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Identifying the factors affecting the airline customers' satisfaction.

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1. Abstract.

The main goal of the paper is to find which attributes affect the level of satisfaction of airline passengers. After a comparison, the logit model was chosen to establish the relation between the explanatory variables and the dependent variable. According to the Count R2 metric, the final model correctly predicts 88% of the observations.

Results reveal that customer loyalty, legroom service quality, and flight delay significantly impact satisfaction levels, while gender surprisingly emerges as a significant factor, contrary to initial assumptions. Marginal effects calculations offer both qualitative and quantitative insights, highlighting the nuanced impact of variables on satisfaction probabilities. The findings underscore the importance of considering diverse factors in enhancing customer experience and suggest avenues for further research.

2. Introduction.

The airline industry serves as a crucial foundation for economic development, facilitating global trade, tourism, and international investment. This sector's expansion significantly benefits numerous other industries that rely on air travel, including hospitality, retail, and transportation services. Consequently, the growth of the airline industry stimulates a wide range of businesses, creating a ripple effect that stimulates the overall economy. For example, hotels experience increased occupancy from travellers, retail businesses see a rise in customer spending, and transportation services gain more passengers, all thanks to the enhanced connectivity and accessibility provided by airlines.

The airline industry stands as one of the most competitive and dynamic sectors in the global economy. The profit margins are very low, averaging at the level of 2.6 - 2.7%. The low margins are driven by several factors such as fluctuations in fuel prices, strict regulatory requirements and constant pressure to enhance the customer experience. In such conditions, customer satisfaction plays a pivotal role in differentiating the organisation from the competition.

It has been proved by various studies that companies profit from satisfied customers, however, the factors that affect the level of overall satisfaction, and the degree to which they have an effect on it, are not entirely clear. By understanding these factors, airlines can implement targeted improvements that not only elevate satisfaction levels but also cultivate a loyal customer base. Focusing strategically on customer satisfaction is crucial economically, as it can boost long-term profits and give companies a competitive edge in the market.

3. Literature review.

While many studies have classified service quality influences, few have specifically examined the importance of in-flight service efficiency. Hulliyah (2021) emphasises the significance of in-flight service efficiency and quality, especially food and beverage services, in enhancing passenger satisfaction and loyalty.

Service quality is defined as the customer's overall impression of the service provided, with satisfaction being a direct reaction to consumption. If the service meets customer expectations, they will be satisfied and rate the quality as good, if it exceeds expectations, they will be very happy and rate the quality as excellent. Thus, improving service efficiency depends on an airline's ability to consistently satisfy passengers' needs and desires, which enhances customer loyalty and provides a competitive edge. This leads to stronger customer relationships, increased repeat business, positive word-of-mouth, a better corporate image, and cost savings. Long-term quality enhancement is therefore a valuable investment, yielding significant returns (Hulliyah, 2021).

A recent case study on Royal Air Maroc analysed the factors which could affect the brand love, customer loyalty and positive word-of-mouth (WOM) among Royal Air Maroc passengers using an online survey with convenience sampling. The study's findings, derived from structural equation modelling, reveal that airline and terminal tangibles, empathy, and airline image significantly influence perceived service quality. Moreover, price and perceived service quality positively affect passenger satisfaction, which in turn fosters brand love and loyalty. Satisfied passengers are more likely to feel love for the brand and remain loyal, as well as engage in positive WOM. These results highlight the importance of developing a service quality-based action plan to enhance passenger satisfaction, brand love, loyalty, and positive WOM, providing valuable implications for airline management.

The study "Determinants of travel satisfaction for commercial airlines: A data mining approach" provides an in-depth analysis of factors influencing passenger satisfaction in the airline industry, based on a dataset of 129,880 customer feedback entries. The research identifies five critical factors that significantly impact passenger satisfaction: inflight entertainment, seat comfort, online booking, online support, and customer type. Furthermore, improving the quality of inflight entertainment from “very bad” to “very good” leads to an almost doubled increase in satisfied travellers. Similarly, enhancing seat comfort from “very bad” to “very good” results in a 1.29 times rise in customer satisfaction. Additionally, the study reveals a non-linear pattern in the influence of service qualities on travel satisfaction through a k-mode method. It identifies two distinct customer clusters with contrasting service requirements. Service quality improvements significantly enhance the satisfaction of travellers in one cluster, while those in the other cluster are more sensitive to passenger characteristics. It showcases the importance of understanding and addressing the diverse needs and preferences of different customer segments to effectively enhance overall passenger satisfaction.

Jiang et al. (2022) propose a RF-RFE-Logistic feature selection model to extract factors influencing passenger satisfaction. This model uses recursive feature elimination based on random forest (RF-RFE) for preliminary feature selection. Different classification models, including KNN, logistic regression, random forest, Gaussian Naive Bayes, and BP neural network, are then compared for their classification performance before and after feature selection. The random forest model with RF-RFE feature selection demonstrated the best classification performance, ultimately identifying a subset of 17 variables.

Jiang et al. (2022) also propose a literature review in which they look at what factors are considered significant for airline passenger satisfaction, and those factors are: service quality, delay-related factors, flight frequency but also entertainment and Wi-Fi services as well as visit times and ground service quality.

4. Data.

The data set used for the project comes from the Kaggle service. It is a modified version of another dataset from the Kaggle platform prepared for classification purposes. Our goal is to verify whether an econometric approach towards data with binary dependent variable could be as effective in identifying factors of airline passenger satisfaction as with machine learning approach. The dataset in the original form consists of 22 variables which can be used for modelling (and 2 index columns which are not useful in our case) and binary target variable.

Table 1. Original variables contained in the dataset.

Variable Name	**Description**	**Type of Variable**
Gender	Gender of the passengers (Female, Male)	Nominal
Customer Type	The customer type (Loyal customer, disloyal customer)	Nominal
Age	The actual age of the passengers	Numerical
Type of Travel	Purpose of the flight of the passengers (Personal, Business)	Nominal
Class	Travel class in the plane of the passengers (Business, Eco, Eco Plus)	Nominal
Flight distance	The flight distance of this journey	Numerical
Inflight wifi service	Satisfaction level of the inflight wifi service (0 - Not Applicable;1-5)	Nominal
Departure/Arrival time convenient	Satisfaction level of Departure/Arrival time convenient	Nominal
Ease of Online booking	Satisfaction level of online booking	Nominal
Gate location	Satisfaction level of Gate location	Nominal
Food and drink	Satisfaction level of Food and drink	Nominal

Online boarding	Satisfaction level of online boarding	Nominal
Seat comfort	Satisfaction level of Seat comfort	Nominal
Inflight entertainment	Satisfaction level of inflight entertainment	Nominal
On-board service	Satisfaction level of On-board service	Nominal
Leg room service	Satisfaction level of Leg room service	Nominal
Baggage handling	Satisfaction level of baggage handling	Nominal
Check-in service	Satisfaction level of Check-in service	Nominal
Inflight service	Satisfaction level of inflight service	Nominal
Cleanliness	Satisfaction level of Cleanliness	Nominal
Departure Delay in Minutes	Minutes delayed when departure	Numerical
Arrival Delay in Minutes	Minutes delayed when arrival	Numerical
Satisfaction	Airline satisfaction level (Satisfaction, neutral or dissatisfaction)	Nominal, Target

Our approach towards preliminary data preparation resulted in removal of 83 observations that consisted of NA values. Furthermore we have encoded the target variable to 1 - satisfaction and 0 - neutral or dissatisfaction. The variables describing satisfaction levels from 1 to 5 have been analysed, and observations with answers 0 in those categories were also removed from the data set as they were not meaningful (0 means no answer given in the passenger satisfaction survey) leaving us with 23 789 observations.

