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Preventing Collusion in Indian Airlines: A Game Theoretic Approach

Authors: Aashman Trivedi*; Sanjay Gopalakrishnan

Email: trivediaashman@gmail.com*

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Abstract

The paper examines the dynamics between collusion and competition in the Indian aviation sector, with a special focus on the duopolistic Indigo and Air India-dominated market. The deregulation of Indian aviation in 1994 brought about an important shift in the industry, which ultimately led to the emergence of the competitive market we have today. However, as the industry became a duopoly, collusion became a threat, posing a risk to the interests of consumers. This study examines the pricing, frequency of flights, and CO2 emissions interactions between these two major airlines using game theory models. It also assesses the possible effects of collusion on customers and other stakeholders. A key finding of the study is that collusion risks consumer welfare by raising prices and lowering market competition, even if it may increase profits for businesses. To reconcile consumer interests with sustainable sector growth, the study concludes with recommendations for optimal government intervention policies. These include regulations to prevent collusion and incentives to use sustainable aviation fuels. In our work, the necessity of minimising environmental consequences and maximising economic and social outcomes in the Indian aviation industry is emphasised through the proposal of a sustainable development framework.

1. Introduction

Background

This paper investigates the optimising decisions regarding the commercial aviation industry in India. Air transportation provides an affordable, sustainable, and effective method of travel for Indian consumers. In the past decades, the industry formed an oligopoly dominated by the State. On March 1st, 1994, the central government replaced the Air Corporations Act (1953) with the Air Corporations (Transfer of Undertaking and Repeal) Act (1994). After that, industry regulations eased, and private players soon entered the market: Jet Airways, Sahara Air (later renamed Air Sahara), Modiluft Airlines, Damania Airways, NEPC Airlines, and East-West Airlines all becoming the first entrances into a new predominantly private aviation market. They serviced, however, only the Indian elites who could afford to purchase a flight ticket in the early stages, being far out of reach for the common person. As the industry grew, profit maximisation took the forefront, and problems such as traffic congestion, air pollution, and transportation costs became prevalent. Only a few players managed to remain liquid.

In 2003, Air Deccan (also called Deccan Air) took a bold risk and commenced operations as India's first low-cost carrier (LCC). This decision created a wave of low-cost air carriers such as GoAir, SpiceJet, and later Indigo to cut unnecessary luxuries and make air travel cheap and accessible to laymen. As the years progressed, airlines faced financial struggles that drove them out of business. The 2008 recession, instability and financial hindrances of the industry, and the COVID pandemic were all factors that contributed to the fall, and this led to the collapse

of dominant firms such as Kingfisher, JetAirways, and GoAir. Ultimately, Indigo and Air India took over as the major players in the market.

However, with the new re-privatisation of Air India by the Tata Group, the formation of a duopoly poses the risks of consumer exploitation from high prices. With this objective in mind, this paper attempts to find the equilibria of price, flight frequency, and CO_2 emissions to outline the optimal decisions by firms and the State to protect consumers from exploitation and ensure the industry's profitability.

Some Terminology

The term sustainability has varying definitions depending on the context and origin, even within the aviation industry. Henceforth, we define a sustainable development approach to strive for a balance between economic, environmental, and social factors. The emphasis is on the longevity of the model by ensuring the stability and mutual benefit of the stakeholders in question.

Further, the terms “collusion” and “cooperation” refer to both overt or tacit collaboration between firms to have the same effect of a monopoly in the market. Specifically, collusion can be further broken down into overt collusion and tacit collusion. Overt collusion, the formation of cartels, is where firms explicitly agree to collaborate and limit competition to ameliorate their position of advantage. Tacit collusion, on the other hand, is an informal agreement where firms closely monitor each other’s behaviour, often leading to a form of price leadership where the smaller firms monitor the price of the largest firm in the industry and then adjust their prices to match this.

1.1 Indigo and AirIndia: An Indian Duopoly

The Indian aviation industry is notoriously tricky to navigate due to the price elasticity of consumers, the number of routes and airports throughout the country, and the extensive government regulation. The industry is virtually a pure price-elastic case: airfare is pivotal in influencing the leisure travel segment of the market. This factor distinguished Indigo and Air India from the rest of the industry.

