Work Sample – Campaign Targeting Audiences

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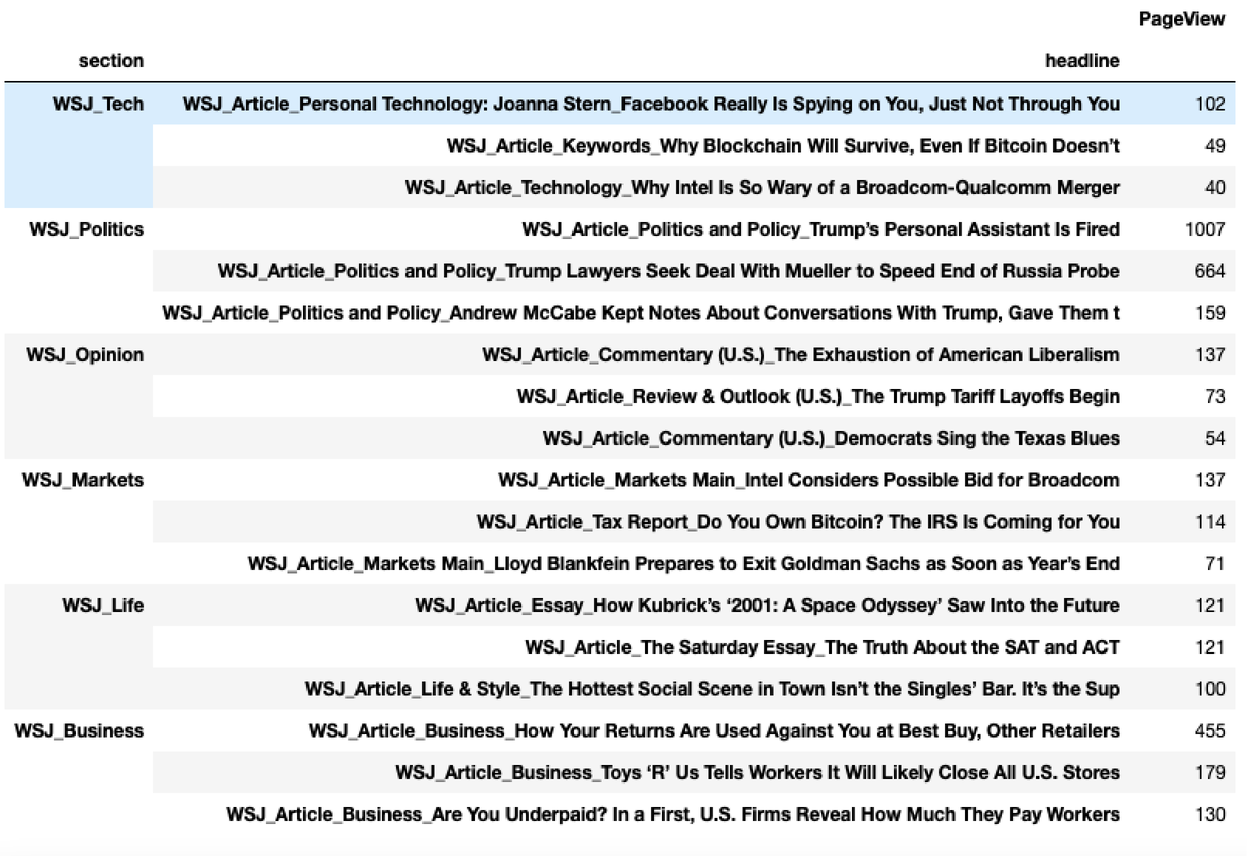
Questions (Part A)

1. What percent of customers returned after the first visit?

11.82% of customers returned after the first visit. This is computed by number of customers who paid a second visit divided by number of customers.

2. What are the top three best-performing stories in each section, by pageviews?

I use headline to define story. The top three best-performing stories in each section are listed here in Table 1.

