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ABSTRACT

The normative focus of political behaviour assumes that voters are rational and apply the same method of reasoning when they choose how to vote. Given the restrictions of this canonical view of voting theory, some authors have decided to explain the voter's decision from a prescriptive or descriptive perspective. In this paper, we develop an adaptive model that describes the different sequential decision-making processes that voters apply. The goal is ultimately to identify the heuristic rules that characterize the political behaviour of individuals. To do this, we use a classification technique from the field of automatic learning: decision trees. On the empirical level, we find that Spanish voters perform sequential reasoning. The first heuristic that guides their choice is the memory of the vote in the last general elections. Next, voters use a sequence of other arguments to decide how to vote.

Key words: voting decision; heuristics; decision tree; probit function.
Classification JEL: C25; C49; D83.

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1. Introduction

If we perform an exhaustive review of the literature on political behaviour, we find that it is strongly influenced by the normative focus on decision theory, the goal of which is to explain how a rational voter should act when making a decision. However, both the normative and the prescriptive focus assume that all individuals use an identical reasoning process. To overcome this limitation, Payne et al. (1993) propose the alternative theory of adaptive decision-making, whose goal is to explain how different individuals make decisions. The descriptive paradigm of the decision shows us the order of the process that human beings follow when they have to choose.

In this study, we develop an adaptive model, descriptive in nature, which explains the sequential decision-making processes voters apply. To do this, we develop a classification technique from the area of automatic learning: decision trees. The ultimate goal is to identify the heuristic rules that govern the voting behaviour of voters. For the learning process, we use the J4.8 algorithm[2] (Witten and Frank, 2000). The results obtained will be contrasted for robustness through comparison to the estimation of a binomial *probit* model, an alternative technique that can be used to classify instances, examples or cases. The data chosen come from Database of the Centro de Investigaciones Sociológicas (CIS).

This document is divided in six sections in addition to the introduction. In the next section, we review decision-making theory and voting behaviour. We then develop an adaptive voting model based on decision trees. For the learning process of the decision tree, we use the J4.8 algorithm (section 3). In section 4, we present the data used and define the attributes and class labels of the decision tree. We then interpret the decision tree obtained and the system of rules deduced from it (section 5). We end the article with a section on conclusions that presents the most significant contributions of the research.

2. Decision theory and voting behaviour

If we examine the formal nature of parametric decision theory, we conclude that the agent’s attitude can be analysed from three different perspectives (Bell, Rafia and Tversky, 1998, and Selten, 1996): (i) normative, which analyses the decision that a rational agent should adopt; (ii) prescriptive, which explains how an agent can choose well, given his or her cognitive and informational limitations; and (iii) descriptive, which studies the form of the decision process.

The normative theory of the individual decision asserts that the choice of a rational agent verifies the principle of utility when there is certainty about the rewards of the different objects or sets that compose the election space However, if the agent is uncertain, the principle of maximization of expected utility is verified. The Allais paradox and consistent experimental evidence contributed by Tversky and Kahneman have criticized normative decision theory for not always explaining the real behaviour of agents correctly. During the 1980s and 90s, many studies were published that tried to explain the decisions of agents that did not fit the standard paradigm of expected utility theory by preserving the central hypotheses of normative decision-making but relaxing some of the assumptions of expected utility theory or introducing modifications (Goldstein, William and Hogarth, 1997).

[2] The J4.8 algorithm implemented by Weka 3.3.5 is an adaptation of the C4.5 algorithm (Witten and Frank, 2000: 269).

The hypothesis of limited rationality goes farther and rejects the canonical paradigm of decision theory: the goal is to explain the choice of a rationally limited agent. Simon (1957) argues that, in an environment of uncertainty, rationally limited agents follow a decision process oriented to the satisfaction of expectations. This process ends when the individual finds a satisfactory alternative that exceeds the levels of aspiration established concerning the variable goal or objective. From the perspective of economic theory, Selten (1999: 13-17) also proposes that rationally limited agents adopt their decision based on the model of adaptive aspiration, since it is impossible for them to optimise a process of choosing conditioned by the short time available to make the decision.

Payne, Bettman and Johnson (1993) show that, in an environment of uncertainty, one cannot assume that all the agents seek as their objective to choose the object or set that satisfies them This occurs because human beings are adaptable and usually use different heuristics when they choose[3]. We can thus describe the decision through the set of rules that are the product of a sequence of operations represented by conditional operators.

From voting behaviour theory, Baldassarri and Schadee (2006: 450-51) indicate that there are two major paradigms for analysing the heuristics that govern the decision process of a voter who is uncertain about the vote: (i) the theory of heuristics and prejudices (Kahneman and Tversky, 1972; Kahneman, 1982; Gilovich, 2002), and (ii) the model of fast and frugal heuristics (Gigerenzer, 1999; Gigerenzer and Selten, 2001). Fast and frugal heuristics are better suited to explaining voting behaviour, since voters have a limited capacity and limited time for reasoning about their decision and seek not optimisation but satisfaction as their goal. This explains why individuals perform sequential reasoning, which can be described through an algorithm in which only one or at most a very small number of heuristics operate.

