Are Unprofitable Airlines More Likely to Be Unsafe?

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Abstract

This paper investigates the relationship between airline profitability and safety in the United States after the consolidation of the industry in the aftermath of the financial crisis, using a dataset of 40 airlines from 2010 to 2019. This study examines the debate surrounding the trade-off between profitability and safety. The study contributes to the literature by analysing the effect of airline operating margin on accident rates in the year following the financial crisis. To this end, a Poisson model is employed to estimate the relationship between the two variables. Our analysis reveals that the impact of operating margin on safety differs depending on the size of the airline. Specifically, our results show that for small and medium-sized airlines, there is a significant negative impact of the operating margin on the accident rates. In contrast, larger airlines experience an increase in accident rates when their operating margin is positive. These findings suggest that the consolidation of airlines in recent decades may have led to reduced safety investments for large airlines in response to reduced competition.

1. Introduction

The airline industry has undergone significant changes in recent years. In the United States, after the financial crisis of 2008, numerous bankruptcies in the industry, led to a significant amount of consolidation of the industry. As a result, the number of airlines in the United States has decreased, and the remaining airlines have become larger and more profitable. This significant consolidation particularly when it comes to large carriers has raised concerns about the safety of airlines, as some argue that the focus on profitability and lack of competition may come at the expense of safety.

The relationship between profitability and safety of airlines has been a topic of debate for the past three decades. Despite the significant amount of research that has been done on this topic, there is still no consensus on whether there is a causal relationship or the direction of the relationship between the two variables. Some studies have found a negative relationship between profitability and safety, suggesting that airlines that focus on profitability may compromise safety measures. Others have found a positive relationship between profitability and safety, arguing that profitable airlines have more resources to invest in safety.

The research that has been done on this topic has also been criticized for being outdated. Most of the studies were conducted before the consolidation of airlines in the United States in the 80's, and therefore it is possible that is does not accurately reflect the current state of the airline industry. This paper aims to fill this gap in the literature by investigating the relationship between profitability and safety of airlines after the consolidation of the industry.

The paper uses a dataset based on 40 airlines carriers operating in the United States from 2010 to 2019. A Poisson model is used to predict the influence of the operating margin of an airline on the rate of accidents the airline experiences in the following year. The operating margin is used as a measure of profitability, and the model controls for other factors that may affect the probability of an accident, such as the average length of a route and the proportion of international departures of an airline carrier. In the model it is shown that the operating margin of an airline does have a statistically significant effect on the rate of accidents of an airline carrier. The model indicates that the effect on the operating margin differs with the size of the airline. The operating margin of small and medium airlines has a significant negative impact of the rate of accidents, while for large airlines it has a significant positive effect. The model

also shows that factors such as the average length of a route or the airline operating in Alaska have a statistically significant impact on the accident rate.

The objective of this paper is to provide new insight into the relationship between profitability and safety of airlines after the consolidation of the industry. The paper seeks to answer the following research questions:

- Does the operating margin of an airline have a significant effect on the number of accidents the airline experiences in the following year?
- Does the relationship between profitability and safety vary for small, medium, and large airlines?
- How do the findings of this paper compare to the existing empirical literature on the topic?

The paper is structured as follows: Section 2 reviews the previous work that has been done on the profit-safety link, both in the airline industry as well as in other industries such as railroad and nuclear energy in the United States. Section 3 presents the data that is being used for the empirical analysis, including the description of the variables and summary statistics. Section 4 presents the methodology used by the paper and assesses the findings in relation to the existing empirical literature. Section 5 discusses the limitations of the study, including data limitations and potential improvements. Section 6 presents the conclusions drawn from the findings and discusses the implications of the research for the airline industry.

2. Literature Review

During the 70's in the U.S. there has been a mass deregulation of a few industries, most impactful out of these being the deregulation of the airline industry. As with any transportation industry the operators must keep in mind the safety of passengers while also trying meeting shareholder expectations for profit. The company's stance on the link between safety and profitability is that "safety is good for business". Osborn & Jackson (1988) argue that having accidents represents a cost for the company and that safety is a must to generate profits, as such executives argue that there is no trade-off between profit and safety. Of course, given that accidents are rare, and profit is continual there may be an argument that there are financial pressures to compromise on safety. Thus, the true effect that profitability has on safety remains in question.

