Do two parties represent the US?
Clustering analysis of US public ideology survey

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Abstract
Recent surveys have shown that an increasing portion of the US public believes the two major US parties inadequately represent the US public opinion, and think additional parties are needed [1]. However, there are high barriers for third parties in political elections. In this paper, we aim to address two questions: “How well do the two major US parties represent the public’s ideology?” and “Does a more-than-two-party system better represent the ideology of the public?”. To address these questions, we utilize the American National Election Studies Time series dataset [2], a dataset of opinion surveys of 20,502 individuals over multiple political issues since 1948. We perform unsupervised clustering with Gaussian Mixture Model method on this dataset, and we find the cluster center found under a two-cluster restriction is close to the party centers, which are estimated using the mean position of the individuals self-identified with the parties. We conclude that the major US parties are representative of the US population under the constraint that the political system is limited to two parties. We investigate if more than 2 parties represent the population better by comparing the Akaike Information Criteria for clustering results of various number of clusters. We find that additional clusters give better representation of the data, even after penalizing for the additional parameters. This suggests a multiparty system represents the ideology of the public better.

Introduction
From the government shutdown in 2013 to the 14 hour filibuster on gun control in 2016, it is evident that cooperation between the political parties of the United States is steadily decreasing. The growing fissure between the Democratic and Republican ideologies and stances on issues is causing a gridlock in the U.S. government. Frustrated by the lack of change, Americans are finding it difficult to support either political party. In a recent survey, 53% of likely US voters think it is fair to say that neither party in Congress is the party of the American people. Even 52% of those who identified as Republicans and 44% of those who identified as Democrats agree that neither major political party is the party that represents the American people [3]. This lack of confidence in the U.S. government bring into question the role of political parties and the principles of a democratic system to represent individuals and be a government of the people, by the people and for the people [4].

In this study, we aim to address two questions: “How well does the two major US parties represent the public opinion?” and “Does more than two parties better represent the ideology landscape?”. In the past,

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there have been attempts to determine the political typologies of the American public. In 1986, Fleishman used cluster analysis to determine that there are six clusters of political attitudes that best represent the opinions of Americans. However, the dataset used was small (only 483 individuals) and outdated [5]. The Pew Research Center also conducted a study in 2014 that concluded with eight groups of political attitudes. However, the technique used to find these clusters is ambiguous and not detailed in their results (Street et al., 2014).

Here, we use Gaussian Mixture Model to identify groups of individuals who have common political attitudes. The dataset used is the American National Election Studies, including self-reported ideology of more than 20,000 individuals on various political issues from 1948 to 2012. The large sample size of data combined with the compatible method of clustering provides a representative model of the America’s public opinion space.

Two systems are be compared. First, we fix the number of clusters to two, in order to model the current two-party system in the US, which is reinforced by the single-member district plurality electron process and other barrier for additional parties to entry. Second, we allow for additional clusters, and use the Aikaike Information Criteria to compare goodness of the clustering for clustering result of different clusters.

### Data and Methods

A public opinion dataset from the American National Election Studies [2] is used for the analysis of political party representation.

Cluster analysis will be performed on the dataset using the Gaussian Mixture Model, a machine-learning technique that compares the likelihood of a set of data being generated by a number of clusters. This model uses the Expectation-Maximization algorithm to find the parameters of a Gaussian distribution that maximizes its likelihood. From this maximized likelihood, the Akaike Information Criterion is calculated to determine the optimal number of components for a model. Because the Information Criterion penalizes extra parameters, the problem of overfitting the data is accounted for.

The cluster analysis was conducted on three subsets of data. The first includes opinions of individuals from 2012 on 2 political issues to simplify the model into two dimensions. The second contains opinions of individuals from 2012 on 11 political issues to represent the multidimensionality of opinion spaces. The third subset includes opinions of individuals from 1990 to 2012 on 3 political issues to observe trends over time. The political issues used for this analysis are based on a 7 point scale to ensure a wide range of possible choices for the individuals. See Appendix A for detailed explanations of the political issues and the way the question was posed. Only individuals with a complete set of data for each subset were included. The sample size for 2012 is 5914 individuals and the total sample size from years 1990 to 2012 is 20,502 individuals. For the 7 point scale questions, there were also options for “Don’t Know” and “NA”. These answers were assigned to the value of 4, the median of the 7 point scale because they represent a group of individuals who is neutral about a specific political issue.

