International Collaboration And Competition Following Volcanic Ash Clouds:
A Game Theory Perspective

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ABSTRACT

The biggest disruption in the history of civil aviation, caused by the recent Icelandic Volcanic ash clouds in April 2010 with an estimated loss of $2.5 billion, created a dispute and finger-pointing between the European Commission, European and U.S airlines. A game theoretic model, integrated with each player's rational choice, for the competition between the two airlines and the EU Commission is developed and used to identify attributes that affect their decision making. The model is operationalized through the assumption that the decision each player makes depends on being subject to EU 261 Regulations. In this non-cooperative game of strategy, backward induction and sequential decision making are used to study the equilibrium strategy for all players involved.

BACKGROUND

- **The Icelandic Volcano** erupted from Mount Eyjafjallajökull (Icelandic for "island-mountain glacier") in Southern Iceland.
- From April 15-20, 2010 flights were cancelled and airports throughout Europe were closed.
- Affected 1.2 million passengers a day, eclipsing the impact of 9/11 when U.S. airspace was closed for three days.

Game Theory:

- A collection of Mathematical models formulated to study decision making in situations involving competition and cooperation (Benedetto, 1987).
- Established as a mathematical field of study after the 1944 publication of "Theory of Games and Economic Behavior" by John von Neumann and Morgenstern.

SCENARIO DESCRIPTION

- The proposed approach identifies each player's rational action as a sequential move.
- This Volcano Game involves 4 players, the Customer, European Commission, U.S. airlines, and European airlines.
- Customers were stranded in airports throughout Europe for more than six days.
- EU 261 Regulation entitles air passengers to either a full refund or a re-routing and proper accommodations if their flight is delayed or cancelled.
- U.S. carriers operating in Europe did not pay off claims submitted by stranded passengers who arranged their own accommodations and meals.
- European airlines are demanding government compensation for their out-of-pocket costs during the volcano event.

GAME FORMULATION

- The extensive form representation of this game is depicted in Figure 1. The game starts at the *initial decision node*, where nature moves randomly, the Icelandic Volcanic Eruption, and a customer in Europe chooses whether to board a European carrier or a U.S. carrier.
- Each of the two possible choices for the customer is represented by a *branch* from this initial decision node. At the end of each branch is another decision node, at which point the two airlines decide whether to compensate their customers for hotel, meal, and transportation costs. Suspension and cancellation of flights due to the Icelandic Volcanic Eruption (April 15-20, 2010) are the causes of these costs.
- Depending on the decision taken by the two airlines, the European Commission comes into play to make sure passenger care regulations remain intact and enforce the law if necessary. This is represented by another branch from the previous decision node.
- After the European Commission's move, we reach at the end of the game, represented by the *terminal nodes*. At each terminal node, we list each player's payoffs ascending from the sequence of moves leading to that terminal node.

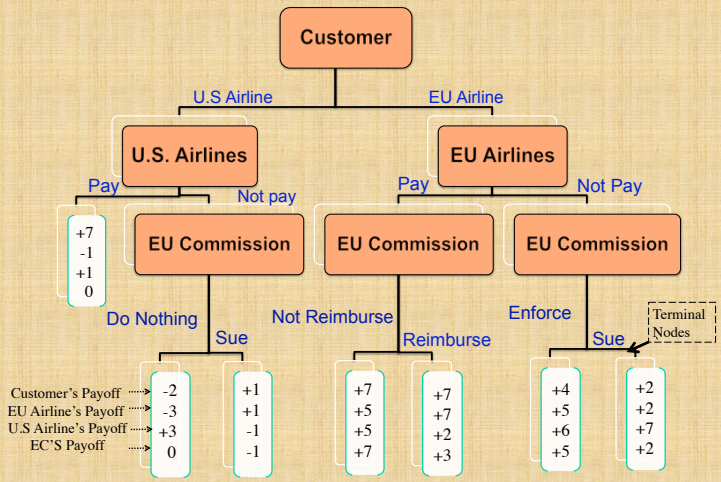


Figure 1. Extensive Form representation for the "Volcano Game Tree"

BACKWARD INDUCTION

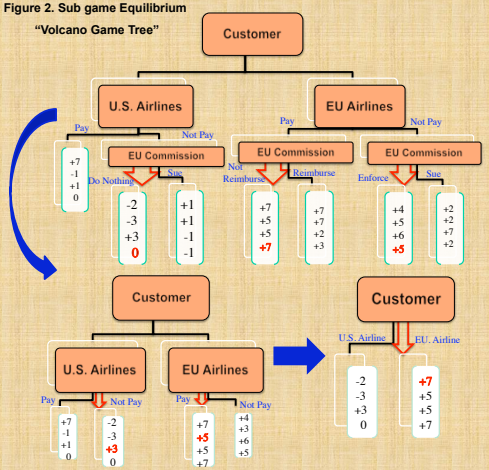
Backward Induction is used to find the Subgame Perfect Equilibrium. Each player is assumed to move optimally at each node and is expected to act in their own best interest.

- Find the optimal choice at the last decision nodes.
- Eliminate non optimal actions.
- At each subsequent node, pick the best strategy for the next player.
- Work backwards to the start of the game.

Look Forward, Reason Back!

SUBGAME EQUILIBRIUM

Figure 2. Sub game Equilibrium



Backward Induction leads to a **subgame equilibriums** in which:

- The European Commission prefers Not to Compensate the European airlines for their out-of-pocket costs and enforce the law if the European airlines do not pay off claims and make proper accommodations for stranded passengers. Moreover, the Commission decides to take NO action against U.S. airlines which did not make pay offs to passenger claims
- U.S. airlines choose not to make proper accommodation to stranded passengers and European airlines, in accordance with the EU 261 regulation, make the proper accommodations.
- A customer knowing that there is possibility of not getting the proper accommodation if a flight is cancelled, will choose to board a European airline.

CONCLUSION

- The applications of game theory are far-reaching. Consistency and mathematical foundations make game theory a prime tool for modeling and designing automated decision making processes in interactive environments.
- This is a simple system designed without a mathematical model. Future research will include extending this topic by gathering data, using theory of utility functions and applying mathematical model to describe the model accurately.

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ACKNOWLEDGMENTS

- Research Mentor: Dr. Jun Zhuang
- Graduate Students: Xiaojun Shan, Long Zhang and Fei He
- CSTEP Team: Shanna Crump-Owens, Dr. Folarin Erogbogbo, Matthew Woodfork Christopher Williams and Tawanna Gilford