Final Project

Ryan Yu

Introduction and data

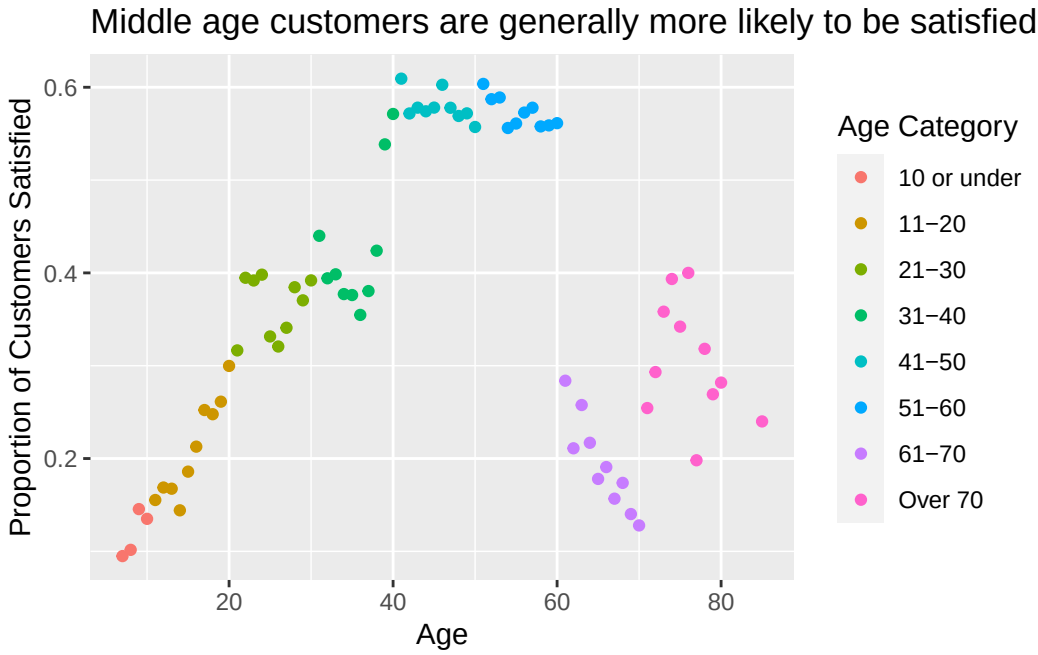
Air travel is an extremely popular form of transportation in the United States with over a million people flying every day. Everyone's experience is unique, whether they are travelling for work, vacation, school, etc. My research is motivated by the many different factors of air travel that contribute to a passenger's satisfaction. Understanding the factors that contribute to passenger satisfaction is crucial for airlines to improve their services. My research aims to answer the question: What are the most important factors that drive overall passenger satisfaction, and how effective are these factors at predicting overall customer satisfaction? My data set was collected through a US passenger satisfaction survey and compiled on Kaggle. The data set was originally split into "training" and "testing" data, which were random mutually exclusive parts of the same survey. In my research, the two data sets are recombined and an additional binary variable for satisfaction was added. Fourteen factors were included in the survey, with participants rating their satisfaction for each factor from 1 to 5, with 1 being least satisfied and 5 being most satisfied. Additionally, a rating of 0 corresponded to "Not Applicable", however I have changed the satisfaction levels of 0 to NA as to not skew the analysis. These factors include many different aspects of a passengers experience during a flight, from booking services to online check-in to the food offered during the flight, etc. Other variables include gender, customer type (loyal/disloyal), age, type of travel (business/person), class of travel, flight distance, departure delay, arrival delay, and overall satisfaction. There are 129880 total observations with each correspond to one person's unique survey answers. Out of those, 50874 reported to be overall satisfied and 68330 reported to be overall neutral or dissatisfied (not satisfied).

The table below shows the fourteen factors in the survey with the average of all responses (grouped by overall satisfaction as well as combined):

	Satisfied	Not Satisfied	Combined
Inflight wifi	3.393511	2.398750	2.813526
Departure/Arrival time	3.14203	3.28529	3.223411
Ease of online booking	3.244406	2.617090	2.883001
Gate location	2.972903	2.980055	2.976948

Food and drink	3.528888	2.961526	3.208034
Online checkin	4.153870	2.708061	3.33164
Seat comfort	3.966417	3.038039	3.441388
Inflight entertainment	3.964202	2.893142	3.358542
On-board service	3.856171	3.019742	3.383153
Leg room	3.834051	3.006488	3.366377
Baggage handling	3.966914	3.374912	3.632114
Check-in service	3.649004	3.043008	3.306293
Inflight service	3.970990	3.389832	3.642333
Cleanliness	3.746509	2.933359	3.28668

The average satisfaction score varies between 2.81 for in-flight WiFi service to 3.64 for in-flight service. For the most part, being overall satisfied corresponds to a higher average score for the factors (with departure/arrival time and gate location being the only two exceptions). Additionally, the factors have varying spreads between average scores of overall satisfied passengers and not satisfied passengers. For example, online checkin has a much higher average score when looking at overall satisfied passengers compared to not satisfied passengers while gate location has a very small difference in average scores when looking at overall satisfied compared to not satisfied.



