A discrete choice model of voters' decision in the general election 2019 using LASSO regression

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Abstract. Statistical modelling faces problems when too many variables are involved in the model. Using all variables in the model will result in overfitting which in turn produces unstable predictions. LASSO (Least Absolute Shrinkage and Selection Operator) is a method that can be used to overcome this problem. LASSO selects more important variables with the goal of improving the prediction accuracy and interpretability. This paper identifies factors those influenced voters in 2019 presidential election using LASSO penalized logistic regression. This logistic model is also known as a discrete choice model. The data used in this study is the result of an exit poll conducted during the election day with a total sample of 2,289 respondents. The response variable in this study is a vote choice. The independent variables include sociological, psychological, political economy, and campaign variables. The results showed that there were 17 of 27 variables having nonzero coefficients. These variables include candidates’ personal qualities which show the largest effect, followed by the incumbent performance variable. On the other hand, variables such as religion, education, and ethnicity have much less effects. This implies that the psychological and political economy factors played more important role than the sociological factor in determining voters’ decision. Based on this finding the prospective candidate in the future election should focus their campaign strategy on enhancing positive images (empathy, integrity and capability) as well as offering better programs to convince voters.

1. Introduction

Statistical modeling faces problems when too many variables are involved in the model. Using all variables in the model will result in overfitting which in turn produces unstable predictions. LASSO (Least Absolute Shrinkage and Selection Operator) is a method that can be used to overcome this problem.

LASSO was introduced by Tibshirani [1] as a method for shrinking coefficients and selecting more important variables with the goal of improving the prediction accuracy and interpretability. In least squares method LASSO shrinks the coefficients $\beta = (\beta_1, ..., \beta_p)^T$ toward zero according to a penalty $\lambda \sum_{j=1}^{p} |\beta_j|$ in the objective function $\min_{(\beta_0, \beta) \in \mathbb{R}^{p+1}} \left[ \frac{1}{2n} \sum_{i=1}^{n} (y_i - \beta_0 - x_i^T \beta)^2 + \lambda \sum_{j=1}^{p} |\beta_j| \right]$, $\lambda > 0$, which is equivalent to $\min_{(\beta_0, \beta) \in \mathbb{R}^{p+1}} \left[ \frac{1}{2n} \sum_{i=1}^{n} (y_i - \beta_0 - x_i^T \beta)^2 \right]$ subject to $\sum_{j=1}^{p} |\beta_j| \leq t$, $t \geq 0$. While in logistic regression LASSO shrinks the coefficients toward zero based on the objective
function \(\min_{(\beta_0, \beta) \in \mathbb{R}^{p+1}} \left[-\frac{1}{n} \sum_{i=1}^{n} \left[y_i \left(\beta_0 + x_i^T \beta\right) - \log(1 + e^{\beta_0 + x_i^T \beta})\right] + \lambda \sum_{j=1}^{p} |\beta_j|\right]\) \cite{2}. The LASSO coefficients can be obtained using coordinate descent algorithm \cite{3}.

LASSO has been applied in a number of previous studies. Kristensen et al. (2017) applied a LASSO-penalized multinomial logit model to predict party choice \cite{4}. Cantoni and Pons (2019) used LASSO to select more important variables associated with voter turnout \cite{5}. Meanwhile, Chen et al. (2019) applied LASSO to identify factors associated with tuberculosis in West Java \cite{6}.

This paper identifies factors that influence voters in 2019 presidential election using LASSO penalized logistic regression. This logistic model is also known as a discrete choice model.

2. Research Method

2.1. Data

The data used in this study is the result of an exit poll conducted during the election day with a total sample of 2,289 respondents. The response variable in this study is a vote choice (1 = Candidate A, 0 = Candidate B). The independent variables include sociological, psychological, political economy, and campaign variables, those are 27 variables in total. Overall, the independent variables used in this study are explained in Appendix.