A priori, the heuristic vision of the theory of political behaviour has some advantages over the canonical paradigm: (i) it does not require that the voter act as a rational agent, (ii) it does not impose that all voters apply the same decision process, and (iii) it permits identification of the rules that govern the heterogeneous behaviour of voters (Sniderman, Brody and Tetlok, 1991, and Lupia, McCubbins and Popkin, 2000).

For Lupia and McCubbins (2000), voters use the political information that enables them to make a reasoned choice, the same choice that they would have made had they known the consequences of their actions. What do voters need to know when they make their decision? To answer this question, Lupia and McCubbins formulated the theory of the calculus of attention, based on the knowledge and calculations that the voter must make before adopting a rational decision. Voters must know something about the consequences of the actions. Only so can they calculate the benefit they expect to gain from attending to a stimulus that predisposes them to adopt an incorrect decision. In addition to knowledge, any rational voter must anticipate the possible consequences of the different actions he or she can adopt, that is, the voter must have rules that orient this decision.

From the cognitive theory of voting behaviour, Taber and Steenbergen (1995) performed an experiment with 145 students from Stony Brook, applying computational methods to explain the complex

[3] In general, the heuristic is a set of cognitive mechanisms shaped by evolution and learning in the human mind (Todd and Gigerenzer, 2003: 149).

symbolic processes that can orient voters' decisions. These authors argue that the rules operating in voting behaviour can be identified by the application of algorithms that explain how the inputs of the decision—that is, the information on the attributes and alternatives from which to choose—are transformed into outputs. Hogarth (1987) and Wright (1984) have proposed a high number of decision rules that describe voters' behaviour, but from a descriptive perspective.

3. The model and the method

The goal of this study is to describe the sequential decision process followed by different voters based on the voting preferences revealed. To achieve this, we propose an adaptive model that explains how the voters decide based on decision trees. For the learning process of the tree, we use the J4.8 algorithm. Unlike the canonical paradigm of the theory of voting behaviour, this model does not introduce any specific assumption about the goal that the voter pursues:

Voter *i*[4], reveals that he or she voted for y_f, such that y_f belongs to the domain *Dom(Y)*[5]. In addition to the decision observed in the voter, we have other information χ , which is the space composed of all of the attributes or characteristics that orient the choice $\chi = Dom(X_1)\times\cdots\times Dom(X_j)\times\cdots\times Dom(X_n)$.

Our database includes a set of examples, ε, such that each is a tuple of n attributes ($X_1,\cdots X_j,\cdots X_n$) plus a class label y_f that classifies it. ε consists of *s* instances $\left(\overline{x}_i, y_f\right)$[6], each of which is composed of the n entry values of the vector $\overline{x}_i$ and one exit value y_f.

If we apply a classificatory learning process to the set ε, we are able to extract knowledge on how voters decide. The classification is a process that learns a function $\xi : \chi \rightarrow Y$. In graphic terms, the previous function can be represented by a decision tree formed of nodes and branches. There are three kinds of nodes: (i) the root, which is the first node of the tree, (ii) the leaves, or the end nodes in which a decision is made about the class to be assigned, and (iii) the descriptors or intermediaries, which are the intermediate nodes between the root and the leaves[7]. Each internal node contains a univariate test of the values of the attribute chosen.

The criterion used as a heuristic for choosing an attribute X_j in the decision tree and inserting the corresponding internal node is the maximization of the information gain ratio R_G obtained from the set ε :

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[4] Let us assume that there are different kinds of voters $(i = 1,\cdots,s)$. To simplify the notation, we omit the subindex that refers to the voter.

[5] To simplify the model, we assume that the *Dom(Y)* includes two values: voting for the *incumbent* candidate, y_g or choosing the *challenger* y_q. Among the political options that shape the *challenger,* we do not include the following options: that the voter will not vote, will abstain or will turn in a blank ballot.

[6] $\overline{x}_i = \left(x_{1,i},\cdots,x_{j,i},\cdots,x_{n,i}\right) \quad \forall i = 1,\cdots,s$.

[7] The root and intermediate nodes are also called internal nodes.

$$\underset{X_j \in \chi}{arg\,max}\, R_G(\varepsilon, X_j) = \frac{G(\varepsilon, X_j)}{I(\varepsilon, X_j)} \quad (1)$$

where

$$G(\varepsilon, X_j) = Ent(\varepsilon) - \sum_{|x_j|} \frac{|\varepsilon(x_j)|}{|\varepsilon|} Ent[\varepsilon(x_j)] \quad (2)$$

$$I(\varepsilon, X_j) = -\sum_{|x_j|} \frac{|\varepsilon(x_j)|}{|\varepsilon|} Ent[\varepsilon(x_j)] log_2\left(\frac{|\varepsilon(x_j)|}{|\varepsilon|}\right) \quad (3)$$

$Ent(\varepsilon)$ is the entropy of the set ε [8].

x_j is the value of the attribute X_j, for the case of the voter *i*.

$|x_j|$ the number of different values of x_j.

$\varepsilon(x_j)$ is a subset of ε, by which we verify that $X_j = x_j$.

$|\varepsilon(x_j)|$ the cardinal of $\varepsilon(x_j)$.

$|\varepsilon|$ the total number of examples, instances or cases available.