The probability of being satisfied seems highest for middle age (groups aged 41-50 and 51-60) people while younger and older passengers have a smaller probability of being satisfied. There

is a notable difference in the proportion of satisfied passengers between age groups with a sharp drop off once the passenger age reaches 60 years old.

Methodology

For my analysis, I chose to use a logistic regression model. Since overall satisfaction is a binary variable (satisfied or not satisfied), a logistic regression model provides valuable comparisons between different values of the predictor variables in terms of odds ratios for satisfaction. The model will show which variables affect the probability of being satisfied the greatest. We can then test the model on our data to determine the effectiveness of our model at predicting overall satisfaction. For predictor variables, I used all fourteen factors in the survey, as well as age (categorized), flight distance, customer type (loyal/not loyal), arrival delay, gender, type of travel, travel class, and an interaction term between type of travel and travel class. The main effects were chosen as they are all factors that could affect a passenger's satisfaction in their flying experience. The interaction term is included because I believe that the relationship between travel class and satisfaction depends on the type of travel due to business travels having a stronger preference and desire to fly business class. Departure delay is not included in the model because the departure delay does not matter as much as the arrival could still be on time, therefore I only included the arrival delay in the model since the two variables are highly co-linear and arrival delay matters much more to passengers than departure delay.

The original data set had missing data points that have been addressed through Multiple Imputation via Chained Equations (MICE). The missing data seems random throughout and could probably be explained by some flights not offering some of the factors (for example, some flights don't offer in flight entertainment).

The assumption of independence holds up well in our model as each observation is a single passenger on a different flight. Therefore the observations are pretty independent of each other, with minor violations that could be caused by major disruptions that affect an entire airport/region and not knowing the airline that the passenger flew on. However, with the large scale of observations, these minor violations should not affect our model by much.

Afterwards, in order to determine the model's effectiveness, I calculated the sensitivity, specificity, positive predictive value, and negative predictive value.

Results

$$\widehat{Satisfaction}\ odds = e^{-10.72 + 0.034*male + 2.35*loyal\ customer + 0.0000045*flight\ distance + (-3.68)*personal\ travel}$$
$$+ (-0.99)*economy + (-1.10)*economy\ plus + 0.80*inflight\ wifi\ service + (-0.29)*time\ convenience + 0.27*ease\ of\ online\ booking$$
$$+ (-0.22)*gate\ location + (-0.05)*food\ and\ drink + 0.85*online\ checkin + 0.015*seat\ comfort + 0.052*inflight\ entertainment$$
$$+ 0.32*onboard\ service + 0.26*legroom + 0.13*baggage\ handling + 0.34*checkin\ service + 0.13*inflight\ service + 0.24*cleanliness$$
$$+ (-0.0048)*arrival\ delay + 0.36*11\ to\ 20\ years\ old + 0.42*21\ to\ 30\ years\ old + 0.13*31\ to\ 40\ years\ old + 0.44*41\ to\ 50\ years\ old$$
$$+ 0.36*51\ to\ 60\ years\ old + (-0.091)*61\ to\ 70\ years\ old + (-1.08)*over\ 70\ years\ old$$
$$+ 0.87*personal\ travel*\ economy + 0.76*personal\ travel*economy\ plus$$