There have been a few studies into the profit-safety relationship, with most being concentrated into the transportation and nuclear energy industries. Both industries being immensely complex, potentially very dangerous without regulation and both have been deregulated in the 70's. For example, Golbe (1983) looks at the profitability and safety connection in the U.S. rail industry. Finding a positive relation between the contemporaneous profitability and safety of railroads. Such that in years when the railroad company is more profitable it is also involved in fewer accidents when compared to less profitable railroads. However, Golbe's (1986) analysis of pre-deregulation U.S. airlines finds that profitability and safety do not have a statistically significant relationship and any relationship that may be present is weak, additionally it found that said relationship is of the wrong sign then would be expected from conventional wisdom, however a short coming of Golbe (1983, 1986) is that they utilize the profitability and accident rate in the same year, thus leaving the possibility of reverse causality.

McKenzie and Shugart (1986) and Rose (1987) analyse further this relation using the same methods but expand the date set further to data from 1954 to 1984, thus including data on airlines after the deregulation. Their findings are similar to those that came before and have the same short coming of not using a lagged measure for profitability. Further they fail to compare the profitability-safety link before and after deregulation.

Rose (1990) revisits the profit-safety link proposing that accidents would influence profitability. and improving on the methods that have been previously used. They use a larger data set then before and use lagged operating margins as a measure of profitability in the previous year and introduce a fixed time effect into the model. They estimate the effects using a Poisson model, and along the basic model, it introduces a model in which airlines are split into groups according to their number of departures. This leads to the finding that there is a significant positive relation between profitability and safety for smaller airlines while for medium and large airlines profitability has no statistically significant effect on safety. However, this paper, like the ones before fails to investigate the safety pre and post deregulation.

On the other side we have research indicating that profitability has a negative effect on safety performance. Marcus et al. (1990) look at this relationship in the nuclear energy sector. With lagged profitability being positively related to the safety in the sense that occurrences of dangerous events in U.S. nuclear plants are higher in the facilities operated by a less profitable energy company. Going back to airlines, Dionne et al. (1997) looks at this issue in the Canadian airline industry where there are more smaller carriers when compared to the United States that serve remote locations adding to the previous analyses by considering all accidents not only fatal accidents as these have a limited number of observations. Their findings indicate that profitability is negatively correlated with the airline's safety, with this relation being especially strong for smaller Canadian airlines. Raghaven and Rhoades (2005) have an updated look into U.S airlines with the methods that are like the ones of Rose (1990) but add some insight into safety before and after deregulation. The paper expands the data to the period from 1955 to 2002 and add a dummy variable for the years after deregulation to the model used. Their results indicate that operating margin has a significant positive effect on the safety of airlines and additionally find that airlines before deregulation and follow the same trend of decrease in the number of accidents, although they also recognise that there is a slowdown in this trend in the years leading to 2002, theorising that this may be caused by the priority of growth over air carrier safety. However, the paper fails to revisit the model of Rose (1990) that includes airline size as a factor. Singal (2003) conducted an investigation of U.S. airlines safety using a different method to approach the question from a financial health perspective. Instead of profitability, they used bond ratings as a proxy for financial performance. This investigation determined that airlines that have higher bond ratings are slightly safer than others. The author draws attention to the fact that they were unable to establish causation between financial health and airline safety and that results may be bias due to small airlines tending to receive worse credit rating or not be rated at all.

All these results construct an inconsistent image of the relation between profitability and safety. One consistent result in the literature has been that profitability and safety have a significant link when it comes to smaller airlines, but they do not agree on the sign of the relation. And with safety records showing that new entrant airlines in the 90's were worse in terms of safety than the established carriers (Savage, 1999). It would be informative to investigate the airline

data after the year 2000 and more specifically following 2010 in the aftermath of massive consolidation of the biggest airlines following the financial crisis, with this possibly disincentivizing the safety motive of airlines due to weakening competition.

In conclusion, there does not seem to be a clear answer to the relation between profitability and safety, while a lot of research seems to indicate that the marginal operating profit does not affect the airline's safety. There are also instances where the same methods but with slightly different data, indicates to the existence of a relationship between profitability and safety, be it positive or negative. When it comes to different approaches to look into this relationship problems rise again with biases that come with the methods used, with author also highlighting this potential issue.

3. Data

3.1 Population of the Study

The population of the study consists of 40 U.S. scheduled passenger air carriers operating between the years 2010-2019. It is important to note that some airlines have data available only for part of the sample time period, with 14 airlines exiting the industry before the year 2019, primarily due to the merger or acquisition of the airlines. Additionally, three new carriers have entered the airline industry in the years after 2010.