$G(\varepsilon, X_j)$ measures the expected reduction of entropy, that is, the information gain obtained by decreasing the uncertainty in the set ε when we choose the attribute X_j. $I(\varepsilon, X_j)$. It is the separation of information, that is, that part of entropy in the set ε that corresponds to the values of attribute X_j.

In this case, we define the following entropy function:

$$Ent(\varepsilon) = -\sum_{y_f} \frac{frec(y_f, \varepsilon)}{|\varepsilon|} log_2\left(\frac{frec(y_f, \varepsilon)}{|\varepsilon|}\right) \quad (4)$$

where

$frec(y_f, \varepsilon)$ is the number of instances ε that contain the class label y_f.

$\frac{frec(y_f, \varepsilon)}{|\varepsilon|}$ the probability of an instance whose class label is y_f.

$\log_2\left(\frac{frec(y_f, \varepsilon)}{|\varepsilon|}\right)$ the information transmitted by the instance whose class label is y_f.

From the decision tree obtained, we can deduce the system of rules (Witten and Frank, 2000) by looking at the tree from the root to the leaf, passing through the descriptor nodes. Every rule consists of two elements: (i) the antecedent, which is a conjunction of the univariate tests performed in the

[8] Entropy $Ent(\cdot)$ is a measure of the disorder of a system, seen as the uncertainty in a set of examples (Abramson, 1963).

different internal nodes of each root, and (ii) the consequent, which is the class label predicted from the instances that satisfy the antecedent. The rules extracted are not independent and thus as a set describe the heuristics of the sequential decision process that the different voters follow when they have to choose how to vote.

For the learning process of the decision tree, we use the J4.8 algorithm. Initially, the algorithm takes all of the instances included in ε. If all of the examples belong to the same class label, the process ends, inserting a leaf node with its corresponding class label. In the opposite case, we choose the attribute X_j that best divides ε and insert a node with this characteristic, which represents a univariate test. Once the node has been created, for each different value x_j of the attribute X_j, we trace an arc and invoke the algorithm recursively to generate a sub-tree that classifies the examples of ε that verify $X_j = x_j$. We stop the process when all of the instances in the set belong to the same class label (Ruiz Sánchez, 2006: 17).

4. Data, attributes and class

The utility of the information extracted from the decision tree obtained is conditioned by the data used. Therefore, before executing the J4.8 algorithm, the following phases must be completed: (i) compilation of the information available, (ii) elimination of noise, completion of the missing values and elimination of *outlier* data, (iii) construction of new attributes from the original ones, and (iv) reduction of the database, eliminating the inconsistencies and proceeding to a prior selection of the attributes.

The data used in this research come from Study 2307 of the CIS Data Bank. This was a nationwide survey performed in October 1998, whose size is 2490 interviews. The sampling procedure used is multi-stage and stratified by conglomerates, using random walks to choose final sample units.

It was not necessary to apply any smoothing techniques, since we did not find noise in the data. We had to check that we had eliminated those instances with a missing value and that we did not identify any *outlier* data in the database.

Two new attributes were constructed to contrast whether the attribution of responsibility conditions the influence of sociotropic evaluation on the voting decision.

After performing an exhaustive analysis of the database, we eliminated the instances that correspond to interviewees 1784 and 1901, as they were inconsistent: they exhibited the same values in the attributes of a different value in the class label.

Once we eliminated the examples with missing values, the inconsistencies and the respondents who answered that they would not vote, would abstain or would turn in a blank ballot, the sample size was reduced to 780 cases.

The class reflects the voting preferences of the Spanish voter: the label “Gov” corresponds to the voter who would vote for the *incumbent* (during this period, the Partido Popular (the Popular Party)), if there were elections tomorrow; while “NoGov” represents a vote for the *challenger* (opposition parties and coalitions). In addition to class, we include sixteen attributes that reflect the influence on voting behaviour of the degree of responsibility attributed to the government for the economic situation, as well as the sociotropic and egotropic character of the vote, voters, the sociodemographic characteristics, contextual factors and the memory of voting in the general elections.

The degree of responsibility attributed to the executive is an attribute that consists of four values: “None,” “Low,” “Considerable” and “High.”

The retrospective evaluation of the country’s economic situation (RETROSPECTIVE NATIONAL ECONOMY) takes the value –1 when the voter thinks that the current situation is worse compared to the economic situation of the previous year, the value 0 if the voter finds the situation to be the same, and the value 1 when the voter believes that the current situation is better than the past. The prospective evaluation of the country’s economic situation (PROSPECTIVE NATIONAL ECONOMY) adopts the value –1 if the voter expects that the country’s economic situation will be worse next year than it is now, 0 when the voter perceives that it will not change, and 1 if the voter thinks it will improve.

As to the egotropic evaluation, we have differentiated between the retrospective evaluation (RETROSPECTIVE HOUSEHOLD ECONOMY) and the prospective (PROSPECTIVE HOUSEHOLD ECONOMY). The first variable takes the value “Worse,” when the voter believes that his or her personal or family economic situation has worsened as compared to the previous year, “The same” if he or she perceives that nothing has changed and “Better” if he or she considers that the family’s economic situation has improved throughout the past year. The prospective evaluation of the family’s situation is “Worse” when the voter expects the family’s economy to worsen during the next year, “The same” if the voter predicts that his or her economic situation will not change and “Better” if the voter believes that his or her family’s economy will improve.