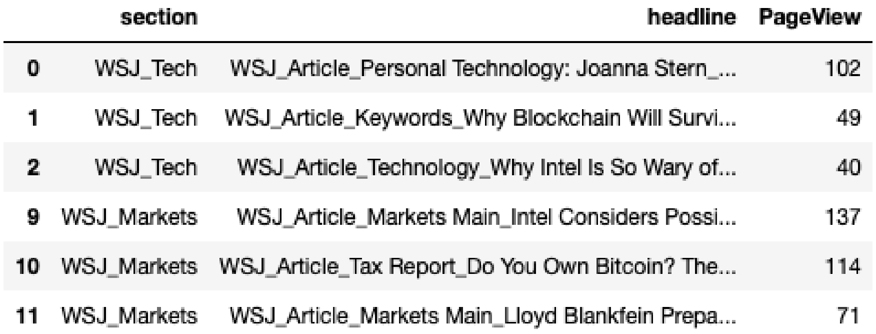


		PageView
section	headline	
WSJ_Tech	WSJ_Article_Personal Technology: Joanna Stern_Facebook Really Is Spying on You, Just Not Through You	102
	WSJ_Article_Keywords_Why Blockchain Will Survive, Even If Bitcoin Doesn't	49
	WSJ_Article_Technology_Why Intel Is So Wary of a Broadcom-Qualcomm Merger	40
WSJ_Politics	WSJ_Article_Politics and Policy_Trump's Personal Assistant Is Fired	1007
	WSJ_Article_Politics and Policy_Trump Lawyers Seek Deal With Mueller to Speed End of Russia Probe	664
	WSJ_Article_Politics and Policy_Andrew McCabe Kept Notes About Conversations With Trump, Gave Them t	159
WSJ_Opinion	WSJ_Article_Commentary (U.S.)_The Exhaustion of American Liberalism	137
	WSJ_Article_Review & Outlook (U.S.)_The Trump Tariff Layoffs Begin	73
	WSJ_Article_Commentary (U.S.)_Democrats Sing the Texas Blues	54
WSJ_Markets	WSJ_Article_Markets Main_Intel Considers Possible Bid for Broadcom	137
	WSJ_Article_Tax Report_Do You Own Bitcoin? The IRS Is Coming for You	114
	WSJ_Article_Markets Main_Lloyd Blankfein Prepares to Exit Goldman Sachs as Soon as Year's End	71
WSJ_Life	WSJ_Article_Essay_How Kubrick's '2001: A Space Odyssey' Saw Into the Future	121
	WSJ_Article_The Saturday Essay_The Truth About the SAT and ACT	121
	WSJ_Article_Life & Style_The Hottest Social Scene in Town Isn't the Singles' Bar. It's the Sup	100
WSJ_Business	WSJ_Article_Business_How Your Returns Are Used Against You at Best Buy, Other Retailers	455
	WSJ_Article_Business_Toys 'R' Us Tells Workers It Will Likely Close All U.S. Stores	179
	WSJ_Article_Business_Are You Underpaid? In a First, U.S. Firms Reveal How Much They Pay Workers	130

Table 1: Best Three Performing Stories in Each Section

3. Based on this data, would you choose to promote a Tech story or a Markets story on social media? Why?

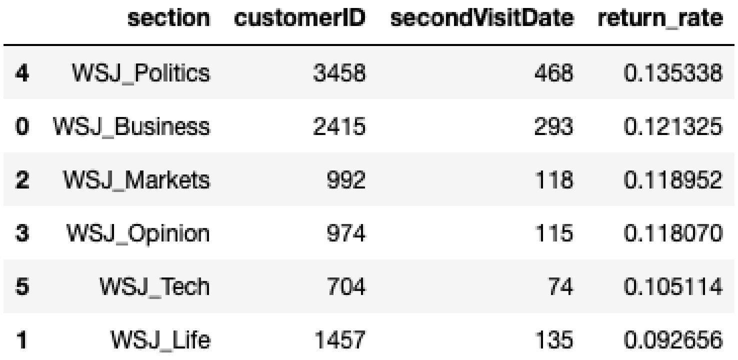
With a closer look at this data, in Table 2, Markets story performs better than Tech story in terms of pageviews of the top three best performing stories.