The study focuses on all regularly scheduled airline carriers in the United States between 2010 and 2019, with the exception of commuter airlines, air taxis, charter, and cargo carriers this is due to the non-comparability of the data. The data on accidents has been gathered from the National Transportation Safety Board's (NTSB) database on all accidents and incidents investigated in the United States. The NTSB is the independent U.S. government agency responsible for investigating and reporting accidents that occur within the aviation, maritime, and railroad industries.

The financial data of the airline carriers is drawn from the Form 41 Financial Schedule filed by the airline carriers and is accessible from the Bureau of Transportations Statistics' (BTS) TranStats database. The data on air carrier routes is gathered from the Form 41 Traffic Schedule submitted by the airline carriers and is accessible through BTS' TranStats database.

The data collected on each carrier includes the rate of accidents per thousand departures (ACC_RATE), the average length of the airline's flights in thousands of miles (AVSTAGE), the number of departures of the airline in thousands (DEPART), and operating margin (OPMARG). In addition, there is a year-specific time effect (TIME) included to control for the various underlying conditions that may change the risk of flight over time. In order to be able to control for differences in safety that may arise from the risk of operating in foreign countries, we also include the fraction of an airline flights that are international (INTL), and to control for the additional risk of operating in the Alaskan climate, a dummy variable is included to indicate Alaskan carriers (ALASKA).

3.2 Description of Variables

The outcome variable used in this study is the rate of accidents experienced by a given airline in a given year. This variable is used as a proxy for safety because it is a clear and accurate indication of an airline's safety record. While incidents may also be used as a proxy for safety, the data on incidents is of lower quality and incidents do not necessarily have an impact on the

safety of passengers. Therefore, for the purposes of this study, accidents are used as the primary measure of airline safety.

To control for factors that may affect airline safety, several measures are included in the analysis. One of the main measures used and the one we are most interested in for the purpose of this study is the operating margin of the airline in the previous year. This measure is used to gauge the profitability of the airline's operations and allows us to ignore profits from other activities, such as trading of fuel and fidelity programs. In addition to this, the study includes other measures that are expected to be associated with airline safety, including the average length of the airline's routes in thousands of miles, the proportion of the airline's flights that are cross-border routes, and whether the airline is operating in Alaska.

In the second analysis, the study groups the airlines into three size categories: small, medium, and large. This grouping is based on the average annual departures of the airlines over the sample period. This analysis is conducted to determine whether the relationship between the variables and airline safety varies depending on the size of the airline. By grouping the airlines in this way, the study is able to explore whether the operating margin may be more important for smaller or larger airlines, and whether there are any significant differences in the relationship between variables and airline safety across the different size categories.

3.3 Descriptive Statistics

In table 1 are presented the summary statistics for the variables that are used in our analysis in the first time period and the last time period.

Table 1. Summary Statistics

Variable Name	2010		2019	
	mean	sd	mean	sd
Accident Rate per thousand departures	0.0922	0.15122	0.1023	0.1949
Operating Margin at t-1	0.0330	0.1269	0.0064	0.1814
Average Route Length in hundred thousand miles	1.0841	0.6451	0.5986	0.6681
Departures (in hundreds of thousands)	5.2556	6.3366	4.8407	8.0671
Proportion of International Flights	0.2220	0.2400	0.0853	0.1440

It can be observed that there has been a significant decrease in the proportion of international flights over the years, with a mean of 0.22 in 2010 and 0.08 in 2019, indicating a 14% decrease. This trend can be attributed to the rise of low-cost domestic flights, particularly by carriers such as JetBlue and Southwest, which have increasingly focused on short-haul routes (Southwest, 2022). An additional reason for this is the shift of passengers from U.S airlines to low-cost Scandinavian carriers for transatlantic flights (Centre for Aviation, 2018).

Furthermore, the average route length has also decreased from 1.08 in 2010 to 0.59 in 2019. This decline may be explained by the consolidation of major U.S. airlines through mergers, leading to a reduction in international routes, as well as a decrease in demand for intercontinental flights between the U.S. and Europe. This could be heightened by the low-cost Scandinavian airlines highlighted above.

The variable "Operating Margin at t-1" for the year 2010 had a mean of 0.03, while for the year 2019 it had a mean of 0.01, representing a reduction of 0.02. It should be noted that the presence

of an airline with an operating margin of -1.04 skews the distribution of this variable. Without this airline, the mean operating margin would be 0.05.

4. Analysis and Results

4.1. Model Specification

The principal question that we are addressing is whether empirical data shows that a casual relation exists between the accidents of an airline and its profitability. Most studies looking into the profitability-safety link have adopted the lagged operating margin model created by Rose (1990). This study also uses the lagged operating margin. In order to investigate the link between operating margin and accident rate and several explanatory variables that represent characteristics of the airlines.