We restrict the covariance matrix to diagonals only. This not only reduces the number of parameters that the model must calculate, but also limits the clusters to those that model a coherent platform for a political party. In two dimensions, a highly correlated diagonal cluster that contains individuals who have opposing views on government can be prevented from forming.
Results

Two Cluster Analysis

2012- 2 Issues

Figure 1: 2012 – 2 Issues, 2 Clusters. Ideology landscape over two issues (x and y axis). Each marker represents an individual. The individuals self-identified as republican, democrat, and independent are marked in red, blue, and grey respectively. The darker the color, the stronger the party identification. The ‘X’s mark the two cluster means found by the Gaussian Mixture Model. The two triangles represent the political party means, estimated by averaging of the ideological positions of those that self-identified with each party.

Table 1: 2012 – 2 Issues, 2 Clusters. This table includes the number of iterations it took in the Gaussian Mixture Model to get the results. It shows the Log-likelihood value that was maximized, the resulting mean and diagonal covariance values, and the Akaike Information Criterion.

|         |       |
|---------|-------|
| Iterations | 58    |
| Log-likelihood | -22133.2 |
| Mean      | 5.9802 6.6861 |
|           | 3.6293 4.0996 |
| Covariance | 1.0165 0.2181 |
|           | 2.5013 2.2122 |
| AIC       | 4.43E+04 |

The results from the 2 cluster analysis on 2 political issues in 2012 is shown in Figure 1. The x and y-axis represent two different political issues and each dot on the graph is an individual. The political issue on the x-axis is Guaranteed Jobs and Income Scale while the political issue on the y-axis is Aid to Blacks Scale. See Appendix A for details on each political issue. Because the data is discrete, a small amount of noise was added to the coordinates in order to visualize the data. Each data point is also color coded to represent what party the individual self-identified with. Party affiliation was asked on a 7 point scale; Strong Democrat, Democrat, Independent-Democrat, Independent, Independent-Republican, Republican, and Strong Republican. Republicans are represented by shades of red, Independents by grey, and
Democrats by blue. Figure 1 shows one cluster mean found very close to the Democratic Party mean and another found further to the right than the Republican Party mean. Table 1 displays the exact coordinates and covariance of the clusters found. This suggests that the Republican Party takes a more moderate stance on issues, between the center and extreme right, than some of its supporters. A possible reason for this may be so that the Republican Party can attract more votes. This can be supported by the fact that one of the clusters found by the mode is considerably smaller than the other cluster, shown in Table 2. In order for the Republican Party to be a viable competitor to the Democratic Party, it must be able to maintain its size by attracting votes from the independents. As a result, the Republican Party mean lies in between the center and the second cluster mean. Table 2 also shows that each cluster is made of predominantly one party, which indicates that the current political party system is reflective of the public opinion.

|               | 2 Clusters |
|---------------|------------|
|               | 1          | 2          |
| % of Total    | 72.74%     | 27.26%     |
| Democrat      | 48.68%     | 16.25%     |
| Independent   | 35.98%     | 38.77%     |
| Republican    | 15.34%     | 44.98%     |

Table 2: 2012 – 2 Issues, 2 Clusters Size and Percentage Makeup. This table includes the size of each cluster and the percentage of self-identified Democrats, Independents, and Republicans that make up each cluster.

(More combinations of two issues have been attested to exclude the effect of correlation. See Appendix B for details on correlation analysis.)

11 Issues (year 2012)

Figure 2: 2012 – 11 Issues, 2 Clusters. The ‘X’ s are where the cluster means were found. The two triangles represent the political party means; red for republican and blue for democrat. These were found by taking the average of the opinions of those that self-identified as democrat and as republican. Principle Component Analysis was then used to plot the points onto two dimensions.

|          |         |
|----------|---------|
| Iterations | 55      |
| Log-likelihood | -133915 |
| AIC      | 2.68E+05 |
Table 3: 2012 – 11 Issues, 2 Clusters. This table includes the iterations it took in the Gaussian Mixture model to maximize the likelihood, the likelihood value, and the Akaike Information Criterion.

|   | Value | Count | Percent   |
|---|-------|-------|-----------|
| 1 | 1399  | 23.66%|
| 2 | 4515  | 76.34%|

Table 4: 2012 – 11 Issues, 2 Clusters Size. This table includes the number of individuals and percent of total in each cluster.