In addition to the prospective evaluation of national and family economy, we included two interaction factors that show how the effect of the sociotropic evaluation is conditioned by the degree of responsibility for the economic situation that the voter attributes to the national government: (i) A_ RETNATECON, the product of the responsibility attributed times the retrospective sociotropic evaluation and (ii) A_PRONATECON, the result of multiplying the attribution of responsibility by the prospective sociotropic evaluation. Both characteristics range from value -3 to 3.

In addition to the attributes mentioned above, we include four sociodemographic characteristics for the voter: education (EDUCATION), whether the voter is unemployed or employed (ACTIVITY), age (AGE) and ideology (IDEOLOGY). We distinguish four levels in education: (i) basic and primary studies, etc. as “Primary”; (ii) compulsory and high secondary education, and vocational training as “Secondary School”; (iii) diploma studies in architecture and technical engineering as “Technical Studies”; and (iv) Bachelor’s, Master’s, and PhDs as “Tertiary Education.” In the case of activity, we only distinguished between out of work (“Unemployed”) and working (“Employed”). For the attribute that represents age, we considered three groups: (i) voters between the ages of 18 and 29 years, or “Young People”; age 30 to 63, “Adults;” and 64 or over, “Retired” The characteristic IDEOLOGY takes three values: (i) “Left,” for voters between the positions 0 and 4 of the ideological spectrum, (ii) “Centre,” for voters between 5 and 6; and (iii) “Right,” for voters who identify with positions 7, 8, 9 and 10 in the ideological space.

We can also specify four attributes that represent the effect of the political context: the retrospective and prospective evaluation of the country's political situation (RETROSPECTIVE NATIONAL POLITICS and PROSPECTIVE NATIONAL POLITICS, respectively), the president's leadership of the government (LEADERSHIP) and the evaluation of the national government (GOVERNMENT). The first characteristic has three values: (i) "Worse," if the voter thinks that the current situation is worse than the political situation the year before; (ii) "The same," if the voter finds that the situation has not changed, and (iii) "Better," if the voter believes that the current situation is better. The prospective evaluation of the country's political situation also takes three values: (i) "Worse," when the voter expects that the political context will worsen during the next year; (ii) "the same," if the voter predicts that the situation will not change; and (iii) "Better," if the voter thinks that the country's political situation will improve. In the case of the president's leadership of the government, we distinguished between voters who assign a value greater than or equal to 5 ("Approve") and those who assign a point-value below 5 ("Do not approve"). We have included the satisfaction that the government's management has generated among the electorate as yet another attribute that characterizes the political context, assigning five values: "VeryPoor," "Poor," "Average," "Good" and "VeryGood."

The last attribute that we have specified is the memory of the vote in the general elections held in 1996 (VOTE 1996). This characteristic takes two values: (i) "PP," if the voter voted for the PP in this election, and (ii) "Others," if the voter chose other political options.

5. Heuristics and reasons for the vote in Spain

To interpret correctly the results of the decision tree obtained and the heuristic rules that describe voting decisions in Spain, it is necessary to perform a descriptive analysis of the class labels and attributes. We can then evaluate the learning method used by performing a validation analysis and examining the entropy. The evaluation phase culminates in an analysis of the robustness of the decision tree obtained.

The data used come from a survey performed in October 1998. This year had special importance for the Spanish economy, as Spain's participation in the Economic and Monetary Union (EMU) was approved in May. After the first two years of legislature, the economy was in an expansive phase: since 1996, the GNP had grown at interannual rates of over 3%, and unemployment had decreased at an interannual rhythm of almost 3%. The public deficit in terms of the GNP was under –2%, and the interest rate in effect for the monetary authority was less than 3%.

Of the 780 instances comprising the sample of voters, 45.3% show that if there were general elections the next day, they would vote for the PP, while 54.7% would choose another political option. In spite of the fact that the party in government did not have (absolute) majority backing, it did have a high level of trust, as 96.2% of those who voted for Aznar's party in the 1996 general elections declared that they were willing to renew their confidence in him.

In addition to voting memory, other traits distinguish the PP's voters: (i) 89.8% are located in the centre of the ideological spectrum, whereas 6.5% identified with the right and 3.7% with the left; (ii)

50.3% are optimistic about the country's political future, vs. 46.3% who predict that the political environment will not change; (iii) 90.1% attribute much or most of the responsibility for the country's economic situation to the government, while only 2.3% attribute no responsibility to the executive branch; (iv) the absolute majority performs a positive sociotropic evaluation, as opposed to 41.5% who believe that the country's economic situation has not improved over that of the previous year; (v) 87% are employed; (vi) the absolute majority are adults, while 23.7% are young people and 13% retired; (vii) 62.4% are quite satisfied with the government's management, 15% have a very high opinion of the executive, and 1.4% give the government a poor or very poor evaluation; and (viii) the absolute majority believes that the family economy will not change, 25.7% perform a positive retrospective egotropic evaluation, and 13% believe that the situation has not changed with respect to the previous year.

