The *Factor* represents one relevant characteristic of the domain, such as the cost of funds. The list of factors is as follows:

- Cost of funds,
- Pressure from competition,
- Financing needs,
- Demand for loans,
- Supply of loans,
- Debt restructuring,
- Use of alternative finance,
- Loans for house purchase,
- Consumer credit,
- Bank's liquidity position.

In relation to the arguments *bank* and *factor tendency*, the first refers to the credit institution while the second relates to the tendency associated to the factor. The values allowed for the tendency are as follows: increase, unchanged, decrease and non-existence.

The *Condition* reflects objective factors in the survey which are taken into account in the decision-making by the economic agent.

The *Economic Sentiment* is represented in the following way:

Economic Sentiment (bank, Economic Sentiment tendency)

The *Economic Sentiment* reflects subjective factors in the survey which can influence the banks' decisions. It was decided, at this stage of the work, to use a single predicate covering all the subjective aspects of the situation: expectations as to the economy in general, sectors or risks relating to the guarantees requested.

The argument *Economic Sentiment tendency* expresses the combination of these subjective features. Its possible values are as follow: very optimistic, optimistic, neutral, pessimistic and very pessimistic.

Using this literal, the forecast made by the system regarding the decision to grant credit can be related to various hypotheses.

The *Decision* component is made of a set of literals: $[D_1, D_2, \ldots, D_m]$, where each literal D_j has the following structure:

Decision (bank, decision tendency)

The *Decision* is the predicate of the solution and represents the behaviour of the bank related to the credit decision. The predicates considered are as follows:

- Approval of loans,
- Collateral requirements,
- Maturity,
- Spread.

In relation to the arguments, the first argument of each literal relates to the credit institution while the second refers to the tendency of the result obtained for a specific institution. The list of tendencies for predicate-decision is as follows:

- Tightened considerably,
- Tightened somewhat,
- Unchanged,
- Eased somewhat,
- Eased considerably.

As an illustration, a specific case is presented:

Case ([cost_of_funds (bank, increase),
Pressure_from_competition (bank, non-existence)],
[economic_sentiment (bank, pessimistic)],
[approval_of_loans (bank, tightened somewhat),
spread (bank, tightened considerably)]).

A. Decision-making process

The system starts by checking the case base relating to enterprises or to households, according to the current problem. It searches for the most similar cases to the problem currently described to the system.

The basis for computing the similarity between cases weights the similarity associated to the *Conditions* and the similarity associated with the *Economic Sentiment*.

The cases are selected when their similarity with the current problem exceeds the minimum level of similarity specified to the system. To this end, two levels of similarity were taken into consideration: one, more restrictive, for a first assessment of the cases and another one, less restrictive, for a further assessment when no cases are found satisfying the more restrictive similarity criterion. A 0.7 value was taken as the lower limit for the first similarity level and 0.5 for the second. The choice of these values was experimentally chosen.

Once the cases are selected, the next stage is the identification of the case or cases with the highest degree of similarity. If only one case is found, the problem is solved by adapting the solution of the selected case. Where various cases are found with the same degree of similarity, the economic analyst will have to decide on the best solution. In both situations, if a new case is created, it will automatically be added to a specific case base for storing new cases that were not directly retrieved from the answers to the survey. It is the economic analyst who makes the decision of whether or not to put the cases in the main case base.

In terms of retention, it is important to mention that the economic analyst has the final word regarding the inclu-

sion in the main case base, whereas inclusion is automatic for the secondary case base (as long as similarity is less than 1).

If there are no situations where the similarity threshold is reached, a second process is computed and potentially similar cases are selected. The basis for this is the less restrictive similarity criterion [lower limit, upper limit[(where the upper limit corresponds to the lower limit in the more restrictive criterion). The parameterization proposed corresponds to the interval [0.5, 0.7[.

When the best case or cases have been found using this second criterion, the condition attached to each case or cases will be adapted using the method of predicate instantiation. This procedure uses a table of predicates synonyms in the form:

synonym (P1, P2)

This clause means that the predicates P1 and P2 are synonymous. For example, the clause *synonym (market behaviour, demand for loans)* means that the *market behaviour* is considered synonymous with the *demand for loans.* After any substitution of predicates deemed necessary, the system again compares the problem with adapted cases, proposing the solution of the best case. The solved problem becomes a new case, which is, automatically added to the secondary case base (derived cases not resulting from the survey).