The two political issue analysis was then applied to higher dimensions in order to model a more complex system of opinion space. The multidimensional opinion space was graphed on two dimensions found through principle component analysis, which finds two axes with the most variation of data. The data is then projected onto these two axes. The results from this analysis is shown in Figure 2. Even with 11 political issues, the positions of the two clusters are consistent with those found with two political issues. One cluster is found very close to the Democratic Party mean, and another cluster is found farther right than the Republican Party mean. Table 3 shows that the Akaike Information Criterion for 11 political issues is much larger than that for two political issues due to the increase in number of parameters. Likewise, the size of the two clusters is the same for two and 11 political issues.

2012-1990- 3 Issues

Figure 3: 2012-1990 – 3 Issues, 2 Clusters. The ‘X’ s are where the cluster means were found. The two triangles represent the political party means; red for republican and blue for democrat. These were found by taking the average of the opinions of those that self-identified as democrat and as republican. Principle Component Analysis was then used to plot the points onto two dimensions.
The two cluster analysis was then repeated for 9 years between 1990 and 2012 using three political issues common between the years. See Appendix A for details on the political issues. The results shown in Figure 3 are consistent with those in Figure 1 and 2. Except in 2008 and 1990, one cluster is found close to the Democratic Party mean and another to the right of the Republican Party mean. The deviation in 2008 can be explained by the lack of data collected in that year. 1990 is a more particular case, in which one cluster is found way left of the Democratic Party mean and another in the middle of the two party means.

A better visualization of the data is shown in Figure 4 and Figure 5, the distance between the cluster means and party means, and the distance from the center. The distance between the cluster means is significantly greater than the distance between the party means. The dip in 2008 can again be explained by the lack of data collected in that year. This suggests that the Gaussian mixture model found that the public opinion is better represented when the two clusters are farther apart than where the party means currently lie. However, it is noteworthy that the distance between the party means is increasing over time. This suggests that the view of the Republican Party may be migrating to the right, where the cluster mean was found, because that is where most of its supporters lie. Figure 5 displays the distance of each cluster and party mean from the center. This graph supports the claim that the Republican Party has consistently taken a more moderate stance than that of some of its supporters.

![Distance vs. Time](image)

**Figure 4: 2012-1990 – 3 Issues, 2 Clusters. Comparison of Distance between Cluster Means and Party Means.** The blue line represents the distance between the cluster means and the red line represents the distance between the party means.
Figure 5: 2012-1990 – 3 Issues, 2 Clusters. Comparison of Distance from Center. The lines with the ‘x’s represent the distance from one cluster mean to the center. The purple and yellow lines represent the distance from one party mean to the center.

Optimal Number of Clusters
The second system focuses on discovering the optimal number of clusters that represents the individuals in the dataset. The analysis was conducted on the 2012 – 2 Political Issue dataset and repeated three times for validation of the results. The best model was determined by minimizing the Akaike Information Criterion value.

The first iteration of the analysis compares the AIC values calculated from the likelihood generated by the Gaussian Mixture Model. The results indicate that 6 clusters is a good representation of the data, shown in Figure 6. The analysis stopped at 10 clusters due to a surprising feature of the covariance values. Displayed in Table 5, most of the covariance values for the clusters are zero in one of the dimensions. This suggests that the model finds that two clusters better represent a group of individuals who have the same opinion on one issue, and only differ by 1 value on the second issue. However, this method of clustering does not represent a coherent political platform, as there is a margin of flexibility in an individual’s answer on a specific issue. The model should not change if one day, an individual answers 6 and the next day 7 on one issue. This problem arises because the data is discrete. As a result, the model is either overfitting the data or determining that clusters with a covariance of zero is a better explanation for the data set.
Figure 6: 2012 – 2 Issues, 2 Clusters. The ‘X’s are where the cluster means were found. The two triangles represent the political party means; red for republican and blue for democrat. These were found by taking the average of the opinions of those that self-identified as democrat and as republican.

| Iterations | 40 |
|------------|----|
| Log-likelihood | 4227.26 |
| Mean | 3.2690 2.3457 |
| | 5.2306 7.0000 |
| | 1.0000 1.0000 |
| | 4.9685 6.0000 |
| | 4.3149 5.0000 |
| | 3.8281 4.0000 |
| Covariance | 1.9810 0.5765 |
| | 3.3060 0.0000 |
| | 1.0e-05 * 1.0000 1.0000 |
| | 2.0842 0.0000 |
| | 2.0784 0.0000 |
| | 2.1873 0.0000 |
| AIC | -8.40E+03 |

Table 5: 2012 – 2 Issues, 2 Clusters. This table includes the number of iterations it took in the Gaussian Mixture Model to get the results. It shows the Log-likelihood value that was maximized, the resulting mean and diagonal covariance values, and the Akaike Information Criterion.