To evaluate the efficiency of the J4.8 algorithm, we perform a cross-validation, dividing the sample chosen into 10 partitions. To avoid overfitting of the decision tree, we post-prune it. To eliminate any node in the pruning process, we set the confidence level at 99%. To improve the classificatory capacity of the tree obtained, we choose to (i) specify that the minimum number of instances classified within a subgroup (or per leaf) equals 1, (ii) reduce the induced error of pruning the decision tree by determining that the pruning conditions are verified in at least two partitions, (iii) use a *soft classifiers* system to calculate the classification probabilities of the different instances used in the test, applying Laplace's Law of Succession.

After we executed the J4.8 algorithm, the decision tree obtained consisted of 16 levels, 8 nodes and 16 leaves. If we perform an individual validation of the 16 rules inferred from the tree, we conclude that the absolute majority of the instances included in the test are classified by the first and the last rule. The other 13 rules are less relevant in classifying new instances, although it is true that their capacity to classify correctly is always appreciably greater than the errors.

From a global perspective, the decision tree classified 717 instances correctly, that is, 91.92%, and was wrong for 63 examples. The Kappa statistic value confirms that the decision tree obtained is a good classifier of new cases. The values of the absolute and relative mean error certify that the rules obtained reflect the process of the Spanish voter's decision very well (table 1).

If we analyse the confusion matrix, we confirm that the decision tree obtained does indeed have a very high goodness of fit in classifying. Since we do not have information on the costs generated when the classification is wrong and therefore cannot calculate the cost matrix of the decision tree, we calculate the AUC (*area under the ROC curve*), which shows that the automatic learning system used to construct the decision tree is excellent.

Beyond the previous indicators, two other measures ratify the goodness of the decision tree constructed to classify new instances: precision and level of reach of the automatic learning system used. The F statistic shows that precision and reach of the prediction are two appropriate, harmonized measures for analysing the goodness of the automatic learning system (table 1).

From the test of the entropy indicators, we infer that the selection process of the attributes used based on the division of the training instances shows a significant Konomenko and Brakkoo's index of absolute information gain and a high Konomenko and Brakkoo's information gain ratio (table 1). The entropy analysis must be completed with other indicators of the complexity of the construction of the decision tree: (i) the pruned tree shows a complexity index of 538.2559 bits per attribute and 0.6901 bits per instance; (ii) the cost of the pruning process does not exceed 301.2919 bits per attribute and 0.3863 bits per instance when compared with the complexity index of the unpruned decision tree; and (iii) if the decision tree were pruned to root level, the cost in terms of information would increase with respect to the decision tree obtained by 236.9641 bits per attribute and 0.3038 bits per instance (table 1).

The process of evaluating the decision tree culminates in a study of its robustness. As a comparative reference, we use the estimation of a binomial probit function, alternative classification technique for decision trees. The goal is ultimately to evaluate the reliability of the decision tree as a classifier by adopting as a reference the estimation of a probit function, a deductive technique.

This requires prior contrast of whether there are significant differences between the groups of voters that can be characterized from the degree of responsibility that they attribute to the national government: "Low," "Considerable" or "High." To diagnose whether there are significant differences in the voters' voting behaviour, we perform the heteroskedasticity contrast by groups of Davidson and MacKinnon (1985), starting from the statistics of verisimilitude quotient, Lagrange multiplier, and Wald statistic. The diagnoses of the tests performed are not unanimous: the verisimilitude quotient leads us to accept the hypothesis that there is heteroskedasticity, while the Lagrange multiplier and the Wald statistic confirm the opposite, that there is no heteroskedasticity by groups of voters[9]. The homoskedastic model shows a ratio of correct predictions of 93.33%, while the index of the heteroskedastic model decreases to 85.77% (table 2).

Eliminado:

From the decision tree in Figure 1, we conclude that Spanish voters follow a sequential decision process when they must choose how to vote. Another trait that characterizes the voter's decision is robustness, insofar as he or she performs an incremental search for information that ends in the incorporation of additional redundant information, when the voter does not give any more value to the choice.

The first heuristic that the voters incorporate in their decision process is the memory of the vote from the general elections (VOTE 1996). If the voter voted for the PP in the 1996 election, he or she shows willingness to vote for the party in government again if there were elections tomorrow. In contrast, voters who did not vote for the PP in the 1996 general elections continue the decision process, incorporating a new attribute: ideology (IDEOLOGY). After placing the government on the ideological spectrum, the voters position themselves ideologically. If they are to the left of the executive, they will opt not to vote for the PP. If they are located on the right, they will vote for the party in power (figure 1).

The voters who do not have a markedly left or right ideology—that is, those located in the centre of the ideological spectrum—continue the process of sequential searching, incorporating a new attribute that contributes additional information: the prospective political situation of the country (PROSPECTIVE NATIONAL POLITICS). To the extent that the voter expects that the political context of the country will worsen or at least not change during the next year, he or she will choose to no vote for the PP. However,

[9] The quotient of verisimilitude is 531.26, the Lagrange multiplier is 0.16281370D-21, and the Wald statistic is 1.07.

if the voter predicts that the political situation will improve, he or she will continue the sequential process of incorporating additional information (figure 1).