Based on careful analysis one simplified variable was introduced to the dataset - ‘wifi_good_bad’ created based on ‘Inflight wifi service’ variable to simplify the relationship between the levels of satisfaction from WiFi service to be binary with levels ‘Useful’ meaning WiFi of a quality 3 and higher and ‘Bad’, with a quality of 1 or 2. The variable ‘Inflight wifi service’ was therefore removed from the data set.

Due to the fact that variable 'Class' explains the same phenomenon as few of the other variables available in the model ('Leg room service', 'Seat comfort'), which was confirmed with the chi-square test resulting in p-values for both variables < 5% (we reject the null hypothesis that the variables are independent) the variable was removed from the data set.

Furthermore, a similar approach was taken towards the variable 'Type of Travel' which phenomenon is well reflected in the variables 'wifi_good_bad', as the WiFi on aeroplanes allows for work during business trips but also 'Departure/Arrival time convenient' which reflects convenience of time, which might be related to taking flights in business hours. In both cases the chi-square test resulted in p-values for both variables < 5% (again we reject the null hypothesis that the variables are independent).

'Flight Distance' variable might also explain the phenomenon behind the 'Type of Travel' variable: domestic or short-haul flights for business meetings versus long-haul flights for personal vacations. Therefore the variable 'Type of Travel' was also removed from the data set.

Furthermore, exploratory data analysis for some of the variables was conducted. The target variable contains 10 235 observations with success out of total 23 789 observations, resulting in the balance of 43% in the data (Figure 1). We find this balance to be fair for further modelling.

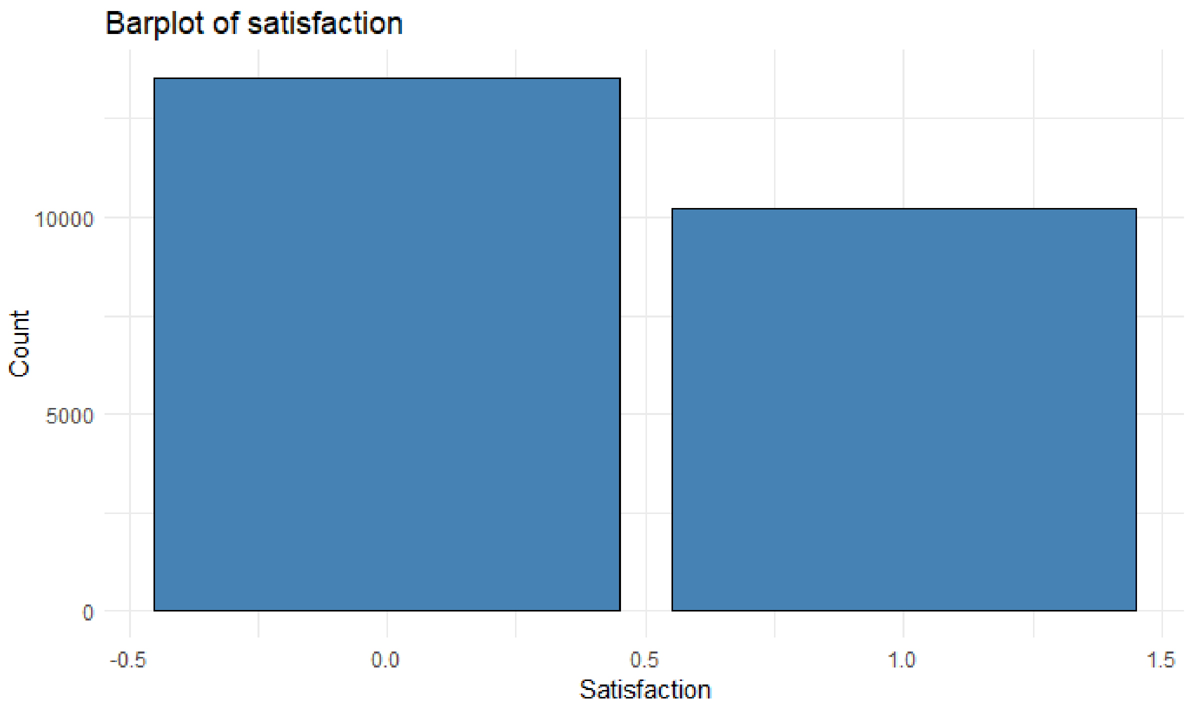

Figure 1. Barplot of satisfaction.