To estimate our models, we use the Poisson model with maximum likelihood estimation (MLE). This is a suitable choice as it is capable of capturing the rare and discrete nature of accidents in the aviation industry. The Poisson model is a popular choice for count data analysis, as it models the occurrence of events (in this case, accidents) as a function of explanatory variables. The MLE method is used to find the parameter values that maximize the likelihood of observing the data given the model. This provides us with estimates of the coefficients of the explanatory variables and allows us to test the statistical significance of these variables.

We are using a model similar to the one used by Rose (1990). We use the following model to estimate the effect of operating profit:

$$Model\ (1): X_{it}\beta = \beta_0 + \beta_1 OPMARG_{it-1} + \beta_2 AVSTAGE_{it} + \beta_3 INTL_{it} + \beta_4 ALASKA_{it} + \beta_{5t} + \varepsilon_{it}$$

With i denoting the number of airlines in the sample and t denoting the time. The exponent of the outcome variable $X_{it}\beta$ denotes the accident rate for airline i at time t. The outcome variable is dependent on the operating margin of the airline at t-1, the average length of its flights in thousands of miles, the proportion of international departures, a dummy variable for airlines operating mainly in Alaska, a term β_{6t} denotes the fixed time effect for the year t, and ε_{it} is the error term that contains all other factors that may affect the accident rate. The model assumes that ε_{it} follows a Poisson distribution with mean zero and is uncorrelated with X_{it}.

In this model, we expect to find a negative relationship between operating margin and accidents, as airlines with higher operating margins are assumed to have greater resources to invest in safety measures. The other explanatory variables are expected to capture important factors that may affect airline safety, such as the length of the routes operated by the airline, the proportion of cross-border routes operated, and whether the airline operates in Alaska.

Furthermore, we extend our analysis to investigate if the relationship between profitability and safety differs for airlines of different sizes. To accomplish this, we grouped the airlines into three categories based on their average number of departures and include dummy variables representing each group in our model.

$$Model\ (2): X_{it}\beta = \beta_0 + \beta_1 OPMARG_{it-1} + \beta_2 SMALL + \beta_3 MED + \beta_4 LARGE + \beta_5 SMALL\_OPMARG + \beta_6 MED\_OPMARG + \beta_7 LARGE\_OPMARG + \beta_8 AVSTAGE_{it} + \beta_9 INTL_{it} + \beta_{10} ALASKA_{it} + \beta_{11t} + \varepsilon_{it}$$

However, due to perfect collinearity, one of the dummy variables is dropped from the model. We also include the operating profit multiplied by the dummy variable for each group to test whether the effect of profitability on safety varies across airline sizes.

4.2 Estimation Results

Table 2 presents the results of the first model used in this study, which does not account for the size of airlines.

Table 2. Finding of Model (1)

	Dependent Variable
	ACC_RATE
Constant	-1.091***
	(0.213)
Operating Margin at t-1	0.301
	(0.407)
Average Flight Length	0.483***
	(0.100)
Proportion of International Flights	1.092**
	(0.434)
Alaska Carrier	-0.024
	(0.326)
Time	Fixed Effects
Observations	282
Log Likelihood	-404.412
Akaike Inf. Crit.	836.824
Note:	*p<0.1; **p<0.05; ***p<0.01

As per the definitions in the empirical model section of this paper, the coefficient on "Operating Margin at t-1" represents the estimated causal effect of an airline's operating margin on the number of accidents. The variables "Average Flight Length" and "Proportion of International Flights" have the expected signs, with both variables increasing the rate of accidents for an airline. However, the variables "Operating Margin" and "Alaska Carrier" have opposite signs to what we would be expecting.

The coefficients on "Average Flight Length" and "Proportion of International Flights" are both statistically significant at the 1% and 5% levels, respectively. However, the primary coefficient of interest, "Operating Margin at t-1", has an estimated value of 0.301 with a standard error of 0.407. This suggests that a higher operating margin is associated with a higher number of accidents, but the coefficient is not statistically significant at any level. Similarly, the coefficient for "Alaska Carrier" has a small negative impact on the number of accidents, which is opposite to what was expected, but is not statistically significant.

When we compare these findings to the study by Rose (1990), we observe that some of the results are similar. For instance, flight length and international flights continue to have a significant impact on airline safety. However, we find the opposite effect for operating margin

and airlines based in Alaska. In contrast, Rose (1990) found that operating margin had a negative impact on airline safety and that the effect was significant. Our results suggest that the operating margin has a positive sign, but it is not statistically significant.