	section	headline	PageView
0	WSJ_Tech	WSJ_Article_Personal Technology: Joanna Stern_...	102
1	WSJ_Tech	WSJ_Article_Keywords_Why Blockchain Will Survi...	49
2	WSJ_Tech	WSJ_Article_Technology_Why Intel Is So Wary of...	40
9	WSJ_Markets	WSJ_Article_Markets Main_Intel Considers Possi...	137
10	WSJ_Markets	WSJ_Article_Tax Report_Do You Own Bitcoin? The...	114
11	WSJ_Markets	WSJ_Article_Markets Main_Lloyd Blankfein Prepa...	71

Table 2: Best Three Performing Stories in Tech and Markets

As shown in Table 3, in terms of the overall pageviews and return rate, which is calculated by dividing the number of second visits by the number of first visits, the Markets section performs better than the Tech section. The two-sample t-test of the null hypothesis of equal return rates of Markets and Tech has a p-value of 0.3714, which is greater than 0.05. This shows that there is no statistically significant difference between these return rates. We need more data to accurately measure the return rates of different sections. However, based on the realized pageviews and return rates, I will **choose to promote a Markets** story to social media, as it is slightly better than Tech.



	section	customerID	secondVisitDate	return_rate
4	WSJ_Politics	3458	468	0.135338
0	WSJ_Business	2415	293	0.121325
2	WSJ_Markets	992	118	0.118952
3	WSJ_Opinion	974	115	0.118070
5	WSJ_Tech	704	74	0.105114
1	WSJ_Life	1457	135	0.092656

Table 3: Visits and Return Rate in Each Section

4. Create a visualization exploring the relationship between any of the content characteristics (such as section, author, keywords, etc...) and returning visitors. This is an open-ended task. Briefly describe the visualization and the insight.

To study the relationship between **section and returning visitors**, I find that Politics has the highest return rate at 13.53%, followed by Business at 12.13%, and Markets at 11.89%. Life has the lowest return rate at 9.26%. The lines in Figure 1 show the range of one standard error above and below the estimates. Again, the exact ranking of return rates is subject to large estimation errors.

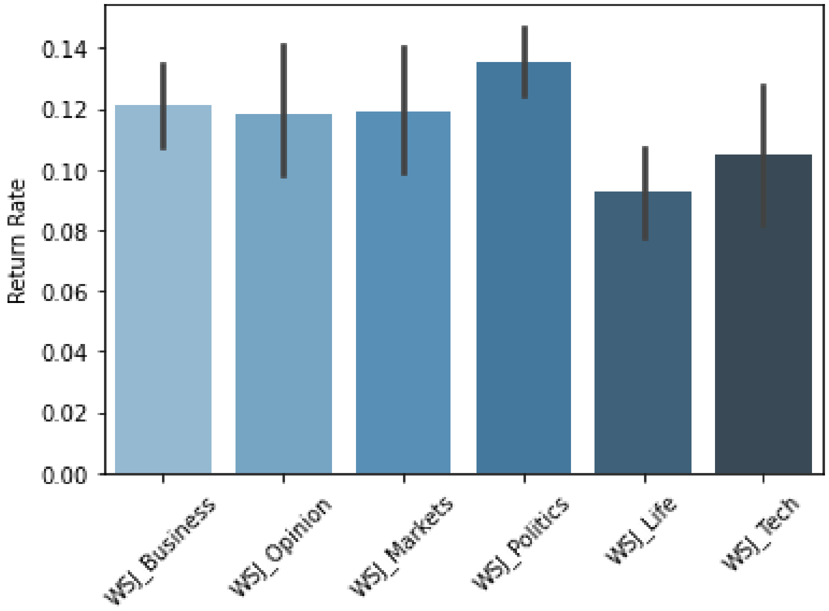


Figure 1: Return rate in Each Section

To study the relationship between **author and returning visitors**, I compute the return rates of frequently read authors (pageviews above 200). Figure 2 shows the frequently read authors weighted by return rate. The font size is proportional to return rates. *Khadeeja Safdar* ranked in the top with 565 pageviews and 14.15% return rate. *Michael C. Bender* ranked in the second place with 1717 pageviews and 13.8% return rate.