In order to validate the results and make sure that the model is not overfitting the data, the data set was cross validated. A 5-fold partition was used. The training set, 4/5 of the data, ran through the Gaussian Mixture Model and found a set of parameters that maximized the likelihood value. These parameters were then used to calculate the likelihood of the testing data, the leftover 1/5 of the data. This procedure was iterated for 20 clusters. Figure 7 shows the AIC values calculated for each cluster.
Figure 7: 2012 – 2 Issues. Comparison of AIC using Cross Validation. The figure displays the AIC values calculated from the likelihood generated through a 5-fold cross validation up to 20 clusters.

Even after 20 clusters, the AIC values seem to decrease infinitely. As a result, it was determined that the problem of the model is not overfitting, but the zero covariance.

A constraint was added to the model in order to prevent a covariance of zero. It was determined that the covariance value should be greater than 1 in order to represent a coherent political party. The results, shown in Figure 8, indicate that 3 clusters is a better representation of the data than 2 and 4 clusters. The result is robust, as the covariance values found for these 3 clusters are not hovering very close to the covariance constraint. The locations of the 3 clusters lie along the diagonal of the opinion space, with an extremely left group, a moderate group near the current Democratic Party, and a right group. This suggests that there are enough strong left supporters in the Democratic Party to become their own party. However it is questionable whether the moderate party would have a substantial political platform to present as it takes middle stance on every political issue.
Figure 8: 2012 – 2 Issues, 3 Clusters. The green ‘X’ s represent the cluster means. The two triangles represent the political party means; red for republican and blue for democrat. These were found by taking the average of the opinions of those that self-identified as democrat and as republican.

| Mean   | 5.525 | 6.194 |
|--------|-------|-------|
|        | 3.714 | 4.178 |
|        | 1.450 | 0.971 |
| Covariance  | 1.363 | 1.000 |
|        | 1.870 | 1.340 |
|        | 1.723 | 1.986 |
| AIC           | 4.68E+04 |

Table 6: 2012 – 2 Issues, 3 Clusters. This table displays the mean, covariance values, and Akaike Information Criterion found by maximizing the Gaussian likelihood function.

Discussion

In the two cluster analysis, it was determined that the current two political parties are a good representation of the public opinion. The Democratic Party mean lies very close to one cluster, and the Republican Party mean takes a position that is closer to the center than the second cluster in order to attract the votes of the Independents. However, this model is based on the notion that it is unlikely for a major third or fourth party to form. The system of the US government reinforces bipartisanship and prevents the formation of more dominant parties.

On the other hand, when this limitation is removed, the optimal number of clusters that represents the population is always greater than two. This model is based on a multiparty system that allows more than two political parties to run for office and potentially win an election independently or in coalition. The benefits of having multiple parties lie in the ability of the political system to incorporate more variations of opinions. As the percentage of the population that is represented in government increases, voter turnout will also grow. Knowing that they have more than two options will help voters become more involved in their political system. The multiparty system also encourages cooperation in the government as party members need to work together in order to maximize the likelihood of winning an election. Even though there is the possibility that these coalitions will fail once elected, the presence of the other parties will not allow a complete standstill to occur in the government.

The limitations in this analysis lie in the inability to determine the exact number of clusters that best represents the data. Due to the discreteness of the data, a covariance of zero in one dimension is causing the model to find clusters that do not correspond to a coherent political party. As a result, a constraint was added to make sure that each cluster has a covariance that is greater than one. However, when this analysis was done for a greater number of clusters, the covariance values began to straddle the constraint. This indicates that the clusters found are being limited by the constraint. Subsequently, more research needs to be done in determining the value to set the constraint that corresponds to a political platform. The analysis for the optimal number of clusters was also limited to data on two political issues. However, the public opinion space is not based on only two issues. In the future, the two dimensional analysis should be applied to higher dimensions to make sure that the clusters found are not dependent on one political issue. Another limitation of this analysis lies in fact that each political issue has equal weight in determining the clusters. In truth, there are some political issues that voters prioritize and deem more important than others. These issues should have more weight in determining where the clusters form. One
of the main limitations lie in the discreteness of the data. In the future, methods of dealing with discrete datasets in statistical analysis should be researched.