B. Similarity computing

The similarity of two cases results from weighting the similarity of the *Condition* with the similarity of the Hypothesis (i.e., economic sentiment). The result derives from the following calculation:

- Calculation of the similarity of the *Condition* (S1),
- Calculation (if necessary) of the similarity of the *Economic Sentiment* (S2),
- Calculation of general similarity (S) : S = S1*S2.

The similarity of the *Condition* (S1) is given as follows:

$$\frac{1}{1+\frac{|DDim|}{SDim}+SDif}$$

where:

DDim – Difference between the number of literals in the problem and in a case.

SDim – The sum of the literals in the problem with the number of the literals in a case.

SDif – The sum of the differences found by comparing the elements which make up a problem and the elements corresponding to a case. This will therefore be the sum of the differences relative to the predicates and the arguments.

For the calculation of *SDif*, the following factors were taken into consideration:

- The difference between predicates,
- The difference relating to the tendency argument.

The number of conditions in the problem and in the previous case is important, because the importance of the number of different predicates will increase as the dimension of the problem and the previously existing case decreases. The corollary of this premise is that the difference between the predicates should be weighted by 1/n, in which n=max (P,C) is the maximum between the problem dimension and the dimension of the previously existing case.

In the same way, the dimension is also relevant when arguments have to be differentiated. This being so, it was decided that the difference between arguments should be computed as follows:

- Difference between remote tendencies: 1/n
- Difference between close tendencies: 1/4n

(n = max (P,C))

As the number of conditions increases, the weight of a differential factor (argument or predicate) leads to less influence on the value of the overall similarity.

The weighting of the differences between arguments is more or less important depending on the values being compared. It was therefore decided to give greater weight to remote tendencies 1/n and lesser weight to close tendencies (1/4n). For instance, the difference between the tendencies “increase” and “reduction” will therefore, as a corollary, have more weight than the difference between the tendencies “increase” and “unchanged” or “unchanged” and “decrease”.

When the predicates are different, no weighting is given to the differences of arguments since it is taken that these may not make sense, i.e., an increase associated with a predicate may correspond to a reduction relative to another predicate, in terms of influence on whether credit is granted.

When the number of different predicates is the same as the maximum between the new problem conditions and the previously existing case condition it was decided not to consider the existing case as a potential solution.

The proposed formula and weightings for similarity computation were chosen so that the computation could be as general as possible, independent of specific situations and resulting from an empirical analysis of the facts already recorded. The introduced factors which take into consideration the number of literals were put in on the understanding that both the sum and the number of literals are quantitative factors of relevance to separate out different situations.

The representation of the economic sentiment reflects the subjective factors considered in this study: expectations relating to the economy in general, the prospects for certain sectors or enterprises and the risks attached to requested guarantees. The representation of this sentiment in the hypotheses, as already mentioned, allows its importance in the decision-making process to be assessed. For example, it would be possible to assess the impact on a solution by changing the tendency (optimist, pessimist) of the economic sentiment.

In terms of economic sentiment, the similarity criterion was defined as follows:

- Similarity = 1, when economic sentiment is the same,

- Similarity = 0.9, when the tendencies are close:
  very optimistic and optimistic or
  very pessimistic and pessimistic
- Similarity = 0, in any other situation.

The value chosen for the similarity in situations where tendencies are close is justified by the consideration that they will not be very different, from the practical and subjective point of view. In relation to other situations, at this stage of the study, they are not taken into consideration because they are difficult to judge.

Since the similarity between cases is S1*S2, it is necessary to assume a value for S2 when the new problem or the previously existing case do not have economic sentiment. We have chosen the value 0.8, for the following reasons: The chosen value had to be less than 0.9 (the value of a case with economic sentiment where the tendency is close to the problem). The chosen value would have to be sufficiently high to allow these cases (without economic sentiment) to be considered. A case without economic sentiment is considered to be less relevant than a case with an approximate economic sentiment.

The proposed similarity criterion derives from the idea that, in addition to the formal methods to model the human behaviour, it is also important to conduct an empirical analysis in order to consider the multiples aspects and the uncertainty associated to the domain specific scenarios [5].