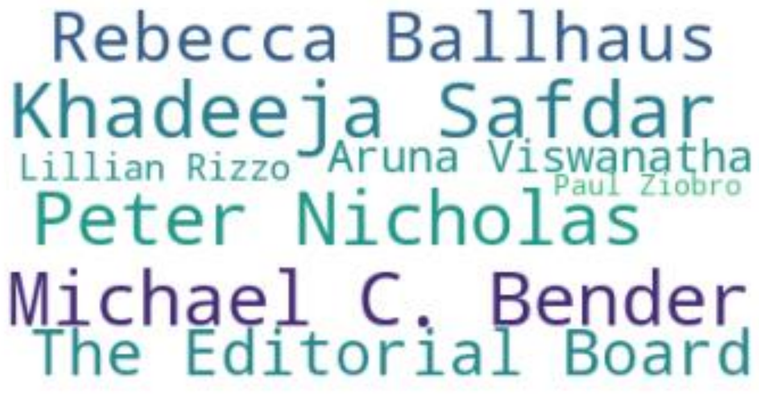


Figure 2: Word Cloud for Popular Authors by Return Rate

To study the relationship between **keywords and returning visitors**, I compute the return rates of frequently read keywords (pageview above 100). Figure 3 shows the frequently viewed keywords weighted by return rate. The font size is proportional to return rates. *Leder* viewed 266 times with a return rate of 16.16% ranks at the top. And *lawyers*, *interview*, *obstruction of justice* and *2016 presidential election* followed, with return rates around 14%.

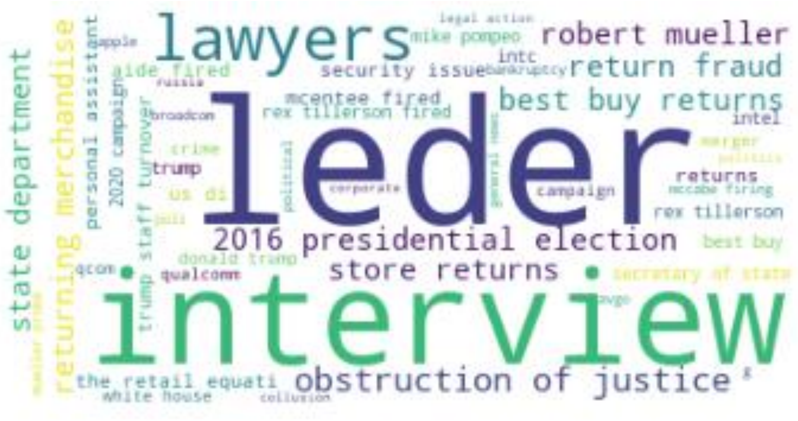


Figure 3: Word Cloud for Popular Keywords by Return Rate

5. What other interesting stories can you tell with this data?

Frequent readers generate more revenues than others. It is worth exploring what frequent readers' first read is about. I use total visits as a proxy for how frequent customers view and divide customers into different blocks:

- Block 1: totalVisits between 2-5, which contains 1104 observations;
- Block 2: totalVisits between 6-9, which contains 112 observations;
- Block 3: totalVisits between 10-20, which contains 54 observations;
- Block 4: totalVisits above 20, which contains 23 observations.

Then I examine the distribution of first-reads' sections within each customer block. The result is shown in Figure 4. The length of stacked bars represents the probability of first-reads' sections. During their first visits, frequent readers tend to read more **Business** and **Opinion** sections, and less **Markets** sections relative to infrequent readers.