The heuristic that represents the interaction effect between the degree of responsibility attributed to the government and the retrospective sociotropic evaluation (A_ECONCOUNRETROS), *a priori* contributes highly relevant information, but at a high cost in terms of information, as it requires the voter first to determine the degree of the government's responsibility and from there to evaluate whether the economic situation of the country has improved, worsened or remained unchanged as compared to the situation a year ago. On introducing this new attribute, we affirm that the voters who assign more than two points to this characteristic—that is, who attribute a high degree of responsibility to the national government and also believe that the economy has improved—prefer to vote for the governing party. In contrast, voters who assign this attribute a value of less than or equal to 2 continue their sequential reasoning, incorporating additional characteristics in their reasoning process (figure 1).

The voter incorporates a new attribute in the increasing search process that reflects his or her work situation: the state of activity. Being employed or unemployed is a sociostructural factor that can condition the voting decision, whenever the voter implicitly attributes some responsibility to the executive. This explains why unemployed voters end the process of choosing by punishing the governing party and voting for another political option (figure 1).

Voters who are employed incorporate a new characteristic, sociostructural in nature, in their reasoning process: age (AGE). Young and retired people choose not to vote for the PP, whereas adults incorporate new information to make a decision (figure 1).

The new heuristic that voting adults introduce into their reasoning is the evaluation of the government's management (GOVERNMENT). Although the voters do not have perfect information to judge the executive's activity, they do evaluate the activity it performs. This involves a sign or informative short-cut that contributes to leading the voters who consider that the government's management is very poor, poor, or average to conclude their reasoning process by punishing the *incumbent*, since they choose another political option. In contrast, those who value the executive's management very highly vote for the PP. Only one group decides to continue its reasoning process: those who evaluate the executive's activity positively (figure 1).

The voters who believe that the government's management has been good end the voting decision process by introducing a final heuristic in their reasoning: retrospective egotropic evaluation (RETROSPECTIVE HOUSEHOLD ECONOMY). *Pocketbook* evaluation is another argument that determines how Spaniards vote, since it contributes additional information at a low cost: voters need only analyse whether the family's economic situation has changed or not with respect to the previous year. Voters who believe that the family's economy has not undergone any change in the last year prefer to vote for the party in power. Those who perform a negative or positive retrospective egotropic evaluation choose to punish the PP by voting for another political option.

Why do voters who believe the family's economic situation has improved over the past year choose to punish the governing party? If we review the branch of the decision tree from the root to the leaf, we find the arguments that explain why Spaniards who think that the family's economy has improved choose to punish the PP: (i) in the 1996 general elections, this group of voters voted for another political option and (ii) they assign a value of less than or equal to 2 to the attribute that shows the interaction between the degree of responsibility attributed and the retrospective sociotropic evaluation (figure 1).

6. Conclusions

Heuristic analysis is an alternative to the canonical vision of voting behaviour. Its goal is to discover the group of signs or informational short-cuts that the voter uses to identify the causes and evaluate the consequences of his or her decision. As early as 1957, Anthony Downs, and subsequently Popkin (1991), argued that voters use heuristics when they have to vote.

In the light of the foregoing, we decided in this paper to develop an adaptive model that describes the decision process that voters apply in determining their vote. We base our argument on decision trees. From the decision tree obtained by applying the J4.8 algorithm, we deduce the group of heuristic rules that govern voting behaviour.

At the empirical level, we discovered that the electoral reasoning of Spaniards is sequential and that the decision is robust, insofar as it involves an increasing search for information that ends when the information incorporated does not contribute any additional value.

The memory of the vote in the last general elections is the first heuristic that determines the choice: those who voted for the PP in the 1996 general elections end their decision because they prefer to vote for the governing party. However, those who chose another political force in that election continue the decision process, incorporating a new attribute into their process: ideology. Voters in the centre of the ideological spectrum introduce a new characteristic in their decision-making: the country's prospective political situation. Those who predict that the political situation will improve in the next year choose to add a new heuristic in their reasoning, one that reflects the interaction effect between the degree of responsibility attributed to the government and the retrospective sociotropic evaluation. Voters who attribute a high degree of responsibility for the country's economic situation to the executive and who believe that the economy has improved over the past year choose to vote for the PP again. The rest of the voters incorporate a new attribute in their decision process: their state of activity. Those who are employed add a new characteristic that is sociostructural in nature: age. Adults then go on to evaluate the national government's management. If they consider that this management has been good, they end their reasoning by introducing a final attribute: the evaluation of the family's prospective economic situation.

The empirical results of this study show: (i) that ideology is a relevant factor in voter orientation; (ii) that the influence of retrospective sociotropic evaluation in voters' decisions is conditioned by the level of responsibility that they attribute to the national government for the country's economic situation; (iii) that applying the reward-punishment rule is the end result of a reasoning process that is affected by the voter's ideology and the retrospective sociotropic evaluation; and (iv) that egotropic evaluation is a heuristic that influences only a very small group of voters, allowing us to conclude that is it not relevant in explaining Spaniards' voting behavior (Jaime Castillo, and Sáez Lozano, 2007).

The model presented in the third section and the empirical results presented in the fourth show that mechanisms of a cognitive nature operate in voters' individual decisions, permitting voters to choose and restrict the information necessary to orient their votes. We thus believe that this study reinforces the thesis that it is not appropriate to continue defending the assumption of perfect rationality (Brennan and Hamlin, 1998), that is, to continue assuming that voters finally choose the political option that enables them to maximize their utility level.