India also has a limited 117 airports under the Aviation Authority of India’s (AAI) jurisdiction, requiring a hub-and-spoke model (as opposed to the Point-to-Point model) for most routes apart from those that connect major cities. The Indian government, furthermore, has set forth elaborate plans and arduous objectives for the future of Indian aviation. As India becomes a leading economic power, the state wishes to compete with Western counterparts in aviation. Henceforth, we see investment stimulus and schemes such as ‘Ude Desh ka Aam Naagrik’ or UDAN (translated to “let the common citizens of the country fly”) that encourage higher frequency of routes and servicing low-service airports at subsided prices.

Indigo was founded in 2006 by Rahul Bhatia of InterGlobe Enterprises and Rakesh Gangwal, the former CEO of US Airways. The firm's success relied on its unique start-up model, the lease-back model, where they bulk-ordered A320s from Airbus at a heavy discount due to Airbus’s uncompetitiveness in the Asian market. This low-cost carrier model gave them a fleet of Airbus A320s at a 50% discount and allowed them to rent crafts relative to their

demand. Through operational efficiencies, on-time performance, and a no-frills service approach, IndiGo expanded its market very fast.

IndiGo is the largest airline in India by market share, commanding over 60% of the domestic market as of 2024. It has a fleet size of more than 300 aircraft, including Airbus A320s, A321neos, and ATRs, flying to over 60 destinations spread across the domestic circuit and overseas. IndiGo is characterised by its low-cost model, high-frequency point-to-point routes, and delivering on its reputation of punctuality with efficient service.

Tata Airlines—later Air India—was founded by J.R.D. Tata, in 1932, was the original airline and was regarded as the father of Indian aviation. It initiated its operations by carrying airmail between Karachi and Bombay. In 1946, it adopted the name Air India, and in 1948, it started international services with flights to London. In 1953, the Government of India nationalised the airline and divided its operations into Air India International and Indian Airlines for internal routes. However, Air India fell into financial struggles throughout the years, and the airline became disregarded due to its poor service quality. In January 2022, the Tata Group privatised Air India and became part of the Tata airline group with expansion plans for the future.

The domestic market share of Air India, now owned by the Tata Group, would be around 15 percent. The fleet comprises over 120 aircraft, including Boeing 787 Dreamliners, Boeing 777s, and Airbus A320 family aircraft. Air India has an extensive network of destinations in North America, Europe, Asia, and the Middle East, with substantial domestic operations. Under Tata's management, the carrier is undergoing a severe transformation process to upgrade its fleet, enhance service standards, and regain profitability.

While SpiceJet and Akasa Air also hold prominent market share stakes, we assume the industry is a theoretical oligopoly as these dominant players hold nearly 90% of the market share between them.

1.2 Problem Statement

Business-related travel is less price elastic in comparison, creating complications and unpredictable variables in the system.Therefore, theory may not have self-evident implications, yet we attempt to develop qualitative models that fit the situation as best as possible. We will also consider the context of the situation. At the same time, we build our game theoretic models to contextualise and depict the dynamics between Air India and Indigo, specifically neglecting other firms.

As the aviation industry gradually forms a duopolistic model of two dominant firms, with the remaining smaller firms comprising only a fraction of the larger market, collusion, and competition become looming threats to airline and consumer interests. Firms collude to better their collective position, yet this may not be at the direct cost of consumers and may even advantage consumer interest. This paper aspires to outline a plausible model for the new state of the industry to safeguard both airline and consumer interests.

Thereon, as Indigo and AirIndia continue to majorly shape the dynamics of the Indian market through their operations and market presence, we aim to model these dynamics to gain a deeper understanding of the

relationship that exists between this duopoly and how collusion would impact stakeholders in the market, as measured by our sustainability function. The contributions of this research to address this issue are as follows: use a sustainable development approach to solve the problems mentioned above and optimise utility in the market. To achieve this, three steps will be taken: (1) model the dynamics between Indigo and Air India specifically, (2) analyse the implications of collusion on current Indian market dynamics, and (3) suggest policies that are optimal for the various stakeholders.