V. RESULTS

The fundamental objective of the performed tests was to assess the capacity of the system to come up with answers in the main area of concern – as a tool to help the economic analyst to forecast and understand the behaviour of economic agents responsible for granting credit. One of the specific aims was to assess the role played by the economic sentiment in the decision-making process of those granting credit. The tests were carried out on the two segments of the market, enterprises and households, for which two case bases were used.

The Eurosystem has set out rules on confidentiality, regarding both the identification of banks taking part in the survey and also the individual replies. Our case bases were therefore built on aggregate data from individual replies, in line with the information published quarterly by the Banco de Portugal.

A. Interaction with the system

To illustrate how the system can be used, let us take the following economic case:

- Market behaviour is improving,
- The cost of funds is increasing,
- Competition between the banks is decreasing,
- There is a pessimistic economic sentiment as regards the economy in general.

To find the reply (the forecast) from the system, the procedures for a CBR approach are carried out through *Prolog* language interpreter. Two procedures were run: the first relating to the main similarity criterion and the other relating to the second.

1. Basic procedure carried out (1st criterion)

solve_Problem (enterprise,
[market_behaviour (bank, increase),
cost_of_funds (bank, increase),
pressure_from_competition (bank, decrease)],
[economic_sentiment (bank, pessimistic)]).

Result:
... no solution found (1st criterion)

As no solution was found, the procedure for the second, less restrictive criterion was carried out.

2. Second procedure carried out (2nd criterion)

Solve2_Problem (enterprise,
[market_behaviour (bank, increase),
cost_of_funds (bank, increase),
pressure_from_competition (bank, decrease)],
[economic_sentiment (bank, pessimistic)]).

Result:

Problem
[market_behaviour (bank, increase),
cost_of_funds (bank, increase),
pressure_from_competition (bank, decrease)]

Economic sentiment
[economic_sentiment (bank, pessimistic)]

Best similar case
[debt_restructuring (bank, increase),
demand_for_loans (bank, increase),
cost_of_funds (bank, increase)],
[economic_sentiment (bank, pessimistic)],
[approval_of_loans (bank, tightened somewhat),
spread (bank, tightened somewhat)]

Similarity: 0.75 (2nd criterion)

Adaptation
[pressure_from_competition (bank, decrease),
demand_for_loans (bank, increase),
cost_of_funds (bank, increase)],
[economic_sentiment (bank, pessimistic)],
[approval_of_loans (bank, tightened somewhat),
spread (bank, tightened somewhat)]

The interaction described above works as follows: a) when the 1st (more restrictive) procedure was carried out, no solution was found; b) when the 2nd (less restrictive) procedure was carried out using the 2nd similarity criterion, it was possible to reach a result (forecast) through adaptation of the decision specified in the previously existing case that has been selected.

The adaptation procedure uses the method of substitution by reinstatement of the predicate *market behaviour* by its synonym *demand for loans*. This allows for a similarity to be reached within the criterion [0.7, 1], the interval defined for a solution to be considered. The similarity found (0.75) corresponds to the difference of one predicate (pressure from competition and debt restructuring).

B. Replies to the questions

The case bases contain the information reported in the quarterly surveys for 2003 and 2004.

The evaluation of the system has been performed by comparing the predicted solution with the effective answers reported for the 1st and 2nd surveys of 2005.

1) Forecast quality

An analysis of the results for the problems presented in the first quarter of 2005, lead to the following interpretations:

The results point to an approximation between system's forecasts and the actual answers retrieved from the survey specifically as regards the decision for approval of loans (see figure 2). The differences regarding the credit conditions (the spread, maturity and collateral requirements) can to a certain extent be relativized, given the degree of similarity obtained for the solutions put forward by the system.

The second quarter of 2005 shows a similar trend to the previous quarter and is characterised mainly by neutral prospects where the economic sentiment is concerned and this is confirmed by the number of cases with optimistic/pessimistic reference.

When the real cases from the first quarter are incorporated and the CBR system is executed again, the results show that the introduction of cases from the earlier quarter has a positive influence on the results of the second test. The introduction of new cases improves the quality of the system forecasts.