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Figure 1
Decision Tree of the Vote in Spain

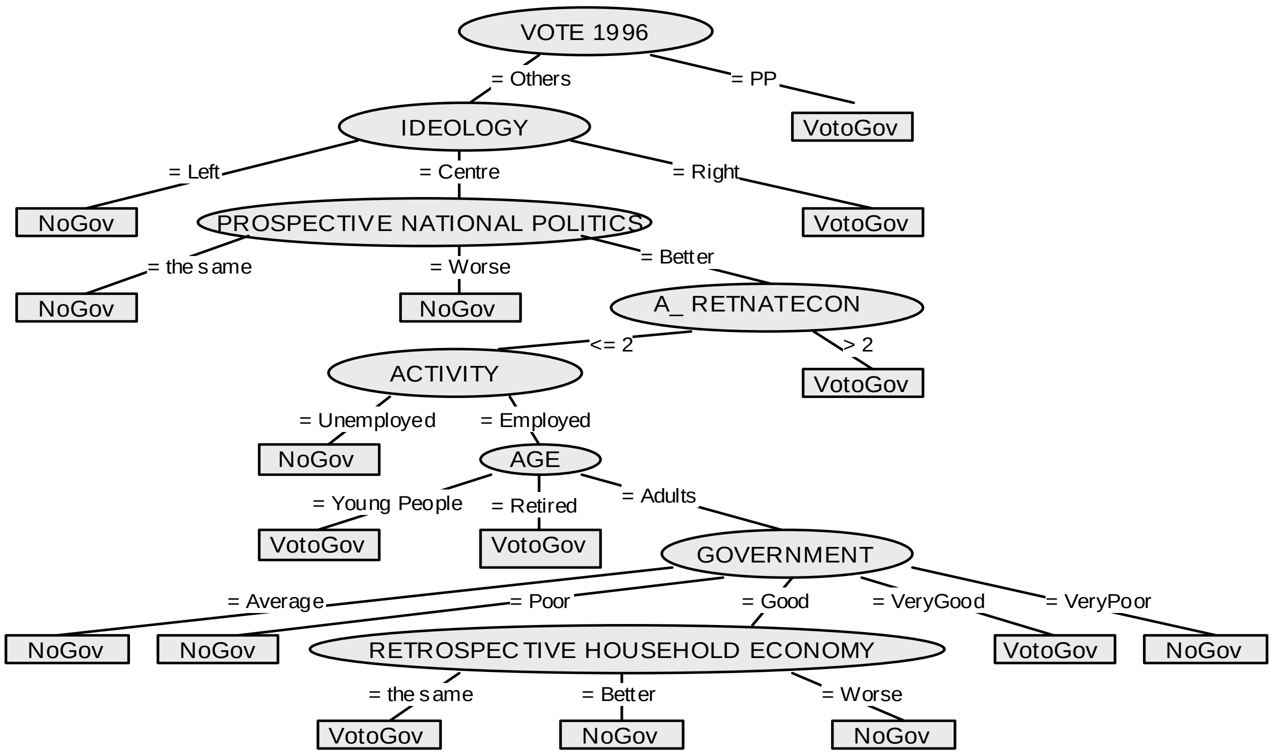

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Table 1

<table>
<tr><th colspan="5">Heuristics of electoral behaviour in Spain</th></tr>
<tr><th colspan="5">RULE</th></tr>
<tr><th>Nº.</th><th>Condition(1)</th><th>Action(2)</th><th>Hits(3)</th><th>Mistakes(4)</th></tr>
<tr><td></td><td>Vote 1996 = Other</td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>| IDEOLOGY = Left</td><td>NoGov</td><td>163</td><td>2</td></tr>
<tr><td></td><td>| IDEOLOGY = Center</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>| | NATIONAL POLITICAL PROSPECTIVE = The same</td><td>NoGov</td><td>42</td><td>7</td></tr>
<tr><td>3</td><td>| | NATIONAL POLITICAL PROSPECTIVE = Worse</td><td>NoGov</td><td>4</td><td>1</td></tr>
<tr><td></td><td>| | | A_RETNATECON < = 2</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>| | | | ACTIVITY = Unemployed</td><td>NoGov</td><td>1</td><td>0</td></tr>
<tr><td></td><td>| | | | ACTIVITY = Employed</td><td></td><td></td><td></td></tr>
<tr><td></td><td>| | | | | AGE = Young People</td><td>VotoGov</td><td>4</td><td>1</td></tr>
<tr><td>6</td><td>| | | | | AGE = Retired</td><td>VotoGov</td><td>1</td><td>0</td></tr>
<tr><td></td><td>| | | | AGE = Adults</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>| | | | | | GOVERNMENT = Average</td><td>NoGov</td><td>2</td><td>0</td></tr>
<tr><td>8</td><td>| | | | | | GOVERNMENT = Poor</td><td>NoGov</td><td>0</td><td>0</td></tr>
<tr><td></td><td>| | | | | | GOVERNMENT = Good</td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>| | | | | | | HOUSEHOLD ECONOMIC RETROSPECTIVE = The same</td><td>VotoGov</td><td>1</td><td>0</td></tr>
<tr><td>10</td><td>| | | | | | | HOUSEHOLD ECONOMIC RETROSPECTIVE = Better</td><td>NoGov</td><td>3</td><td>1</td></tr>
<tr><td>11</td><td>| | | | | | | HOUSEHOLD ECONOMIC RETROSPECTIVE = Worse</td><td>NoGov</td><td>0</td><td>0</td></tr>
<tr><td>12</td><td>| | | | | | GOVERNMENT = VeryGood</td><td>VotoGov</td><td>1</td><td>0</td></tr>
<tr><td>13</td><td>| | | | | | GOVERNMENT = VeryPoor</td><td>NoGov</td><td>0</td><td>0</td></tr>
<tr><td>14</td><td>| | | A_ RETNATECON > 2</td><td>VotoGov</td><td>5</td><td>0</td></tr>
<tr><td>15</td><td>| IDEOLOGY = Right</td><td>VotoGov</td><td>3</td><td>0</td></tr>
<tr><td>16</td><td>VOTE 1996 = PP</td><td>VotoGov</td><td>160</td><td>8</td></tr>
</table>