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### Appendix A: Political Issues

#### 2012–2 Political Issues

| Political Issue | Guaranteed Jobs and Income Scale | Aid to Black Scale |
|-----------------|----------------------------------|--------------------|
| Question        | "Some people feel that the government in Washington should see to it that every person has a job and a good standard of living. Others think the government should just let each person get ahead on his/their own. Where would you place yourself on this scale, or haven't you thought much about this?" | "Some people feel that the government in Washington should make every (prior to 1996 only: possible) effort to improve the social and economic position of blacks. Others feel that the government should not make any special effort to help blacks because they should help themselves. Where would you place yourself on this scale, or haven't you thought much about it?" |
| Scale           | 0 = NA                           | 0 = NA             |
|                 | 1 = Gov. should see to job and good standard of living | 1 = Gov. should help minority groups |
|                 | 7 = Gov. should let each person get ahead on his own | 7 = Minority groups should help themselves |
|                 | 9 = DK                           | 9 = DK             |

#### 2012–11 Political Issues

| Political Issue | Government Health Insurance Scale | Guaranteed Jobs and Income Scale | Aid to Black Scale |
|-----------------|-----------------------------------|----------------------------------|--------------------|
| Survey          | "Some (1994-later: people) feel there should be a government insurance plan which would cover all medical and hospital expenses for everyone. Others feel that (1994-1996: all) medical expenses should be paid by individuals, and through private insurance plans like Blue Cross (1984-1994: or [1996: some] other company paid plans). Where would you place yourself on this scale, or haven't you thought much about this?" | "Some people feel that the government in Washington should see to it that every person has a job and a good standard of living. Others think the government should just let each person get ahead on his/their own. Where would you place yourself on this scale, or haven't you thought much about this?" | "Some people feel that the government in Washington should make every (prior to 1996 only: possible) effort to improve the social and economic position of blacks. Others feel that the government should not make any special effort to help blacks because they should help themselves. Where would you place yourself on this scale, or haven't you thought much about it?" |
| Question        | 0 = NA                           | 0 = NA                         | 0 = NA             |
|                 | 1 = Gov. insurance plan           | 1 = Gov. should see to job and good standard of living | 1 = Gov. should help minority groups |
|                 | 7 = Private insurance plan        | 7 = Gov. should let each person get ahead on his own | 7 = Minority groups should help themselves |
|                 | 9 = DK                           | 9 = DK                         | 9 = DK             |
| Scale           | 0 = NA                           | 0 = NA                         | 0 = NA             |
|                 | 1 = Gov. insurance plan           | 1 = Gov. should see to job and good standard of living | 1 = Gov. should help minority groups |
|                 | 7 = Private insurance plan        | 7 = Gov. should let each person get ahead on his own | 7 = Minority groups should help themselves |
|                 | 9 = DK                           | 9 = DK                         | 9 = DK             |
Survey Question

“Some people think the government should provide fewer services, even in areas such as health and education, in order to reduce spending. Other people feel that it is important for the government to provide many more services even if it means an increase in spending.

Where would you place yourself on this scale, or haven't you thought much about this?”

Scale

| 0 = NA | 1 = Gov. should provide many fewer services: reduce |
|--------|-------------------------------------------------|
| 7 = Gov. should provide many more services: increase |
| 9 = DK |

Political Issue

President on Aid to Blacks Scale

“Some people feel that the President should make every (prior to 1996 only: possible) effort to improve the social and economic position of blacks. Others feel that the President should not make any special effort to help blacks because they should help themselves.

Where should the President do on this scale, or haven't you thought much about it?”

Scale

| 0 = DK | 1 = Gov. should help minority blacks/minorities |
|--------|-------------------------------------------------|
| 7 = Blacks/minorities should help themselves |
| 9 = DK |

Survey Question

“Some people believe that we should spend much less money for defense. Others feel that defense spending should be greatly increased.

What should the President do in regards to Defense Spending or haven't you thought much about this?”

