

# Roll the Boeings: Corporate Risk Aversion, An Expected Payoff Model



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## Abstract

This paper explores corporate risk management by testing and calibrating a model of the two lotteries choice. Over the past few years, Boeing has had a range of issues with several of its aircraft programs in both the commercial aviation and military aviation sectors. The highest profile of these is the 737 Max 8. This paper examines public information and reporting to explore the decision-making processes that led to these issues at Boeing through an economic lens and investigates how corporate decisions fit into our known economic modeling of decision-making.

This paper will examine whether Boeing was making the highest expected payoff choice selection in its engineering decisions and whether it was risk-averse or risk-seeking in its decision-making regarding what design choices to pursue. The paper will also look to tune and uncover the risk premiums Boeing may be using in these decisions and test if they seem like rational values, or if Boeing has been extremely risk-seeking in chase of profits. Public information including stock price fluctuations and publicly known settlements with families, governments, and other companies in the aviation space, as well as earnings calls and other reporting on costs and earnings of proposed alternatives are used to test my hypothesis.

Several discounted cashflow models will be constructed with several different possible worlds, or lotteries, from which Boeing may have been choosing. Values for risk probabilities and risk aversion can then be tuned to see where certain decisions were payoff maximizing for Boeing. Real-world information can then be used to approximate the real-world values of these variables to examine if Boeing made a rational, expected payoff maximizing choice, and if Boeing was extremely risk-seeking in their behavior choosing options with high payoffs but also high downsides should they be on the losing side of the lottery.

## Introduction

The Boeing 737 was initially designed in the 1960s, and its initial flight was made in April 1967. Since its introduction, the 737 has undergone a number of redesigns and improvements. This made the Boeing 737 a 50-year-old design that had been updated repeatedly when Boeing was deciding between upgrading the 737 or designing a whole new aircraft around 2010. Boeing chose to continue trying to upgrade the 737 into the new 737 MAX series, which led to several design challenges and risks.

Having decided to continue with the 737 upgrades and not designing a new aircraft from scratch, Boeing was able to save a lot of money in the design process and deliver the first of the MAX aircraft in a much faster time frame. They would also be able to save money in the manufacturing process since the aircraft would use most of the same tooling and production inputs as the 737s already in production. In 2011 Boeing announced the 737 MAX series.

In October 2018, the 737 MAX 8 had its first deadly crash when one operated by Lion Air crashed in Indonesia, resulting in 189 deaths. A second 737 Max 8 crashed in Ethiopia killing another 157 people. Both of these incidents were investigated and attributed to design issues primarily due to the age of the aircraft design, and compromises that were made in the redesign to allow the 737 to use the most up-to-date engines (U.S. Federal Aviation Administration 2020, 9-10).

## Method

This paper will use the two lotteries choice experiment (Holt and Laury 2002) to examine the risk acceptance that Boeing displayed. In this setup, a decision maker is offered a simple choice between two different lotteries with differing payoff structures. Below are the two choices in the expected value form that Boeing would have to choose between.

- **Expected Value of Redesigning the 737 to the 737 MAX Series**  
 $(1 - P_{737 \text{ MAX Failure}})NPV \text{ of success} + (P_{737 \text{ MAX Failure}})NPV \text{ of failure}$
- **Expected Value of Designing New Plane to Replace the 737**  
 $(1 - P_{\text{New Design Failure}})NPV \text{ of success} + (P_{\text{New Design Failure}})NPV \text{ of failure}$

The NPVs are calculated as discounted cashflow models, as of the decision date, the end of 2010. This will enable an examination of the relationship between the probability of failures that Boeing believed were possible. This also enables us to examine how different prices or upfront investment costs may have altered Boeing's ultimate decision.

## Data

Data is being gathered from public data sources including: Boeing's Website, Boeing's Filings with the SEC, the FAA, and transcripts of the US House hearings on the incidents. Public data from news reports and interviews with key officials at Boeing is also being used.

A discount rate for each model was calculated using a Weighted Average Cost of Capital calculation using data from the Federal Reserve, Boeing Financials, and S&P 500 market data. Information on the cost to design and certify new designs came from Boeing financial data, public interviews, and comments from Boeing officials, and comparing costs of other designs Boeing created around that time.

This data is then used to build four different discounted cash flow models, pairs of which represent the lotteries that Boeing was deciding between.

## Ongoing Research

Preliminary models show that a driving factor is the sheer cost of designing and certifying an entirely new aircraft. The costs are estimated to be about seven to eight times as much as modifying an existing aircraft design.

However, capturing all the externalities, costs, and benefits to Boeing is challenging and may significantly impact the model. Currently, work is ongoing to gather data on these indirect costs and benefits to incorporate into the model.

An events study using Boeing's stock price may also be performed to examine how the model costs and revenues compare to what the market believed would happen as events unfolded.

Another consideration is the future. Since Boeing chose not to design a replacement to the 737, they must now do so in the future and incur those costs down the road, when they will presumably be much more expensive



Image 1. Photo of a Boeing 737 Max aircraft (Boeing).

## Discussion

While this paper aims to examine Boeing's options and its decision-making, it will not tell us the exact discussions that occurred in the boardrooms. Further examination into how costly it may be to design a new aircraft from scratch and if, as Boeing contends, this is stifling innovation may be a discussion more for policymakers. However, this paper seeks to provide a framework for assessing Boeing's choice.

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