2. Review of Relevant Work

Adler, Nicole, and Gianmarco Andreana (2023) (*Aiding airlines for the benefit of whom? An applied game-theoretic approach*) evaluated the effectiveness of government bailouts on the economy and society welfare using game theory where he found that when bailouts are coordinated and homogenous, it causes less chaos. They also found the impact on social welfare loss as a result of bailouts and how they may be ineffective. Their analysis suggested that the airline industry has been severely affected by the uncoordinated provision of state aid, leading to an unlevel playing field for the European carriers and a likely drop in passenger and airline surpluses. In particular, they compared two airlines of similar size before the pandemic and showed that unequal bailout policies would likely disrupt the profitability and structure of the two carriers. Successively, results show that achieving a socially preferable outcome through a coordinated and homogeneous bailout mechanism across the Member States is possible. Their findings were consistent with the analysis of Bianchi (2016), demonstrating that the European Commission would have been more efficient had it required all carrier bailouts to be in the form of loans, hence limiting the adverse effects on social welfare. It's noteworthy that Ryanair received a much smaller loan than Easyjet and the legacy carriers, enabling the ultra-low-cost airline to increase its market share substantially. This highlights how the bailouts, both in form and quantity, will likely impact transport equilibria and the competitive playing field. As Kahn (1988) and Rose (2012) emphasised, the airline industry's deregulation has succeeded with respect to efficiency and competition. (Adler and Andreana) The highlighted inefficiencies result from the coordination failures between governments.

Devendra Singh and Sri Vanamalla Venkataraman (2023) (*Nash equilibrium computation in airline frequency game)* found that in an ideal system, firms would prefer to run only high-demand routes simply because they earn more - the government should intervene to ensure that airlines service the lower-demand routes. In India, the government designed the UDAN scheme to address this issue. Their main finding was that the frequency of two competing airlines could be broken down into the supply of high-demand and low-demand routes; if we want to supply everyone equally, there needs to be an equal duopoly because else there would be a potential revenue and surplus loss. The firm with the greater fleet capacity should take the burden of performing low-demand routes; when the government intervenes and forces both firms to supply low-demand routes, the airlines incur a revenue loss. To ensure that this would help both players, the government should allow for subsidies (unideal), but the best course of action would be to collude for game correction. Overall, he found that collusion is beneficial to airline frequency and routes.

Ghareaghaj et al. (2018) (*Multi-Objective Modelling for Airlines Cooperation by Game Theory and Sustainable Development Approaches*) studied a four-airline cooperative versus non-cooperative approach. The impacts that

they measure are (i) profit, (ii) load factor (minimise empty seats), (iii) minimise difference in passenger demand, and (iv) understanding carbon emissions. (I) They found that airlines, when cooperating, schedule flights optimally, share resources, and reduce operational costs. This maximises the airline's collective profit; on the other hand, in a non-cooperative context, each airline independently maximises its profit by choosing optimal flight frequencies and sizes without coordinating with others. (II) Cooperation in coordinating flight schedules and adjusting flight frequencies based on actual passenger demand was optimal; airlines can minimise the number of empty seats, thereby increasing the efficiency of seat utilisation. (III) They found that airlines that use cooperative strategies to balance the number of flights with passenger demand reduce unnecessary flights and ensure that supply meets demand more accurately; cooperative scheduling helps reduce the number of flights and optimises routes, leading to lower fuel consumption and reduced CO2 emissions. By minimising the total number of flights, airlines can collectively reduce their environmental impact. Ghareaghaj also found cooperation beneficial to the expansion of flight networks and operative costs: airlines can expand their flight networks through cooperation, offering more routes and better connectivity for passengers while sharing the costs and benefits of these expansions; cooperative strategies also help airlines to share costs related to additional flights, maintenance, and operations, leading to a significant reduction in overall operational costs.