Scale

| 0 = DK | 1 = Greatly decrease defense spending |
|--------|-----------------------------------|
| 7 = Greatly increase defense spending |
| 9 = NA |

Political Issue

President on Guaranteed Jobs and Living Scale

“Some (1994-later: people) feel there should be a government insurance plan which would cover all medical and hospital expenses for everyone. Others feel that (1994-1996: all) medical expenses should be paid by individuals, and through private insurance plans like Blue Cross (1984-1994: or [1996: some] other company paid plans).

Where should the President do on this scale, or haven't you thought much about it?”

Scale

| 0 = DK | 1 = Government insurance plan |
|--------|-------------------------------|
| 7 = Private insurance plan |
| 9 = NA |

Survey Question

“Some people think the government should provide fewer services, even in areas such as health and education, in order to reduce spending. Other people feel that it is important for the government to provide many more services even if it means an increase in spending.

Where would you place yourself on this scale, or haven't you thought much about this?”

Scale

| 0 = DK | 1 = Gov. should provide many fewer services: reduce |
|--------|-------------------------------------------------|
| 7 = Gov. should provide many more services: increase |
| 9 = NA |

Survey Question

“Some people believe that the government should spend much less money for defense. Others feel that defense spending should be greatly increased.

What should the President do in regards to Defense Spending or haven't you thought much about this?”

Scale

| 0 = DK | 1 = Greatly decrease defense spending |
|--------|-----------------------------------|
| 7 = Greatly increase defense spending |
| 9 = NA |

Survey Question

“Some people feel that the government in Washington should see to it that every person has a job and a good standard of living. Others think the government should just let each

Where would you place the President on a Liberal-Conservative scale, or haven't you thought much about it?”

Survey Question

“Where would you place the President on a Liberal-Conservative scale, or haven't you thought much about it?”
person get ahead on his/their own.

What should the President do on this scale, or haven't you thought much about this?

| Scale | 0 = DK | 1 = Gov. should see to job and good standard of living | 7 = Gov. should let each person get ahead on his/their own | 9 = NA |
|-------|--------|------------------------------------------------------|----------------------------------------------------------|--------|

0 = DK | 1 = Extremely liberal | 3 = Slightly liberal | 5 = Slightly conservative |

2 = Liberal | 4 = Moderate | 6 = Conservative | 7 = Extremely conservative |

9 = NA

2012-1990 – 3 Political Issues

| Political Issue | Guaranteed Jobs and Income Scale | Aid to Black Scale | Government Service-Spending Scale |
|-----------------|----------------------------------|--------------------|-----------------------------------|

Survey Question

"Some people feel that the government in Washington should see to it that every person has a job and a good standard of living. Others think the government should just let each person get ahead on his/their own. Where would you place yourself on this scale, or haven't you thought much about this?"

| Scale | 0 = NA | 1 = Gov. should see to job and good standard of living | 7 = Gov. should let each person get ahead on his/their own | 9 = DK |
|-------|--------|------------------------------------------------------|----------------------------------------------------------|--------|

0 = NA | 1 = Gov. should help minority groups | 7 = Minority groups should help themselves |

9 = DK

Appendix B: Correlation analysis

2012-2 Political Issues

Combination 1:

Issue 1: Government Health Insurance Scale
Issue 2: Guaranteed Jobs and Income Scale

Correlation coefficient: 0.4872
Combination 2:
Issue 1: Guaranteed Jobs and Income Scale
Issue 2: Aid to Blacks Scale
Correlation coefficient: 0.4861

Combination 3:
Issue 1: Government Health Insurance Scale
Issue 2: Defense Spending Scale
Correlation coefficient: 0.2923
Combination 4:
Issue 1: Government Health Insurance Scale
Issue 2: Government Services-Spending Scale
Correlation coefficient: -0.4843

|   | AIC   | BIC   | AIC   | BIC   | AIC   | BIC   |
|---|-------|-------|-------|-------|-------|-------|
| 1 | 4.51E+04 | 4.51E+04 | 4.45E+04 | 4.46E+04 | 4.29E+04 | 4.30E+04 |

It is observed that when two combinations have similar correlation coefficients, the graphs are similar. Even though sometimes the correlation coefficients are different, the difference does not influence the results of AIC and BIC. The only thing changed is the slope of contour, which is the same as the correlation coefficients. Therefore, the effect of correlation can be excluded.