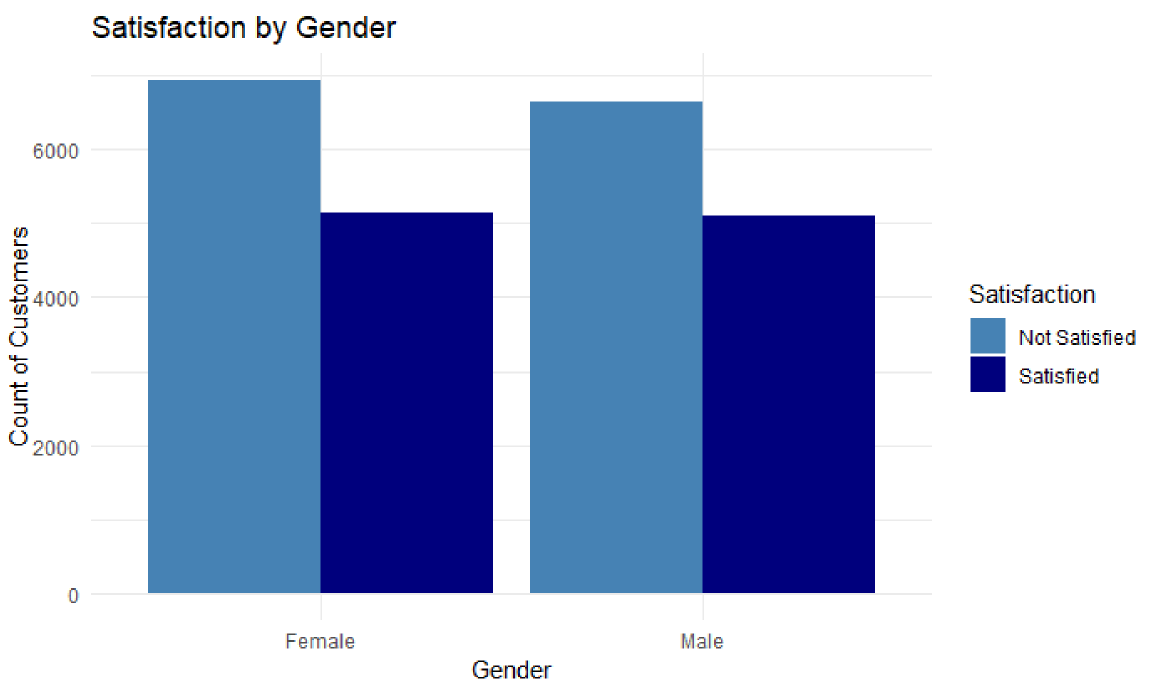

Figure 2. Satisfaction by gender of customer.

In Figure 2. one can observe that the distribution of success observations is similar between both observed genders of customers.

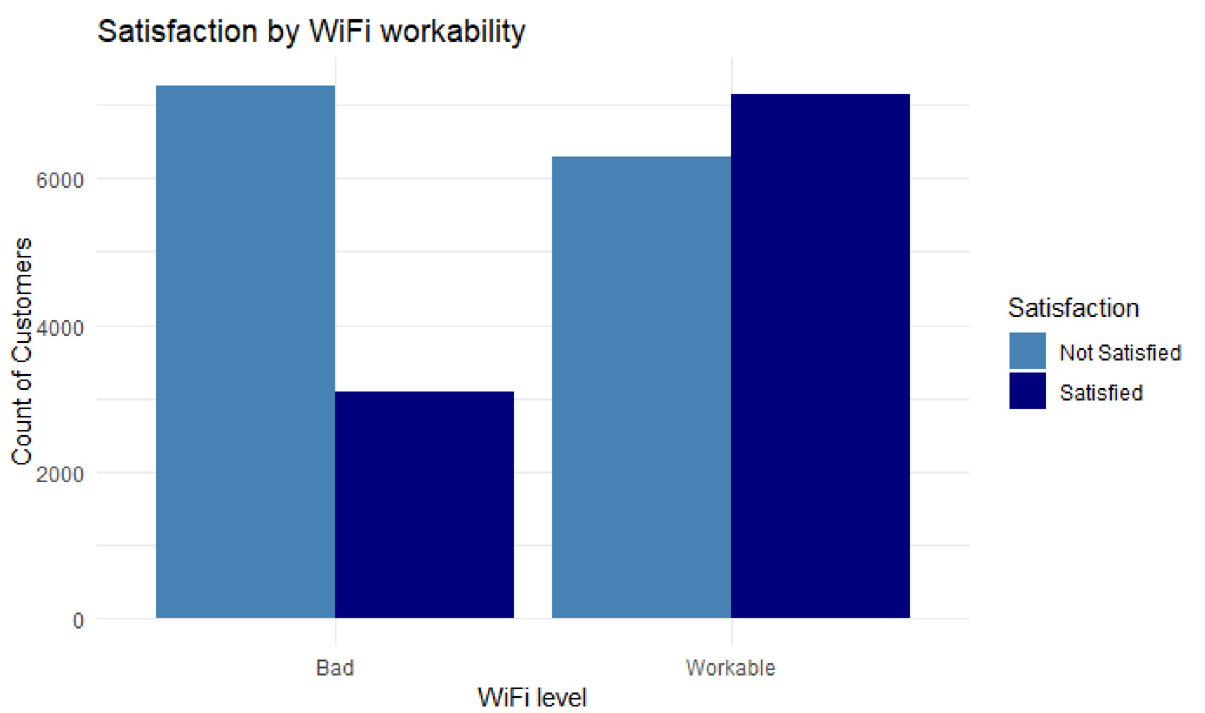

Figure 3. WiFi usefulness vs distribution of satisfaction.

In Figure 3. one can observe that there are a lot more satisfied customers in the group that find WiFi service to be good during the flight - this might suggest that this variable will be important in further modelling.

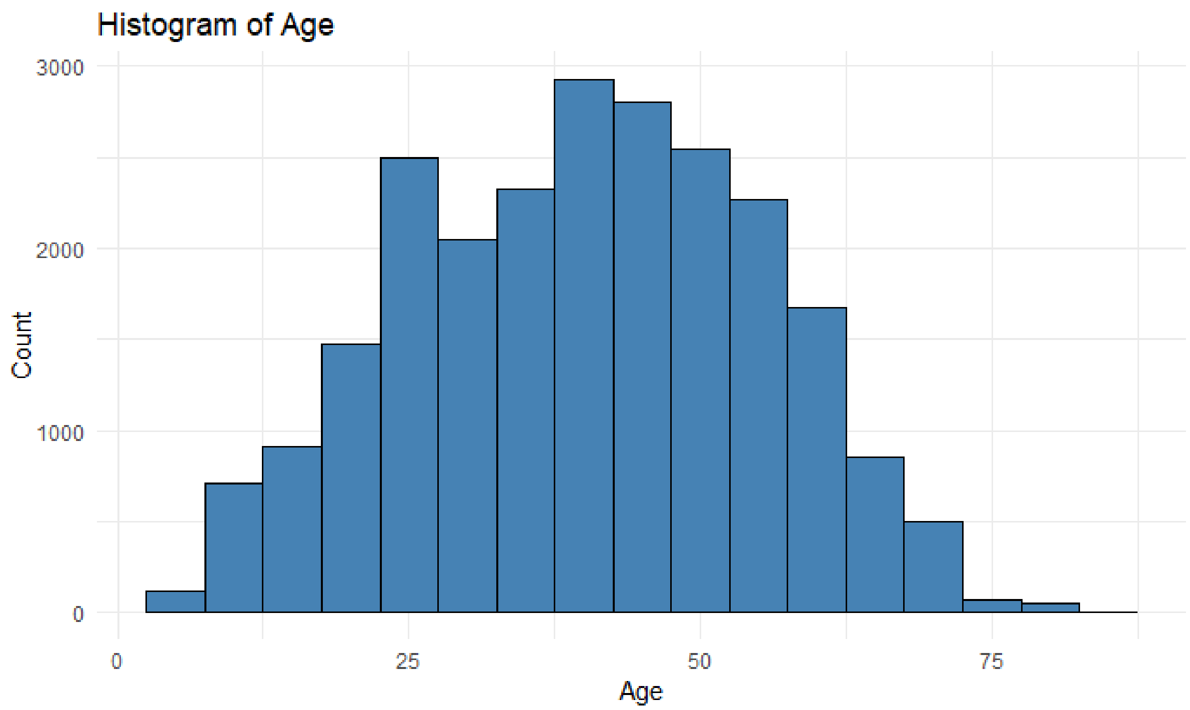

Figure 4. Distribution of age of the customers.