2.2. Data Analysis

The data analysis in this study is divided into 3 parts:

a. Descriptive analysis to describe the relationships between the response variable and each independent variable.

b. 10-fold cross validation 10-folds cross-validation to determine the optimum hyperparameter \(\lambda (\lambda_{opt})\). This cross-validation is as follows. The dataset is divided at random into 10 groups \((g = 1, \ldots, 10)\), where one group is fixed as the test set and the remaining 9 groups are designated as the training set. LASSO logistic regression with a value of \(\lambda\) is applied to the training set (9 groups beside the \(g^{th}\) group) then the model is used to calculate the deviance of the testing set (the \(g^{th}\) group) \(d_{\lambda}^{(g)} = \frac{1}{n_g} \left[\sum_{i=1}^{n_g} -2[y_i \log \tilde{p}_i + (1 - y_i) \log(1 - \tilde{p}_i)]\right]\), where \(\tilde{p}_i = \frac{\exp(\tilde{\beta}_0^{(g)} + x_i^T \tilde{\beta}^{(g)})}{1 + \exp(\tilde{\beta}_0^{(g)} + x_i^T \tilde{\beta}^{(g)})}\) is the predicted probability for observation \(i\) in the testing set, \(\tilde{\beta}_0^{(g)}\) and \(\tilde{\beta}^{(g)}\) are the LASSO coefficients based on the training set, and \(n_g\) is the number of observations in the testing set. This procedure is repeated 10 times using different testing and training sets to obtain deviances for each testing set \((d_{\lambda}^{(1)}, \ldots, d_{\lambda}^{(10)})\), and the model performance is measured by CV-Dev\(_{\lambda} = \frac{1}{10} \sum_{g=1}^{10} d_{\lambda}^{(g)}\). This cross validation is repeated for different \(\lambda\) values. The \(\lambda_{opt}\) is determined by a criterion 

\[
\lambda_{opt} = \begin{cases} 
\lambda_{\min}, & \text{if nonzero}_{\lambda_{\min}} = \text{nonzero}_{\lambda_{1SE}} \\
\lambda_{1SE}, & \text{if nonzero}_{\lambda_{\min}} > \text{nonzero}_{\lambda_{1SE}} 
\end{cases}
\]

where \(\text{nonzero}_{\lambda}\) is the number of variables having nonzero coefficients based on a \(\lambda\), \(\lambda_{\min}\) is the value of \(\lambda\) which produces the minimum CV-Dev\(_{\lambda}\) (CV-Dev\(_{\lambda_{\min}}\)), and \(\lambda_{1SE}\) is the largest value of \(\lambda\) which produces CV-Dev\(_{\lambda}\) within 1 standard error of CV-Dev\(_{\lambda_{\min}}\).

c. Estimate the LASSO panelized logit regression model by using the full dataset and the \(\lambda_{opt}\).

This final model performance is assessed by the fraction of deviance explained \(D_{\lambda}^2 = \frac{\text{Dev}_{null} - \text{Dev}_{\lambda}}{\text{Dev}_{null}}\), where \(\text{Dev}_{null}\) is the deviance with a constant model (mean), \(\text{Dev}_{\lambda} = -2 \times \loglik(\tilde{\beta}_0, \tilde{\beta}_\lambda)\) is the deviance of the model using \((\tilde{\beta}_0, \tilde{\beta}_\lambda)\), and \((\tilde{\beta}_0, \tilde{\beta}_\lambda)\) are the LASSO
coefficients estimates. The standard error of each coefficient is estimated using bootstrap method with 1000 replications [2], [7].

The LASSO coefficients estimates are calculated using glmnet package in R [3].