Saraswati and Hanaoka (2014) (*Airport–airline cooperation under commercial revenue sharing agreements: A network approach*) analysed the impact of commercial revenue sharing agreements between airports and airlines on industry profits, downstream competition, and social welfare in trying to understand whether profit sharing would work or not. They found that airports should endogenously revenue-share with dominant airlines to maximise profits and optimise their financial gains. They also found that this makes the industry less price competitive and allows the government more leeway for policymaking - ultimately benefiting passengers through potential fare reductions. While revenue sharing was found to be beneficial in the long run, there is no significant evidence of overt collusion in Indian aviation.

Overall, we find that a current consensus is that cooperation is beneficial in supplying lower-demand routes and henceforth flight frequency while also minimising surplus loss. Further, government intervention should be coordinated and equitable to maximise effectiveness.

3. Methods and Techniques

Game theory (Y Narahari, 2014) studies mathematical models of conflict or cooperation between rational decision-makers, used predominantly in economics, politics, psychology, and computer science. The objective of each model, also called 'games,' is to achieve a stable state, defined as a Nash equilibrium, from which no player would want to deviate and, at times, could or could not be optimal. In various models and games, however, a singular optimal state is impossible to achieve; instead, one works to find all Nash equilibria or assumes no equilibrium value if no solution is feasible. Games have primarily two sub-classifications: cooperative and non-cooperative games.

3.1 Non-Cooperative Games and Nash Equilibrium

Nash Equilibrium is a stable state in a game-theory model where no player has an incentive to deviate, though it may or may not be optimal. The players are all pleased with the utility they receive and have no reason to wish to

move to another place, yet this may not be the optimal outcome for everyone (Prisoner's Dilemma). The strategy profile vector $(s_1^*, s_2^*, \ldots, s_n^*)$ would formally be a Nash equilibrium if:

$$u_i(s_i^*, s_{-i}^*) \geq u_i(s_i, s_{-i}^*) \ \forall s_i \in S_i,$$

where u_i the utility function for the player i, s_i^* is the equilibrium strategy for the player i and s_{-i}^* represents the equilibrium strategy of all other players, in our case, there would only be two players: Indigo and AirIndia.

	Player 1: x	Player 1: y
Player 2: x	$-5, -5$	$0, \quad -20$
Player 2: y	$-20, 0$	$-1, -1$

Table 1: Prisoner's dilemma with a strongly dominant strategy

Where:

- x: confess
- y: stay silent

To illustrate, Table 1 depicts a strong dominant strategy through the prisoner's dilemma. In the prisoner's dilemma, two convicts are questioned in separate rooms, and they have the option to either confess or stay silent. For each inmate, we assume that they are non-cooperative, and both of them work to obtain the greatest possible utility, which is the lowest possible jail time. The Pareto Optimality of the solution is if both stay silent (y_1, y_2); however, that puts them at the risk of facing 20 years in the case that the other convict confesses. As a result, both player's course of action would be to confess, as either they will face 5 years in jail (x_1, x_2) or 0 years in prison (x_1, y_2) or (x_2, y_1).

Various games have different Nash equilibria, each with its own pros and cons. Mixed strategy Nash equilibria are where no decision is dominant, and each player chooses their decisions randomly. However, this often leads to unpredictability in the market, as we cannot accurately predict which strategy players would take to maximise utility. However, such equilibria also lead to less exploitation in the market due to this unpredictability.

In a strict Nash equilibrium, a given strategy for any player is strictly better and yields a higher utility regardless of the other players' decisions. This often leads to a stronger incentive to not deviate from the Nash equilibrium point, making it more stable. It also means that the decisions of any given player are more easily computable and predictable.

In the context of the aviation industry, the cooperative and non-cooperative models are variables that drastically alter the extent to which consumer surplus is impacted. As the airlines seek to maximise their utility, consumer surplus will be affected. However, in cooperative models, there is a greater threat to the consumer surplus as collaboration can disregard consumer welfare and benefit if no controlling party, such as the government, is willing to intervene.