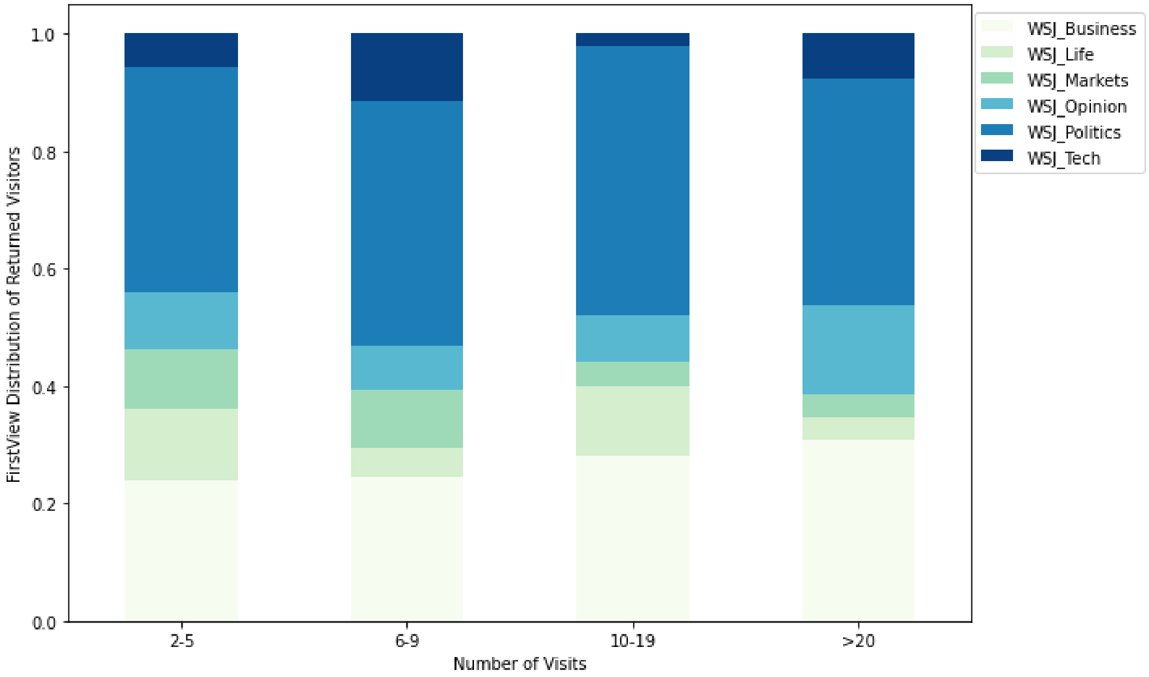


Figure 4: Returned Visitors' First Visit Distribution across Sections

Bonus Questions (Part B)

1. Create a simple model predicting the likelihood of a first-time visitor returning.

I choose *wordCount*, *videoCount*, *author*, *topicKeywords* as predictors. To reduce the number of insignificant predictors, I only include authors of more than 200 first-time pageviews and keywords of more than 500 first-time pageviews. Categorical variables are transformed into dummy variables, and numerical variables are divided by the sample maximum to reduce to ranges of zero and one. We end up with a total of 32 predictors.

I use the Random Forest model to predict return probabilities. Logistic regression regularized by elastic net serves as the benchmark. The sample is divided into a training set of 8,000 observations and a test of 2,000 observations. Table 4 shows the models' out-of-sample Area under Receiver Operating Characteristics (AUROC)[1]. Random Forest yields AUROC of 0.53 which is lower than the benchmark's AUROC of 0.57.

Figure 5 shows the variable importance of random forest. The number of words dominates other variables' importance. Figure 6 shows slope coefficients of non-zero predictors in the logistic model. Only two predictors matter in the logistic model: whether the article is in Politics section and the number of videos.