Decision tree:

Number of Leaves: 16

Size: 8 nodes y 16 leaves

Summary:

Correctly classified instances:	717(91.9231%)
Incorrectly classified instances:	63(8.0769%)
Kappa statistic:	0.8368
Mean absolute error	0.1112
Root mean squared error:	0.2414
Relative absolute error:	22.4375%
Total Number of Instances:	780

Evaluation of entropy:

Konomenko and Brakko relative info score:	61741.8992%	
Konomenko and Brakko information score:	613.7331 bits	0.7868 bits/instance
Class complexity decision tree at the root:	775.22 bits	0.9939 bits/instance
Class complexity complete decision tree (without pruning):	236.964 bits	0.3038 bits/ instance
Complexity of decision tree pruned:	538.2559 bits	0.6901 bits/ instance

Confusion matrix:

		Class true		
		NoGov	Gov	Class predicted(%)[5]
Class predicted	NoGov	398	28	54.61
	Gov	35	319	45.38
	Class true**(%)**[6]	55.51	44.48	

Detailed accuracy by class:

True Positive Ratio	False Positives Ratio	Precision	Recall	F-Measure	ROC Area	Class

0.934	0.099	0.919	0.934	0.927	0.964	NoGov
0.901	0.066	0.919	0.901	0.91	0.964	VotoGov

Notas:

(1) "If the conditions in these attributes".

The symbol | is the logical operator AND.

(2) "Then the voter can vote the government (VotoGov) or other political option (NoGov)"

(3) "Number of examples of the test, which is the class that predicts leaf algorithm J4.8

(4) "Number of examples of the test, which does not correspond to the class that predicts leaf algorithm J4.8.

(5) $\text{Class predicted NoGob} = \frac{398+28}{780} \times 100 = 54.61\%$. $\text{Class predicted Gob} = \frac{35+319}{780} \times 100 = 45.38\%$

(6) $\textit{Class true}\ \text{NoGob} = \frac{398+35}{780} \times 100 = 55.51\%$. $\textit{Class true}\ \text{Gob} = \frac{28+319}{780} \times 100 = 44.48\%$

Table 2

Homoskedastic and heteroskedastic Probit models for economic voting in Spain (by groups)

	Dependent variable: Vote for the government	
Exogenous variables	**Homoskedastic model**	**Heteroskedastic model**
	Coefficients	**Coefficients**
VOTE 1996	2.2109[a]	2.1050[b]
	(.2371)	(.8529)
HOUSEHOLD ECONOMY RETROSPECTIVE	-.27162[c]	-.2849
	(.1622)	(.1506)
NATIONAL POLITICAL PROSPECTIVE GOVERNMENT	.4032[b]	.3852[c]
	(.1703)	(.2072)
	.7596[a]	.7182[b]
	(.1346)	(.3247)
ACTIVITY	.0321	.0581
	(.2272)	(.2618)
AGE	-.4666[a]	-.4540[b]
	(.1269)	(.2283)
IDEOLOGY	1.7079[a]	1.6587[a]
	(.1552)	(.6378)
A_RETNATECON	-.0254	-.0235
	(.0636)	(.0647)
$\gamma_{Attribution\,\mathrm{Re}sponsability=Little}$	-	.1480[c]
		(.4371)
$\gamma_{Attribution\,\mathrm{Re}sponsability=Quite}$	-	-.0912
		(.4047)
$\gamma_{Attribution\,\mathrm{Re}sponsability=Much}$	-	-.0482
		(.4068)
Sample size	780	780
Log likelihood	-135.4322	-134.8704
Constrained log likelihood	-537.3270	-537.3270
Chi-Square	803.7895	804.9131
Degrees of freedom	8	11
Belsley condition number	41.69	41.69
Likelihood ratio index	.75	.75
Correct prediction	93.33%	85.77%
Intuitive prediction index	54.87%	67.31%

Notes: The figures in brackets are the standard errors of estimated coefficients.

a, b and c denote significance levels ($\rho - value$): 1%, 5% and 10%, respectively.

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