Finally, in Figure 4, one could observe the distribution of customers' age. The median age is 41 years old while the mean age is about 40 years old. The quantiles are distributed as follows:

Table 2. Quantile distribution of customers' age.

Quantile	0%	25%	50%	75%	100%
Age	7	28	41	52	85

4.1. Hypotheses.

Based on the literature review and authors knowledge following hypotheses were stated:

H1: Loyalty of a customer affects positively the probability of customer satisfaction from flight.

H2: Customers' gender has no effect on the probability of customer satisfaction from flight.

H3: Improving Leg room service positively influences the probability of customer satisfaction from flight.

H4: Delay related factors negatively impact the probability of customer satisfaction from flight.

5. Model.

In this section, we would like to create a statistical model for binary dependent variable that will help us with identifying the factors that affect the airline customers' satisfaction. As mentioned before we deal with binary dependent variable (1 - satisfied passenger, 0 - neutral or dissatisfied passenger). Possible to use parametric models for such target variable are Logit and Probit models, both designed to explain probabilities of success (in our case satisfied passenger) of an event based on explanatory variables. Choosing the best model type out of these two will be conducted based on diagnostic tests (Linktest and Hosmer-Lemeshow test) and information criterion, i.e. Akaike Information Criterion (AIC). Next steps will consist of calculation and interpretation of marginal effects. During the entire analysis, the assumed significance level (alpha) is 5%.

Specification of the model that we begin our analysis with:

glm(formula = satisfaction ~ `Customer Type` + `On-board service` + `Baggage handling` + `Inflight entertainment` + `Arrival Delay in Minutes` + `Departure Delay in Minutes` + `Flight Distance` + `Departure/Arrival time convenient` + `Ease of Online booking` + `Online boarding` + `Seat comfort` + `Leg room service` + Gender + I(Age^2) + Age + `Gate location` + Age:`Gate location` + Age:`Ease of Online booking` + `Checkin service` + `Food and drink` + Cleanliness + `Inflight service` + wifi_good_bad,
family = binomial(link = "logit"), data = data)

Besides the variables that we were left with after our preliminary feature selection, additionally the squared relation of ‘Age’ variable was added to the model as well as two interactions of the variables: Age:`Gate location` and Age:`Ease of Online booking`, as we believe that those interactions will well represent relation of convenience of services with issues related to the age of the passenger.

5.1. Model choice.

The first step in the modelling process was the choice of the proper model. Since the target variable is binary(1 – satisfied, 0 – neutral or dissatisfied), the most suitable option is to use either a logit or a probit model. In order to establish which would perform better for our specific case, we utilised the Linktest and Hosmer – Lemeshow test to check if the specification is correct and the AIC value to compare the performance of both models. While for the logit model, both Hosmer – Lemeshow and Linktest proved the correct specification of the model, in the case of the probit model, both tests indicated otherwise, suggesting incorrect specification of the model. Thus based on the output of these tests we may already conclude the superiority of the logit model over the probit model.

Additionally, the logit model, with an AIC value of 13,768.400, demonstrates better performance compared to the probit model, which has an AIC value of 13,822.810. This further supports the preference for the logit model based on the AIC criterion.

Table 3. Test results for Logit and Probit

Model	Linktest (H_0)	Hosmer – Lemeshow (H_0)
Logit	Fail to reject	Fail to reject
Probit	Reject	Reject

Table 4. AIC and Specification

Model	AIC	Specification
Logit	13,768.400	Correct
Probit	13,822.810	Incorrect

5.2 General to specific.

After the preliminary feature selection, the general to specific approach was utilized to the variables which do not contribute much to the model. The Linear Hypothesis test was used to assess if the variables intended for removal are indeed jointly insignificant, ensuring they can be safely removed from the model.

We began our analysis by focusing on the variable with the highest p-value, Departure delay. A linear hypothesis test confirmed that *Departure delay* could be removed from the model. Next, we re-estimated the model without *Departure delay* and tested whether all levels of the *Food and drink* variable were jointly insignificant, as this variable appeared to be the least significant among the remaining variables, together with *Departure delay*. The linear hypothesis test indicated that the *Food and drink* variable was not jointly significant, allowing us to remove it from the model as well.

We then estimated a new model without *Food and drink* and *Departure delay*. During this process, we noticed that some levels of a few other variables appeared to be insignificant. We proceeded to test whether all levels of each variable were jointly insignificant, together with *Food and drink* and *Departure delay*. However, none of these tests suggested joint insignificance.

As a result, the final model retained all variables except for *Food and drink* and *Departure delay*, which were removed based on our findings. In the below table, the beginning logit model is denoted with (2) and the final model is denoted with (4).

Table 5. Model summary for Probit model and Logit models

	Dependent variable:			
	satisfaction			
	probit	logistic		
	(1)	(2)	(3)	(4)
\`Customer Type\`Loyal Customer	0.632***	1.160***	1.160***	1.166***
	(0.037)	(0.068)	(0.068)	(0.068)
\`On-board service\`2	0.140**	0.268**	0.266**	0.240**
	(0.060)	(0.110)	(0.110)	(0.109)
\`On-board service\`3	0.317***	0.601***	0.600***	0.595***
	(0.054)	(0.099)	(0.099)	(0.099)