Out of the fourteen factors, in-flight WiFi service, online check-in, boarding service, leg room, check-in service have relatively high magnitude slope coefficients while controlling for the other variables in our model, meaning that changes in the scores of these factors have the greatest impact on the predicted probability of overall satisfaction. For example, for every one point increase in in-flight WiFi service satisfaction, we predict the odds of being satisfied overall to be multiplied by 2.23, while controlling for the other variables in the model. Meanwhile, seat comfort, in-flight entertainment. and food and drink had relatively low magnitude slope coefficients controlling for the other variables in our model, meaning that changes in the scores of those factors have a relatively smaller impact on the predicted probability of overall satisfaction. Increases in gate location, departure/arrival time convenience, and food and drink actually had a negative coefficient, meaning that an increase in the scores of those factors resulted in decreased predicted odds of being satisfied overall, while controlling for the other variables in the model. Other than the fourteen factors on the survey, being a loyal customer results in predicted odds of overall satisfaction that are 10.49 times higher than not loyal customers, while controlling for the other variables in our model. Additionally, travelling for personal reasons had predicted odds of satisfaction that were much lower than business travelers. Sitting in economy or economy plus verses business class also lowers the predicted odds of satisfaction, especially if the traveler is a business traveler. Increased flight delay time has a minor negative effect on predicted satisfaction odds while being male has a minor positive effect. For age categories, being 41-50 years old resulted in the greatest predicted odds of overall satisfaction compared to the other age categories while being over 70 years old resulted in the lowest predicted odds of overall satisfaction compared to the other age categories, while controlling for the other variables in the model. Overall, middle age adult age groups represented greater predicted odds of satisfaction compared to the younger and older age groups, while controlling for the other variables in the model.

Using a threshold of 0.5, out of the 129880 observations, 49097 people were satisfied and correctly predicted to be satisfied, 7331 were satisfied and incorrectly predicted to be not satisfied, 66559 were not satisfied and correctly predicted to be not satisfied, and 6893 were not satisfied and incorrectly predicted to be satisfied. We are able to calculate a sensitivity of

87.01%, a specificity of 90.62%, a positive predictive value of 87.69%, and a negative predictive value of 90.08%.

Discussion

From the results, our model did a good job at predicting satisfaction when the threshold was set at 0.5. We obtained high sensitivity and specificity numbers of 87.01% and 90.62%, respectively, supporting our model's predictive power. The high sensitivity and specificity numbers demonstrate that there were many more true positives and true negatives compared to false positives and false negatives, and that our model seems to do a pretty good job at predicting overall satisfaction from many different factors representing different aspects of a passengers flying experience, as well as personal factors such as age and traveler type.

Some of the factors that affected the odds of predicting satisfaction the most include customer type, type of travel, class of travel, in-flight WiFi, and online check-in. Business travelers tend to go on many more flights than the average leisure traveler and are used to flying frequently, therefore they are less sensitive to minor inconveniences. Additionally, they are more likely to be in business class, which is accounted for in our model, and business class amenities are much better compared to economy/economy plus. It is typical to see people traveling in business class to be more satisfied than someone in economy/economy plus. In-flight WiFi is probably an increasingly important factor to travelers, as many people are constantly attached to their phones and often expect to have service. In-flight WiFi keeps passengers connected while in the air, which is likely seen as very important by people these days, therefore high satisfaction with in-flight WiFi systems provides a large increase in predicted odds of satisfaction. Online check-in eliminates the need to get to the airport much earlier and wait in line to check in at a desk. A streamlined online check-in process saves travelers a lot of time and hassle which is probably why it is one of the factors that increases the predicted odds of overall satisfaction the most. Age is also an important factor, with middle age people more likely to understand the process of flying. Younger and older passengers are more likely to be confused and harder to satisfy, explaining their lower predicted odds of satisfaction in our model. Comparing our model to the visualization from the introduction, higher levels of satisfaction for middle age customers can further be explained by a higher likelihood of business related travel and less particularity when it comes to their flying experience. Most other factors play a smaller role and have a positive correlation with predicted odds of overall satisfaction, as expected. Increases in satisfaction of one aspect of a flight should result in increases in overall satisfaction. However, the departure/arrival time convenience, gate location, and food and drink factors all have a negative correlation with predicted odds of overall satisfaction. An attempt to explain this phenomena is that these factors could have negative correlations with some of the other factors in our model and that passengers consider those other factors more when determining overall satisfaction.

My research is potentially limited by the fact that the data was collected through a survey, with a subjective rating system of the different factors and overall satisfaction. Everyone has

different preferences and weigh each aspect of their experience differently when it comes to determining overall satisfaction. Additionally, the people responding to the survey chose to respond. The demographic of people that declined or ignored responding to the survey could be different than the people who did respond, which could potentially skew the results. To correct this, we could try to determine more objective methods of determining satisfaction and improve our sampling methods.

In conclusion, we analyzed many different factors and their effects on overall satisfaction. These results can be used by the airline industry to determine which aspects of their product they should focus on improving. Airlines are constantly looking to differentiate their product to better compete with competitors, and my research attempts to identify which improvements will appease customers the most. Future studies can include analyzing the costs of making upgrades to their product, analysis of which customers are more profitable and determining their preferences, and research into why customers weigh some factors more than others.