3. Results and Discussion

3.1. Descriptive Analysis

Support for a candidate appeared to vary according to values of the independent variables. In terms of demographics, differences in support can be seen especially in terms of religion, ethnicity, education and region. Candidate A tended to get a bigger support from the non-Muslim voters, Javanese, voters with lower education, and voters who live in areas outside Sumatera. Candidate A also seemed to have greater support from voters who assessed economic condition as better and voters who were satisfied with the incumbent performance. Party identification and candidates’ personal qualities appeared to have positive relationships with the electability of the candidates concerned, whereas belief in negative issues had negative relationship with the electability. Voters who were more exposed to candidate's campaign in various media appeared to be more supportive of the candidate (Figure 1).

Figure 1. Proportion of support for Candidate A (vertical axis) according to explanatory variables (horizontal axis).
3.2. Cross-Validation and Optimum-λ

The cross-validation analysis showed that \( \lambda_{\text{min}} = 0.002466 \) resulted in a CV-Dev of 0.3184, while \( \lambda_{1SE} = 0.009069 \) resulted in CV-Dev of 0.3362. The LASSO logistic regression with \( \lambda_{\text{min}} \) shrinks the coefficients of 7 independent variables to zero, while \( \lambda_{1SE} \) shrinks the coefficients of 10 independent variables to zero (Figure 2a). Since using \( \lambda_{1SE} \) shrinks more coefficients to zero than \( \lambda_{\text{min}} \) then \( \lambda_{1SE} \) is chosen as the optimum-λ.

![Figure 2](image-url)

**Figure 2.** (a) 10-folds cross-validation, the vertical dash lines are the locations of \( \lambda_{\text{min}} \) and \( \lambda_{1SE} \); (b) The coefficient path for LASSO penalized logistic regression with all data, plotted versus the \( \ell_1 \)-norm of the coefficient vector relative to the \( \ell_1 \)-norm of the unrestricted estimate, the vertical dash line is the location of \( \ell_1 \)-norm corresponding to \( \lambda_{1SE} \)

3.3. LASSO Penalized Logistic Regression Model

The LASSO logistic regression model by using the full dataset and the optimum-λ resulted in a deviance ratio of \( D^2 = 76.4\% \), which means that the model has a fairly good performance. This model shrinks 10 variable coefficients to zero: MALE, RURAL, AGE, INCOME, SUMATERA, JAVA, KALIMANTAN, SULAWESI, PARTYIDA, and TVA. This shows that gender, rural-urban, income, region, closeness to parties those supported Candidate A, and Candidate A’s TV commercial exposure were not important factors in determining the vote choice. Then the explanation for voting behavior can be focused more on the remaining 17 variables (Table 1).

The plot of coefficient paths visualizes the most to the least important variable (Figure 2b). By observing each coefficient path from left to right, it can be seen how each variable appears as nonzero (having nonzero coefficient) as the budget \( \ell \) increases, or as the hyperparameter \( \lambda \) decreases (the value of \( \lambda \) is getting smaller as it moves to the right).

If we use a very large penalty then all variables having zero coefficients. When the penalty is reduced slightly, QUALITYA (Candidate A’s personal quality) and QUALITYB (Candidate B’s personal quality) appear almost simultaneously as nonzero. If the penalty is reduced again then APPROV variable (the incumbent performance) becomes nonzero. Furthermore, the gradual decreasing of the value of hyperparameter \( \lambda \) until \( \lambda_{1SE} \) makes the following variables appear as
nonzero in sequence: OUTB, INTB, TVB, OUTA, ECON, INTA, DOORA, DOORB, RELIGION, ISSUA, PARTYIDB, ISSUB, EDUC, ETHNIC.