`On-board service`4	0.357***	0.654***	0.654***	0.646***
	(0.054)	(0.099)	(0.099)	(0.098)
`On-board service`5	0.647***	1.185***	1.185***	1.190***
	(0.058)	(0.107)	(0.107)	(0.106)
`Baggage handling`2	-0.047	-0.089	-0.091	-0.115
	(0.069)	(0.125)	(0.125)	(0.125)
`Baggage handling`3	-0.367***	-0.683***	-0.683***	-0.690***
	(0.064)	(0.116)	(0.116)	(0.116)
`Baggage handling`4	-0.082	-0.152	-0.153	-0.163
	(0.062)	(0.112)	(0.112)	(0.112)
`Baggage handling`5	0.145**	0.253**	0.253**	0.249**
	(0.065)	(0.117)	(0.117)	(0.117)
`Inflight entertainment`2	0.461***	0.832***	0.835***	0.983***
	(0.092)	(0.169)	(0.169)	(0.156)
`Inflight entertainment`3	0.856***	1.572***	1.573***	1.631***
	(0.086)	(0.157)	(0.157)	(0.146)
`Inflight entertainment`4	1.094***	1.960***	1.960***	2.025***
	(0.081)	(0.148)	(0.148)	(0.136)
`Inflight entertainment`5	0.638***	1.103***	1.102***	1.125***
	(0.085)	(0.155)	(0.155)	(0.143)
`Arrival Delay in Minutes`	-0.004***	-0.007***	-0.005***	-0.005***
	(0.001)	(0.002)	(0.001)	(0.001)
`Departure Delay in Minutes`	0.001	0.002		
	(0.001)	(0.002)		
`Flight Distance`	0.0003***	0.0005***	0.0005***	0.0005***
	(0.00001)	(0.00002)	(0.00002)	(0.00002)
`Departure/Arrival time convenient`2	0.030	0.074	0.073	0.068
	(0.058)	(0.108)	(0.108)	(0.108)
`Departure/Arrival time convenient`3	-0.039	-0.067	-0.067	-0.072
	(0.057)	(0.105)	(0.105)	(0.105)
`Departure/Arrival time convenient`4	-0.913***	-1.630***	-1.630***	-1.634***
	(0.053)	(0.097)	(0.097)	(0.097)
`Departure/Arrival time convenient`5	-1.269***	-2.307***	-2.308***	-2.309***
	(0.057)	(0.106)	(0.106)	(0.106)
`Ease of Online booking`2	0.039	0.087	0.088	0.104
	(0.155)	(0.292)	(0.292)	(0.292)
`Ease of Online booking`3	-0.067	-0.104	-0.104	-0.101
	(0.148)	(0.278)	(0.278)	(0.278)
`Ease of Online booking`4	0.690***	1.263***	1.262***	1.273***

	(0.142)	(0.262)	(0.262)	(0.262)
`Ease of Online booking`5	1.586***	3.013***	3.013***	3.032***
	(0.164)	(0.305)	(0.305)	(0.305)
`Online boarding`2	-0.044	-0.116	-0.117	-0.119
	(0.062)	(0.114)	(0.114)	(0.114)
`Online boarding`3	-0.205***	-0.420***	-0.422***	-0.420***
	(0.060)	(0.108)	(0.108)	(0.108)
`Online boarding`4	0.925***	1.593***	1.593***	1.597***
	(0.056)	(0.102)	(0.102)	(0.102)
`Online boarding`5	1.655***	2.928***	2.926***	2.932***
	(0.061)	(0.111)	(0.111)	(0.111)
`Seat comfort`2	-0.163**	-0.315**	-0.317***	-0.275**
	(0.068)	(0.123)	(0.123)	(0.121)
`Seat comfort`3	-0.680***	-1.220***	-1.222***	-1.209***
	(0.063)	(0.114)	(0.114)	(0.113)
`Seat comfort`4	-0.372***	-0.660***	-0.661***	-0.636***
	(0.061)	(0.111)	(0.111)	(0.109)
`Seat comfort`5	-0.110*	-0.201*	-0.201*	-0.182
	(0.064)	(0.116)	(0.116)	(0.114)
`Leg room service`2	0.188***	0.393***	0.392***	0.381***
	(0.055)	(0.101)	(0.101)	(0.101)
`Leg room service`3	0.057	0.139	0.138	0.135
	(0.055)	(0.101)	(0.101)	(0.101)
`Leg room service`4	0.609***	1.155***	1.156***	1.156***
	(0.053)	(0.099)	(0.099)	(0.099)
`Leg room service`5	0.718***	1.361***	1.361***	1.365***
	(0.055)	(0.101)	(0.101)	(0.101)
GenderMale	0.092***	0.177***	0.177***	0.174***
	(0.024)	(0.044)	(0.044)	(0.044)
I(Age2)	-0.001***	-0.002***	-0.002***	-0.002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Age	0.082***	0.153***	0.153***	0.154***
	(0.005)	(0.009)	(0.009)	(0.009)
`Gate location`2	-0.188	-0.341	-0.344	-0.345
	(0.131)	(0.242)	(0.242)	(0.242)
`Gate location`3	-0.380***	-0.690***	-0.689***	-0.685***
	(0.122)	(0.226)	(0.226)	(0.226)
`Gate location`4	-0.319**	-0.591**	-0.591**	-0.593***
	(0.125)	(0.230)	(0.230)	(0.230)

\`Gate location\`5	-0.300**	-0.581**	-0.583**	-0.592**
	(0.153)	(0.280)	(0.280)	(0.280)
\`Checkin service\`2	0.062	0.106	0.106	0.108
	(0.050)	(0.091)	(0.091)	(0.091)
\`Checkin service\`3	0.312***	0.559***	0.559***	0.562***
	(0.044)	(0.080)	(0.080)	(0.080)
\`Checkin service\`4	0.277***	0.499***	0.499***	0.501***
	(0.044)	(0.079)	(0.079)	(0.079)
\`Checkin service\`5	0.582***	1.072***	1.073***	1.075***
	(0.048)	(0.087)	(0.087)	(0.087)
\`Food and drink\`2	0.152**	0.277**	0.277**	
	(0.066)	(0.119)	(0.119)	
\`Food and drink\`3	0.047	0.100	0.099	
	(0.065)	(0.118)	(0.118)	
\`Food and drink\`4	0.045	0.118	0.118	
	(0.065)	(0.117)	(0.117)	
\`Food and drink\`5	0.016	0.048	0.047	
	(0.066)	(0.120)	(0.120)	
Cleanliness2	-0.139**	-0.257**	-0.258**	-0.206*
	(0.069)	(0.123)	(0.123)	(0.121)
Cleanliness3	0.132**	0.196*	0.196*	0.215**
	(0.061)	(0.110)	(0.110)	(0.107)
Cleanliness4	0.027	0.040	0.040	0.059
	(0.061)	(0.109)	(0.109)	(0.106)
Cleanliness5	0.294***	0.545***	0.546***	0.552***
	(0.066)	(0.119)	(0.119)	(0.116)
\`Inflight service\`2	-0.093	-0.198	-0.195	-0.236*
	(0.073)	(0.134)	(0.134)	(0.133)
\`Inflight service\`3	-0.482***	-0.918***	-0.916***	-0.926***
	(0.068)	(0.124)	(0.124)	(0.124)
\`Inflight service\`4	-0.171***	-0.338***	-0.335***	-0.352***
	(0.065)	(0.118)	(0.118)	(0.117)
\`Inflight service\`5	0.118*	0.209*	0.213*	0.203*
	(0.068)	(0.124)	(0.124)	(0.123)
wifi_good_badWorkable	0.706***	1.278***	1.278***	1.273***
	(0.038)	(0.070)	(0.070)	(0.070)
Age:\`Gate location\`2	0.003	0.005	0.005	0.005
	(0.003)	(0.006)	(0.006)	(0.006)