While the first model does not find a statistically significant relation between profitability and safety, it is possible that the size of the airlines could have a significant effect on the relation between profitability and safety. Thus, we estimate a second model, as described in the empirical model section, which grouped the airlines based on their average number of departures. The results of this second model are presented in Table 3.

Table 3. Finding of Model (2)

Variable Name	Dependent Variable
	ACC_RATE
Constant	0.241 (0.248)
Small	-1.881*** (0.2225)
Medium	-1.278*** (0.240)
Small x Operating Margin at t-1	-1.403*** (0.447)
Medium x Operating Margin at t-1	-2.625* (1.536)
Large x Operating Margin at t-1	3.055* (1.564)
Average Flight Length	0.274* (0.153)
Proportion of International Flights	0.804 (0.601)
Alaska Carrier	0.943** (0.378)
Time	Fixed Effects
Observations	282
Log Likelihood	-295.12
Akaike Inf. Crit.	626.239
Note:	*p<0.1; **p<0.05; ***p<0.01

From the results of Table 3, it appears that profitability has a stronger effect on safety for larger airlines. Furthermore, the operating margin has a significant effect for all airline sizes when considering the size of the airline as a factor. Specifically, the operating margin coefficient for small airlines is -1.403 and is statistically significant at the 1% level, while the operating margin coefficient for medium and large airlines is statistically significant at the 10% level.

In comparison to model (1), the explanatory variables of International Flight and Average Flight Length have different levels of significance in the second model. International Flight is no longer statistically significant, while being an Alaskan carrier becomes significant at the 5% level, and the Average Flight Length is less significant in the second model.

Our findings suggest that profitability and the rate of accidents have an inverse relationship for at least some of the airlines. Specifically, profitability has a positive effect on safety for small and medium airlines, while for large airlines, the operating margin has a negative effect on safety. These findings are similar to those of Rose (1990), which found negative coefficients for small and medium airlines and a positive sign for large airlines, with only the coefficient for small carriers being statistically significant. However, our coefficients have a larger effect, and all our coefficients are statistically significant.

These results suggest that while the consolidation of airlines may not have influenced the sign of the relation between operating margin and safety, it may have amplified the relation between the two. One possible explanation for these results is the worsening competition for larger airlines, which may lead them to prioritize profits over safety. On the other hand, new competition brought by low-cost carriers and new entrants in the small and medium airline sector may have strengthened competition and increased the emphasis on safety. Furthermore, different decision-making processes at different airline sizes could also play a role in these findings, with larger airlines being more willing to take risks to satisfy the expectations of shareholders. This is something that is argued by Peter (2011).

5. Limitations of the Study

The study could be expanded and improved upon by adding variables such as category or airline (low-cost carrier, regional, etc.), turnaround time of flights, average of fleet, etc. However, some of these may be highly correlated with already existing variables. Therefore, this may lead to unreliable estimators of the coefficients.

One significant way that this study can be expanded is by adding data on airlines for a larger period. With this study covering only the years after 2010, adding data before 2010 could improve the accuracy of the coefficients in our findings.

This study focuses on accidents that occurred in the United States. The safety of the aviation industry may differ in other countries due to regulatory and cultural differences. It may be the case that these finding to not hold for airlines in other countries.

6. Conclusion

This study examines the influence of profitability of an airline on its safety in the years after the consolidation of airlines after 2010, this is done using data available from the NTSB and BTS on the time period 2010-2019. The study uses panel data to provide empirical evidence of a causal relationship between operating margin and rate of accidents of an airline carrier, by using as a dependent variable the operating margin of the airlines and comparing the results with previous findings.

While the findings of this study contribute to the existing literature on airline safety, there are limitations to be considered. The study could be improved by adding variables such as airline category, turnaround time of flights, and average fleet, and by expanding the time period to include data from before 2010. Additionally, the study only focuses on US airlines, and the safety of the aviation industry may differ in other countries due to regulatory and cultural differences.

Our results indicate that the operating margin has a statistically significant effect on the rate of accidents but only when taking into consideration the size of airlines, with a higher operating margin being associated with a higher number of accidents for large airlines, while the opposite is true for small and medium airlines. When comparing the results to previous findings it indicates that a consequence of airline consolidation is the strengthening of the relationship between profitability and safety, in both directions dependent on the size.

These findings have important implications for airline industry stakeholders, including policymakers, regulators, and airline management. It is important for these stakeholders to consider the potential trade-off between profitability and safety in decision-making processes. Furthermore, policymakers and regulators should consider the impact of industry consolidation and competition on airline safety.

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