Candidates’ personal qualities were the most important variables, followed by the incumbent performance. Meanwhile, ethnicity had the lowest effect. In general, this study confirms the results of previous studies that voting behavior can be explained through psychological, political economy, and sociological approaches [8]. In addition, this study also confirms previous research that campaign and disinformation are also factors that can influence voting behavior [9-10].

| Table 1. LASSO-Penalized Logistic Regression Model |
|-----------------------------------------------|
| Coefficient | Standard Error | Z     | P>|Z| | Odds Ratio |
| (Intercept)  | 0.490          | 0.837 | 0.59 | 0.558       | -         |
| MALE         | -              | -     | -    | -            | -         |
| RURAL        | -              | -     | -    | -            | -         |
| AGE          | -              | -     | -    | -            | -         |
| EDUC         | -0.002         | 0.011 | -0.20| 0.840       | 1.0       |
| INCOME       | -              | -     | -    | -            | -         |
| ETHNIC       | 0.009          | 0.086 | 0.10 | 0.921       | 1.0       |
| RELIG        | -0.900         | 0.245 | -3.68| 0.000       | 0.4       |
| SUMATERA     | -              | -     | -    | -            | -         |
| JAWA         | -              | -     | -    | -            | -         |
| KALIMANTAN   | -              | -     | -    | -            | -         |
| SULAWESI     | -              | -     | -    | -            | -         |
| ECON         | 0.393          | 0.149 | 2.63 | 0.008       | 1.5       |
| APPROV       | 1.196          | 0.200 | 5.99 | 0.000       | 3.3       |
| PARTYIDA     | -              | -     | -    | -            | -         |
| PARTYIDB     | -0.582         | 0.279 | -2.09| 0.037       | 0.6       |
| QUALITYA     | 1.766          | 0.135 | 13.08| 0.000       | 5.8       |
| QUALITYB     | -1.897         | 0.124 | -15.36| 0.000     | 0.2       |
| ISSUA        | -0.563         | 0.170 | -3.31| 0.001       | 0.6       |
| ISSUB        | 0.354          | 0.185 | 1.92 | 0.055       | 1.4       |
| TVA          | -              | -     | -    | -            | -         |
| TVB          | -0.579         | 0.180 | -3.21| 0.001       | 0.6       |
| INTA         | 0.208          | 0.150 | 1.38 | 0.167       | 1.2       |
| INTB         | -0.452         | 0.193 | -2.34| 0.019       | 0.6       |
| OUTA         | 0.202          | 0.171 | 1.18 | 0.237       | 1.2       |
| OUTB         | -0.568         | 0.220 | -2.58| 0.010       | 0.6       |
| DOORA        | 0.456          | 0.185 | 2.47 | 0.013       | 1.6       |
| DOORB        | -0.562         | 0.237 | -2.37| 0.018       | 0.6       |

3.3.1. Psychological Factor

Within the psychological variables, PARTYIDA having zero coefficient. The closeness of the voters to parties those supported Candidate A (compared to not closed to any party) didn’t seem to have an important role in the choice. However, this doesn’t mean that party identification is not important at all. The model shows that the closeness of the voters to the parties those supported Candidate B
reduced the tendency to vote for Candidate A, and this effect is significant at 95% confidence level. Party identification, however, remains important despite its limited influence.

The most important psychological variable is Candidates’ personal qualities. Every addition of 1 point of score on the assessment of Candidate A’s personal quality increased 5.8 times the odds for choosing Candidate A. Conversely, every addition of 1 point of score on Candidate B’s personal quality decreased the odds of choosing Candidate A by 0.2 times.

Negative issues regarding candidates contributed to voters’ decision. The more voters were exposed to and believe in negative issues about a candidate, the lower the chance of the voters choosing the candidate. Considering that some of the negative issues during the campaign period were a form of disinformation or hoaxes, this finding needs to be of concern to various parties. Voters’ political decisions should be made based on correct information. The spread of fake news during campaign period would ultimately reduce the quality of election.

3.3.2. Political Economy Factor

Evaluation on the economic condition and incumbent performance have positive coefficients. This shows that voters are basically rational. Voters who were satisfied with the incumbent performance and thought that the economic condition was better than the last year had a tendency to prefer Candidate A (as the incumbent) over voters who had the opposite opinion. The relative tendency to vote for Candidate A among voters who were satisfied with the incumbent performance was 3.3 times greater than among those who were dissatisfied. Meanwhile, voters who considered the economic condition was better than before tended to be more likely to vote for Candidate A 1.5 times greater than voters who thought otherwise.