Based on the result, a few variables, number of words, number of videos and the political section drives most of the model outcomes. To interpret their impacts on the model, I build a decision tree with the three predictors. Figure 7 shows the decision tree. The nodes of the tree show Politics section without video and longer articles with video tend to yield higher return probabilities of 13% relative to other circumstances (10% and 7%).

Model	AUC
Random Forest	0.5318
Logistic Regression	0.5674
Decision Tree with Selected Features	0.5609

Table 4: Model Performance Comparison

[1] ROC curve plots all combinations of true positive rates and false positive rates. AUROC measures the area between the ROC curve and 45-degree line. A higher AUROC indicates better performance.

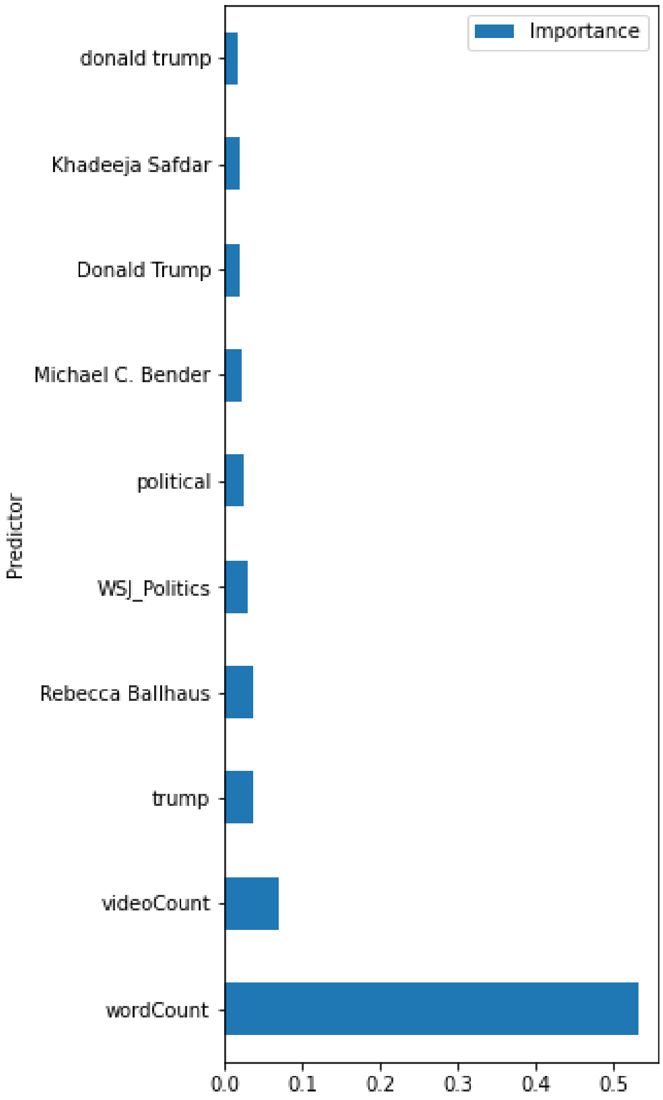