Age:\`Gate location\`3	0.001	0.001	0.001	0.001
	(0.003)	(0.005)	(0.005)	(0.005)
Age:\`Gate location\`4	0.006**	0.011**	0.011**	0.012**
	(0.003)	(0.005)	(0.005)	(0.005)
Age:\`Gate location\`5	0.008**	0.015**	0.015**	0.015**
	(0.004)	(0.006)	(0.006)	(0.006)
\`Ease of Online booking\`2:Age	-0.003	-0.007	-0.007	-0.007
	(0.003)	(0.006)	(0.006)	(0.006)
\`Ease of Online booking\`3:Age	-0.005	-0.011*	-0.011*	-0.010*
	(0.003)	(0.006)	(0.006)	(0.006)
\`Ease of Online booking\`4:Age	-0.010***	-0.020***	-0.020***	-0.020***
	(0.003)	(0.006)	(0.006)	(0.006)
\`Ease of Online booking\`5:Age	-0.014***	-0.029***	-0.029***	-0.029***
	(0.004)	(0.007)	(0.007)	(0.007)
Constant	-4.580***	-8.336***	-8.334***	-8.311***
	(0.165)	(0.307)	(0.307)	(0.305)
Observations	23,789	23,789	23,789	23,789
Log Likelihood	-6,842.404	-6,815.198	-6,815.711	-6,820.155
Akaike Inf. Crit.	13,822.810	13,768.400	13,767.420	13,768.310

Note: *p<0.1; **p<0.05; ***p<0.01

5.3. Model Validation.

To test if the estimates of the final model, after the general-to-specific method, are not biased and reflect reality, the Hosmer - Lemeshow, Osius – Rojek and Stukel tests were employed to check the specification of the model. For every abovementioned test, the H_0 says the specification is correct. The p-values were 0.59, 0.25 and 0.48 respectively. Hence in every case, we failed to reject the H_0 indicating the specification of our model is correct. For additional reassurance, we also conducted a linktest. The results are presented in the table below

Table 6. Results for linktest

	Estimate	P-value	Significance at 5% level
Yhat	0.999	<2e-16	Yes
Yhat2	-0.003	0.515	No

As seen in the table yhat is significant while yhat2 is not, which indicates the correct specification of the model. Finally, the LR test was performed to compare the null model (which includes only an intercept) with the final model. The test yielded a p-value below 0.05, indicating that the final model provides a significantly better fit to the data than the null model. This suggests that the predictors included in the final model are jointly significant in explaining the variation in satisfaction levels. Therefore, we may conclude the final model has the correct specification and should be preferred for understanding satisfaction.

5.4. Model Performance.

The final model's performance will be assessed based on the interpretation of R2 statistics - in our case those will be: McKelvey-Zavoina R2, Count R2, Adjusted Count R2. Results may be found in the table below (Table X.)

Table 7. R2 statistics of the model.

Statistics	Value
McKelvey-Zavoina R2	0.7583
Count R2	0.8823
Adjusted Count R2	0.7265

According to the McKelvey-Zavoina R2 statistic value, if a hidden variable was observed, the model would explain around 75.83% of its variability. Based on the Count R2 statistic value we can say that around 88.23% of the observations were predicted correctly by the model. The value of Adjusted Count R2 statistic allows to say that around 72.65% of the observations were correctly predicted based only on the variables characteristics that were used for the modelling with no regards to the p* threshold value.

5.5. Marginal Effects.

5.5.1 Marginal effects for average characteristics.

Below, the print from 'logitmfx' function is shown in the form of a table with marginal effects calculated for the average values of the predictors, so for the average characteristic.

Table 8. Marginal effects to average characteristics.

```
Marginal Effects:
                                              dF/dx   Std. Err.       z   P>|z|
`Customer Type`Loyal Customer            0.22504930  0.01075002  20.93 < 2e-16 ***
`On-board service`2                      0.05573682  0.02595357   2.15 0.03175 *
`On-board service`3                      0.14043261  0.02382292   5.89 3.8e-09 ***
`On-board service`4                      0.15085973  0.02326070   6.49 8.8e-11 ***
`On-board service`5                      0.28334013  0.02505480  11.31 < 2e-16 ***
`Baggage handling`2                     -0.02573247  0.02760388  -0.93 0.35123
`Baggage handling`3                     -0.14538062  0.02216638  -6.56 5.4e-11 ***
`Baggage handling`4                     -0.03672688  0.02495933  -1.47 0.14116
`Baggage handling`5                      0.05742417  0.02749980   2.09 0.03678 *
`Inflight entertainment`2                0.23617066  0.03773152   6.26 3.9e-10 ***
`Inflight entertainment`3                0.38567853  0.03168088  12.17 < 2e-16 ***
`Inflight entertainment`4                0.46358214  0.02750782  16.85 < 2e-16 ***
`Inflight entertainment`5                0.26701141  0.03387391   7.88 3.2e-15 ***
`Arrival Delay in Minutes`              -0.00105011  0.00013566  -7.74 9.9e-15 ***
`Flight Distance`                        0.00011227  0.00000551  20.36 < 2e-16 ***
`Departure/Arrival time convenient`2     0.01544675  0.02473768   0.62 0.53235
`Departure/Arrival time convenient`3    -0.01616936  0.02347559  -0.69 0.49097
`Departure/Arrival time convenient`4    -0.31137329  0.01489490 -20.90 < 2e-16 ***
`Departure/Arrival time convenient`5    -0.39171719  0.01260266 -31.08 < 2e-16 ***
`Ease of Online booking`2                0.02385606  0.06735951   0.35 0.72322
`Ease of Online booking`3               -0.02273068  0.06219242  -0.37 0.71475
`Ease of Online booking`4                0.30406468  0.06117164   4.97 6.7e-07 ***
`Ease of Online booking`5                0.62027548  0.03653616  16.98 < 2e-16 ***
`Online boarding`2                      -0.02666868  0.02523041  -1.06 0.29051
`Online boarding`3                      -0.09154860  0.02238966  -4.09 4.3e-05 ***
`Online boarding`4                       0.37151201  0.02237536  16.60 < 2e-16 ***
`Online boarding`5                       0.61985457  0.01558921  39.76 < 2e-16 ***
`Seat comfort`2                         -0.06034560  0.02572374  -2.35 0.01898 *
`Seat comfort`3                         -0.23372305  0.01769168 -13.21 < 2e-16 ***
`Seat comfort`4                         -0.13828390  0.02243862  -6.16 7.1e-10 ***
`Seat comfort`5                         -0.04074827  0.02511478  -1.62 0.10470
`Leg room service`2                      0.08920961  0.02428659   3.67 0.00024 ***
`Leg room service`3                      0.03113053  0.02350177   1.32 0.18530
`Leg room service`4                      0.27269923  0.02310811  11.80 < 2e-16 ***
`Leg room service`5                      0.32313941  0.02330519  13.87 < 2e-16 ***
GenderMale                               0.03949060  0.01007841   3.92 8.9e-05 ***
I(Age^2)                                -0.00040154  0.00002140 -18.76 < 2e-16 ***
Age                                      0.03490534  0.00205044  17.02 < 2e-16 ***
`Gate location`2                        -0.07560233  0.05088237  -1.49 0.13733
`Gate location`3                        -0.14686431  0.04513192  -3.25 0.00114 **
`Gate location`4                        -0.12724443  0.04596666  -2.77 0.00564 **
`Gate location`5                        -0.12445770  0.05354071  -2.32 0.02010 *
`Checkin service`2                       0.02481677  0.02110556   1.18 0.23966
`Checkin service`3                       0.13158156  0.01900789   6.92 4.4e-12 ***
```

```
`Checkin service`4                  0.11688914  0.01879451   6.22 5.0e-10 ***
`Checkin service`5                  0.25701073  0.02072930  12.40 < 2e-16 ***
Cleanliness2                       -0.04563102  0.02626507  -1.74 0.08233 .
Cleanliness3                        0.04969094  0.02500439   1.99 0.04689 *
Cleanliness4                        0.01343607  0.02420908   0.56 0.57889
Cleanliness5                        0.13001151  0.02794904   4.65 3.3e-06 ***
`Inflight service`2                -0.05191446  0.02830016  -1.83 0.06659 .
`Inflight service`3                -0.18838708  0.02182291  -8.63 < 2e-16 ***
`Inflight service`4                -0.07872517  0.02572043  -3.06 0.00221 **
`Inflight service`5                 0.04672926  0.02873576   1.63 0.10391
wifi_good_badWorkable               0.27551205  0.01396345  19.73 < 2e-16 ***
Age:`Gate location`2                0.00104969  0.00128340   0.82 0.41342
Age:`Gate location`3                0.00021712  0.00119256   0.18 0.85553
Age:`Gate location`4                0.00261389  0.00121539   2.15 0.03150 *
Age:`Gate location`5                0.00341343  0.00147561   2.31 0.02071 *
`Ease of Online booking`2:Age      -0.00164413  0.00142439  -1.15 0.24839
`Ease of Online booking`3:Age      -0.00236264  0.00136458  -1.73 0.08338 .
`Ease of Online booking`4:Age      -0.00457291  0.00128581  -3.56 0.00038 ***
`Ease of Online booking`5:Age      -0.00655977  0.00151729  -4.32 1.5e-05 ***
```