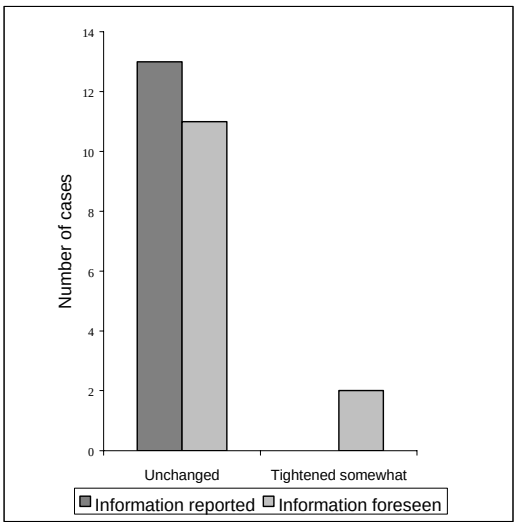

Figure 2- Comparison between information reported and foreseen for the approval of loans – 1st quarter 2005

The comparison of results obtained from the system and those reported through the survey indicates that decisions are similar, specifically regarding the criterion for approval of loans. The differences noted in some of the conditions for approval are relatively unimportant, and when they exist, they vary at most within one degree of the value of the tendency, which is not seen as significant.

2) Within the scope of the factors

The purpose of this section is to assess the influence of a number of factors in the approval of loans. The tests were undertaken by selecting two of the factors deemed most relevant: pressure from competition and the cost of funds.

When the possible influence of other criteria is ruled out, the results indicate that:

The increase / decrease of the cost of funds implies a tightening / easing of credit standards applied to the approval of loan requests;

The pressure from competition seems to lead to the same conclusion, but the influence is not so marked;

The two factors combined, with opposing tendency, clearly reinforce the trend towards approval of loan requests.

The increase in pressure from competition combined with decreasing cost of funds contributes to a less restrictive frame in the criterion for approval of loans. On the other hand, an increase in the cost of funds combined with a decrease of the pressure from competition leads to a more restrictive frame in the criterion for approval of loans.

3) Within the scope of the economic sentiment indicator

The aim here was to test hypotheses for the subjective factor, i.e., to assess the role of the economic sentiment. Specifically, the idea is to understand to what extent the confidence or expectations of economic agents regarding the economic cycle influence the decision.

When the hypothesis is part of the problem it is possible to evaluate the importance of economic sentiment compared to the other factors. In this case, the results point to the influence of economic sentiment in the decision-making process. From the economic point of view, when the sentiment is neutral, the replies indicate a move towards a less restrictive approach to loan approvals. On the other hand, when economic sentiment worsens (pessimistic or very pessimistic), the criterion for approval and the conditions for approval tighten considerably. It can be concluded from this that economic sentiment outpaced other factors in the decision-making process.

When the hypothesis is used with the idea of qualifying the system forecast, it was possible to evaluate how the economic sentiment influences the decision In result, as would be natural, it is possible to verify that when the economic sentiment goes down, the criterion of approval of loans and the conditions applied to credit granting tend to get worse.

VI. CONCLUSIONS

The results obtained lead to the conclusion that the system can forecast with considerable precision (90%) the decision of economic agents.

The experiments with hypotheses also show that the economic sentiment play a decisive role in both considered segments (enterprises and households) regarding the criterion for loan approvals and the other conditions underlying credit granting.

In terms of contributions towards further research, it is proposed a CBR approach to an economic area which is little understood and which is at present being studied by the Banco de Portugal and the Eurosystem. As for the specific approach based on CBR, a heuristic is proposed for the calculation of similarity between cases in the process of selecting previously existing cases analogous to the current problem specified to the system. Furthermore, in the search for solutions, a table of synonyms is used as support for adaptation of the decisions specified in previous cases.

A. Future work

The work described in this paper is the basis upon which a system in the Economic Research Department of the Banco de Portugal will be developed in the near future.

The system proposed can be used by any country in the euro area, or for the euro area as a whole. The system to be developed will allow using the argument *bank* to identify each of the institutions replying to the survey. In this situation, it will be possible to forecast the decisions made by each institution and to study its behaviour.

Some lines of research can be suggested for future development:

1) In terms of the approach

- Compare the approach proposed in this study with situations put forward by other countries in the Eurosystem,
- Incorporate a temporal dimension in the system (quarters and years) to facilitate the interpretation of data in terms of economic cycles.

2) In terms of the system

- Development of a graphical user interface, making the system more user-friendly for the economic analyst,
- The system may be extended to assists the economic analysts in maintaining the case bases.

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