3.3.3. Sociological Factor

The sociological variables those having nonzero coefficients are religion, education, and ethnicity. Religion and education have negative coefficients while ethnicity has a positive coefficient. However, the effects of education and ethnicity less convincing, not significant at 95% confidence level. The more convincing sociological variable is religion. The tendency of voting for Candidate A (versus Candidate B) among Muslim voters is 0.4 times (lower) than that of non-Muslim voters. The influence of religion on the choice is interesting, since Candidate A and Candidate B have the same religious background (Islam). Muslim voters might think Candidate A was less representative of their interests, whereas non-Muslim voters thought Candidate A was more representative of their aspirations.

3.3.4. Campaign Factor

Campaigns played important role in voting. Candidate B’s campaign appeared to have stronger influence than Candidate A’s campaign. The effect of Candidate A’s campaign through TV commercials has even shrunk to zero. This might be related to the different position of the two candidates: Candidate A as the incumbent and Candidate B as the challenger. Most voters probably already knew and could evaluate Candidate A’s programs during his 5 years in office. Therefore, the campaign conducted by Candidate A during the campaign period had no significant effect. At 95% confidence level, only campaigns through volunteers’ visits could increase Candidate A’s electability.

Unlike Candidate A, voters generally only knew about Candidate B’s program when they entered the campaign period. Therefore, the campaign conducted by Candidate B played an important role in providing information and encouraging voters to vote. All campaign forms conducted by Candidate B had significant effects. Voters who were more exposed to any forms of Candidate B’s campaign lowered the tendency to vote for Candidate A to 0.6 times compared to voters who had never been exposed to any candidate campaign.
4. Conclusion

The LASSO penalized logistic regression model with a λ-optimum in this study has a ratio of deviance of $D^2 = 76.4\%$. Based on this model, there were 17 of the 27 variables having nonzero coefficients. These variables were candidate’s personal qualities (QUALITYA and QUALITYB), incumbent performance (APPROV), campaigns through TV commercials (TVB), campaigns through advertisements on the internet or social media (INTA and INTB), campaigns through outdoor media (OUTA and OUTB), campaigns through volunteers’ visits (DOORA and DOORB), economic condition (ECON), negative issues about candidates (ISSUA and ISSUB), religion (RELIG), education (EDUC), and ethnicity (ETHNIC).

Candidates’ personal qualities show the largest effect, followed by the incumbent performance variable. On the other hand, variables such as religion, education, and ethnicity have much less effects. This implies that the psychological and political economy factors played more important role than the sociological factor in determining voters’ decision. Based on this finding the prospective candidate in the future election should focus their campaign strategy on enhancing positive images (empathy, integrity and capability) as well as offering better programs to convince voters.

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Appendix. Independent Variables and The Explanation.

1. Gender (MALE): 1 = male, 0 = female.
2. Rural-Urban (RURAL): 1 = rural, 0 = urban.
3. Age in years (AGE).
4. Education: length of schooling in years (EDUC).
5. Income per month in million rupiahs (INCOME).
6. Ethnicity (ETHNIC): 1 = Javanese, 0 = others.
7. Religion (RELIG): 1 = Islam, 0 = others.
8. Region, represented by the four dummy variables:

| Region    | Dummy Variables |
|-----------|-----------------|
| Sumatera  | 1 0 0 0         |
| Java      | 0 1 0 0         |
| Kalimantan| 0 0 1 0         |
| Sulawesi  | 0 0 0 1         |
| Others    | 0 0 0 0         |
9. Evaluation of current national economic condition compared to last year (ECON): 1 = better, 0 = worse or no change.
10. Satisfaction with the incumbent’s performance (APPROV): 1 = satisfied, 0 = dissatisfied.
11. Identity of party A (PARTYIDA): 1 = feeling closer to the party that supports Candidate A, 0 = does not feel close to the party that supports Candidate A.
12. Identity of party B (PARTYIDB): 1 = feeling closer to the party that supports Candidate B, 0 = does not feel close to the party that supports Candidate B.
13. Assessment of the personal quality of Candidate A (QUALITYA): a composite index of three items on the quality of Candidate A, (1) attentive/care for the people, (2) able to lead in overcoming national problems, (3) trustworthiness; where each item is measured on a 5-point scale (1 = very inattentive/unable to lead/untrustworthy, 5 = very attentive/able to lead/trustworthy). The three items are averaged to form a score on a scale of 1-5, where 1 means very bad and 5 means very good.
14. Assessment of the personal quality of Candidate B (QUALITYB): a composite index of three items on the quality of Candidate B: (1) attentive/care for the people, (2) able to lead in overcoming national problems, (3) trustworthiness; where each item is measured on a 5-point scale (1 = very inattentive/unable to lead/untrustworthy, 5 = very attentive/able to lead/trustworthy). The three items are averaged to form a score on a scale of 1-5, where 1 means very bad and 5 means very good.
15. Attitudes towards negative issues for Candidate A (ISSUA): a combined index of four negative issue items for Candidate A: (1) related to PKI, (2) an accomplice to PRC, (3) anti-Islam, (4) authoritarian; where each item is measured on a 3-point scale (1 = don't believe, 2 = never heard of, 3 = believe). The four items are averaged to form a score on a scale of 1-3, where 1 means do not believe in all issues and 3 means believe with all issues.
16. Attitudes towards negative issues for Candidate B (ISSUB): a composite index of four negative issue items for Candidate B: (1) Christian/Catholic family, (2) involved in activist kidnapping events, (3) fired from the army, (4) temperamental/has mental instability; where each item is measured on a 3-point scale (1 = don't believe, 2 = never heard of, 3 = believe). The four items are averaged to form a score on a scale of 1-3, where 1 means don't believe in all issues and 3 means believe in all issues.
17. Candidate advertisements that are seen more frequently on TV, which are represented by two dummy variables with the reference category “balanced/never seen”:

| Ads of Candidate A | Dummy Variables |
|-------------------|-----------------|
| TVA               | 1 0             |
| TVB               | 0 0             |
18. Candidate advertisements that are seen more frequently on internet or social media, which are represented by two dummy variables with the reference category “balanced/never seen”:

| Dummy Variables | Ads of Candidate A | Ads of Candidate B | Balanced/Never seen |
|----------------|--------------------|--------------------|---------------------|
| INTA           | 1                  | 0                  | 0                   |
| INTB           | 0                  | 1                  | 0                   |

19. Candidate advertisements that are seen more frequently on outdoor media (banners, stickers, flags, etc.), represented by two dummy variables with the reference category “balanced/never seen”:

| Dummy Variables | Candidate advertisements that are seen more frequently on outdoor media (banners, stickers, flags, etc.) |
|----------------|---------------------------------------------------------------------------------------------------|
| OUTA           | Outdoor Media of Candidate A                                                                         |
| OUTB           | Outdoor Media of Candidate B                                                                         |
| Balanced/Never seen | Balanced/Never seen                                                                                   |
|                | 1                                                             | 0                                           |
|                | 0                                                             | 1                                           |
|                | 0                                                             | 0                                           |

20. The candidate’s campaign team that visited the most frequently, represented by two dummy variables with the reference category “balanced/none”:

| Dummy Variables | The candidate’s campaign team that visited the most frequently |
|----------------|---------------------------------------------------------------|
| DOORA          | Campaign team of Candidate A                                 |
| DOORB          | Campaign team of Candidate B                                 |
| Balanced/None  | Balanced/None                                                 |
|                | 1                                                             | 0                                           |
|                | 0                                                             | 1                                           |
|                | 0                                                             | 0                                           |