Based on the calculations we can state that in comparison to the Disloyal Customer, Loyal Customers are more likely by about 22.5 percentage points to be satisfied from service (ceteris paribus). The variable is statistically significant due to p-value < 0.05 significance level. We fail to reject the H1 hypothesis that loyalty of a customer affects positively the probability of customer satisfaction from flight.

Furthermore, customers' gender seems to be not only a significant variable (which is contrary to the assumption made in the H2 hypothesis), but also marginal effects provide an insight that being a male increases the probability of being a satisfied customer by 3.95 percentage point for average observation ceteris paribus. This makes us reject our H2 hypothesis that the gender of a customer has no effects on customer satisfaction.

The ‘Leg room service’ rated 2 seems to increase the likelihood of being a satisfied customer by 8.92 percentage points in comparison to base level (rating 1 of ‘Leg room service’) keeping all the other factors constant. What is quite odd is that the rating 3 of ‘Leg room service’ is statistically insignificant, so we cannot derive any insights from it. For the level 4 of the ‘Leg room service’ variable, the probability of being a satisfied customer increases by 27.27 percentage points in comparison to the base level, ceteris paribus. Finally, the likelihood of average observation being a satisfied customer while giving the rating 5 to ‘Leg room service’ variable increases by 32.31 percentage points in comparison to the base level, ceteris paribus. This observation makes us fail to reject our H3 hypothesis that improving ‘Leg room service’ positively influences the probability of customer satisfaction from flight.

For the ‘Arrival Delay in Minutes’ variable, the increase by one unit will result in decreasing the probability of an average customer being satisfied with the flight by 0.1 percentage points, ceteris paribus. This observation makes us fail to reject the H4 hypothesis that delay related factors negatively impact the probability of customer satisfaction from flight.

5.5.2. Average marginal effects.

The table 9 presents the results for average marginal effects. According to the outcome, the Loyal customer type increases the probability of being a satisfied passenger by, on average, 10 percentage points, as compared to the disloyal customer type. This supports our first hypothesis.

Furthermore, our second hypothesis has been disproved as the gender variable is statistically significant, thus affecting the probability of satisfaction. If the gender of a client is male, the probability of the customer being satisfied increases by, on average, 1.5 percentage points in comparison to female passenger.

Notably, the leg room service positively influences the probability of satisfaction among airline passengers. Even a small upgrade, at level 2, increases the probability of a satisfied customer by 3.3 p.p. Level 3 is insignificant, however, levels 4 and 5 are both statistically significant and show an increase of 11 and 13 p.p. on average respectively, as compared to the base level. It showcases the great importance of leg room service and supports our third hypothesis.

The fourth hypothesis has also been supported by the analysis of average marginal effects, as the ‘Arrival Dealy in Minutes’ is statistically significant and has a negative sign. One minute increase in arrival delay decreases the probability of passengers being satisfied by 0.04 percentage points on average.