Figure 5: Importance of Predictors in Random Forest

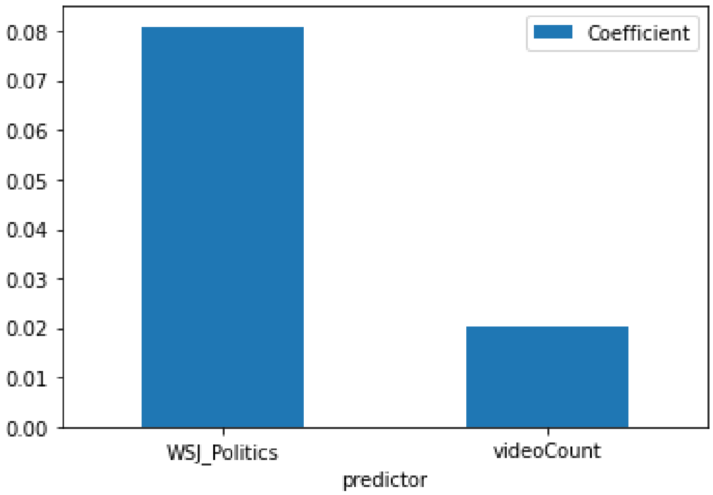


Figure 6: Coefficient of Features in Logistic Regression

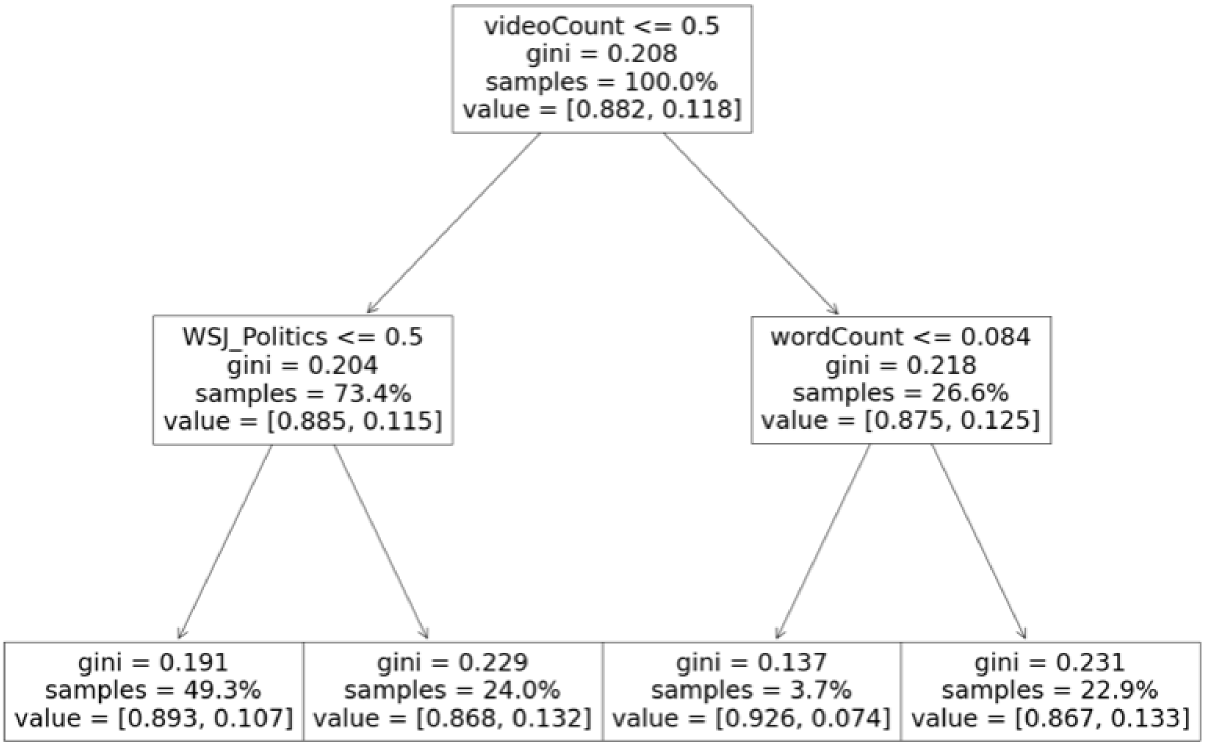


Figure 7: Decision Tree

2. What additional data would you add to improve the model? (Answer in 3-5 sentences)

I will add additional data describing visitor profiles and behaviors. The first visitors are not subscribers, it’s hard to know their demographic information, but we can certainly take advantage of the traffic information to evaluate their engagement, such as the number of visited pages, page view duration, and events describing multi-tasking, click to other articles, click to videos and watching time. We can also take advantage of visitor profile information such as geographics, languages, and platform information.