Table 9. Average marginal effects.

```
Marginal Effects:
                                        dF/dx   Std. Err.       z   P>|z|
`Customer Type`Loyal Customer      0.10447316  0.00609282  17.15 < 2e-16 ***
`On-board service`2                0.02086661  0.00951199   2.19 0.02826 *
`On-board service`3                0.05148200  0.00846359   6.08 1.2e-09 ***
`On-board service`4                0.05786844  0.00901036   6.42 1.3e-10 ***
`On-board service`5                0.11065176  0.01044472  10.59 < 2e-16 ***
`Baggage handling`2               -0.01001216  0.01090362  -0.92 0.35849
`Baggage handling`3               -0.06089462  0.01032319  -5.90 3.7e-09 ***
`Baggage handling`4               -0.01413343  0.00964547  -1.47 0.14284
```

```
`Baggage handling`5                      0.02193863  0.01047360   2.09 0.03620 *
`Inflight entertainment`2                0.08403248  0.01305420   6.44 1.2e-10 ***
`Inflight entertainment`3                0.13838699  0.01198387  11.55 < 2e-16 ***
`Inflight entertainment`4                0.20208661  0.01487370  13.59 < 2e-16 ***
`Inflight entertainment`5                0.10507049  0.01423775   7.38 1.6e-13 ***
`Arrival Delay in Minutes`              -0.00040280  0.00005274  -7.64 2.2e-14 ***
`Flight Distance`                        0.00004306  0.00000228  18.86 < 2e-16 ***
`Departure/Arrival time convenient`2  0.00589490  0.00939543   0.63 0.53038
`Departure/Arrival time convenient`3 -0.00623920  0.00911317  -0.68 0.49357
`Departure/Arrival time convenient`4 -0.14335441  0.00839168 -17.08 < 2e-16 ***
`Departure/Arrival time convenient`5 -0.19852173  0.00855201 -23.21 < 2e-16 ***
`Ease of Online booking`2                0.00907241  0.02540606   0.36 0.72102
`Ease of Online booking`3               -0.00880176  0.02431889  -0.36 0.71740
`Ease of Online booking`4                0.11619107  0.02503908   4.64 3.5e-06 ***
`Ease of Online booking`5                0.30566376  0.03239479   9.44 < 2e-16 ***
`Online boarding`2                      -0.01039675  0.01000300  -1.04 0.29864
`Online boarding`3                      -0.03749790  0.00983697  -3.81 0.00014 ***
`Online boarding`4                       0.15658052  0.01085383  14.43 < 2e-16 ***
`Online boarding`5                       0.32327995  0.01339956  24.13 < 2e-16 ***
`Seat comfort`2                         -0.02401967  0.01066211  -2.25 0.02427 *
`Seat comfort`3                         -0.10958519  0.01055138 -10.39 < 2e-16 ***
`Seat comfort`4                         -0.05373631  0.00890200  -6.04 1.6e-09 ***
`Seat comfort`5                         -0.01567926  0.00970446  -1.62 0.10616
`Leg room service`2                      0.03305556  0.00875229   3.78 0.00016 ***
`Leg room service`3                      0.01178420  0.00879008   1.34 0.18004
`Leg room service`4                      0.10741662  0.00966278  11.12 < 2e-16 ***
`Leg room service`5                      0.12629874  0.00982447  12.86 < 2e-16 ***
GenderMale                               0.01515095  0.00386154   3.92 8.7e-05 ***
I(Age^2)                                -0.00015403  0.00000890 -17.30 < 2e-16 ***
Age                                      0.01338906  0.00084317  15.88 < 2e-16 ***
`Gate location`2                        -0.02991048  0.02086746  -1.43 0.15176
`Gate location`3                        -0.05991946  0.01988330  -3.01 0.00258 **
`Gate location`4                        -0.05153091  0.01992115  -2.59 0.00969 **
`Gate location`5                        -0.05092417  0.02379936  -2.14 0.03238 *
`Checkin service`2                       0.00940822  0.00791311   1.19 0.23446
`Checkin service`3                       0.04949494  0.00706694   7.00 2.5e-12 ***
`Checkin service`4                       0.04411651  0.00702275   6.28 3.3e-10 ***
`Checkin service`5                       0.09823404  0.00821655  11.96 < 2e-16 ***
Cleanliness2                            -0.01798392  0.01065948  -1.69 0.09158 .
Cleanliness3                             0.01877070  0.00931064   2.02 0.04379 *
Cleanliness4                             0.00514640  0.00926023   0.56 0.57838
Cleanliness5                             0.04953856  0.01068879   4.63 3.6e-06 ***
`Inflight service`2                     -0.02052645  0.01157022  -1.77 0.07605 .
`Inflight service`3                     -0.08201780  0.01111961  -7.38 1.6e-13 ***
`Inflight service`4                     -0.03041341  0.01003604  -3.03 0.00244 **
`Inflight service`5                      0.01784407  0.01093327   1.63 0.10266
wifi_good_badWorkable                    0.11746983  0.00668521  17.57 < 2e-16 ***
Age:`Gate location`2                     0.00040264  0.00049236   0.82 0.41349
Age:`Gate location`3                     0.00008328  0.00045747   0.18 0.85554
Age:`Gate location`4                     0.00100264  0.00046691   2.15 0.03176 *
Age:`Gate location`5                     0.00130933  0.00056693   2.31 0.02092 *
`Ease of Online booking`2:Age           -0.00063066  0.00054651  -1.15 0.24851
`Ease of Online booking`3:Age           -0.00090627  0.00052387  -1.73 0.08364 .
`Ease of Online booking`4:Age           -0.00175409  0.00049543  -3.54 0.00040 ***
`Ease of Online booking`5:Age           -0.00251621  0.00058594  -4.29 1.8e-05 ***
```

6. Results.

Due to the fact that our model passess the test for functional form (Linktest) and also diagnostic tests (Hosmer-Lemeshow, Osius-Rojek, Stukel) as well as Likelihood Ratio test for joint significance of all the variables in the model, we were able to conclude about the hypotheses from the model's results. Three out of Four of our hypotheses were supported by the evidence found in the marginal effects analysis. The hypotheses that held were:

H1: Loyalty of a customer affects positively the probability of customer satisfaction from the flight.

H3: Improving Leg room service positively influences the probability of customer satisfaction from flight.

H4: Delay-related factors negatively impact the probability of customer satisfaction from flight.

The hypothesis **H2**: 'Customers' gender has no effect on the probability of customer satisfaction from flight' was rejected due to the fact that the gender variable appeared to be significant in the model, affecting the probability of satisfaction positively if the gender of a passenger is male. The 'no effect' stated in the hypothesis would mean the insignificance of the variable in the model which appeared not to be true.

7. Findings.

The results of our study indicate that Loyal customers are more likely to be satisfied with the service. Furthermore, gender turned out to be a significant factor in terms of predicting the customer's satisfaction, contrary to the prior assumptions of the authors. The leg room service turned out to be also a significant factor, which when improved, in comparison to the base level, positively influenced the likelihood of customers being satisfied. Last but not least, factor related to the delay of the flight, as expected, with the growth of the delay negatively influenced the probability of customers being satisfied with the service - this factor was also statistically significant.

Calculation of marginal effects allowed for not only qualitative interpretation of the result (which would be the only interpretation possible considering only the model estimators), but also quantitative analysis regarding the factors. For example, for the average observation (average passenger) a 1 unit increase in 'Departure Delay in Minutes' variable would be decreasing the probability of an average customer being satisfied with the flight by 0.1 percentage points, ceteris paribus. On the other hand, average marginal effect for all observations for the same variable imply that one minute increase in arrival delay decreases the probability of passengers being satisfied by 0.04 percentage points on average.

The next possible step in the analysis of the topic might be exploring whether non-parametric models could offer improved accuracy and provide more intriguing insights. This implies examining how these models perform compared to parametric ones, assessing their potential to uncover nuanced patterns and relationships within the data, and determining whether their flexibility can capture complex phenomena more effectively.

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9. Appendix.

Link to the projects repository: https://github.com/what-a-life/Econometrics-project

Files in the repository:

- data used for the modelling - test.csv
- link to the dataset: https://www.kaggle.com/datasets/teejmahal20/airline-passenger-satisfaction
- code to reproduce the findings - code.R
- code to calculate the Linktest - linktest.R*
- code for Hosmer-Lemeshow, Osius-Rojek, Stukel tests - AIIGOFTests.R**

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