3.2 Cooperative Games and the Nash Bargaining Problem

Cooperative games (Y Narahari, 2014) are a concept where two rational players gain the ability to discuss the decision available to them to achieve and divide the maximum surplus equitably concerning their bargaining power. The aim of the Nash bargaining problem is to find a mutually beneficial agreement with a minimal net loss and maximising individual surplus (a concept referred to as the Nash bargaining problem). Still, they will settle at the predetermined disagreement point if they reach no mutual agreement.

In a feasible set F, the following assumptions are made:

- Convexity of the set
- Closedness of the set
- The set is nonempty and bounded

To represent this model, we take a set F that represents all possible feasible utilities derived from a given range of outcomes, each represented by a pair (u_1, u_2), that the player can achieve through negotiations. If all parties fail to achieve a single point of agreement, they land at the disagreement point $d = (d_1, d_2)$. By definition, the disagreement point will always be a point where both parties will concede the ability to achieve a maximum surplus. This can be represented visually:

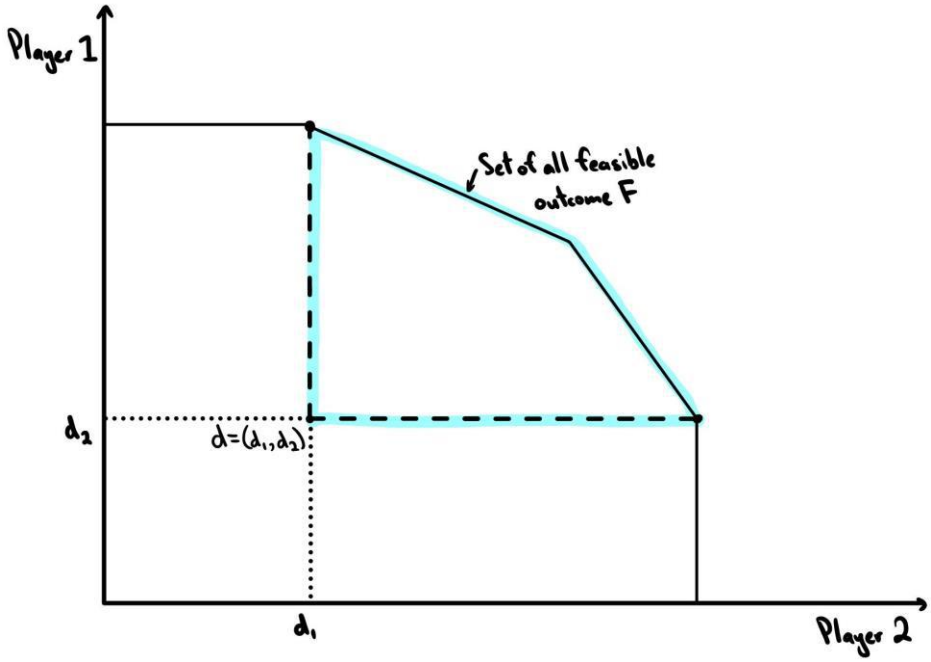

Fig. 1: A two-player cooperative game of set F with a disagreement point of (d_1, d_2).

It is, therefore, the player's responsibility to find a point within the feasible set F where both players maximise utility. A Nash bargaining rule must satisfy the following Nash axioms:

- Individual Rationality: neither player should get less in the solution than they could gain in the disagreement point (represented by the shaded region).
- Pareto Optimality: The state in which resources are optimised in a given system so that any player cannot improve without another worsening (represented by the blue highlight).

- Scale Invariance: if each payoff was to be multiplied by a scalar factor and shifted upwards or downwards, the game shouldn't be affected.
- Symmetry: If the positions of players 1 and 2 are entirely symmetric in the bargaining problem, then the solution should also treat them symmetrically.
- Independence of Irrelevant Alternatives: feasible alternatives that should not affect the solution irrespective of the decision taken.

Nash proposed the following expression that outlines the objectives of the Nash bargaining rule, with appropriate consideration that fairness and the prior axioms are met:

$$argmax_{U_1,U_2}(U_1 - d_1)(U_2 - d_2)$$

Where:

- $U_1 \geq d_1$
- $U_2 \geq d_2$
- $U_1 + U_2 = S$

Where S is the total surplus or utilities gained by both players combined.

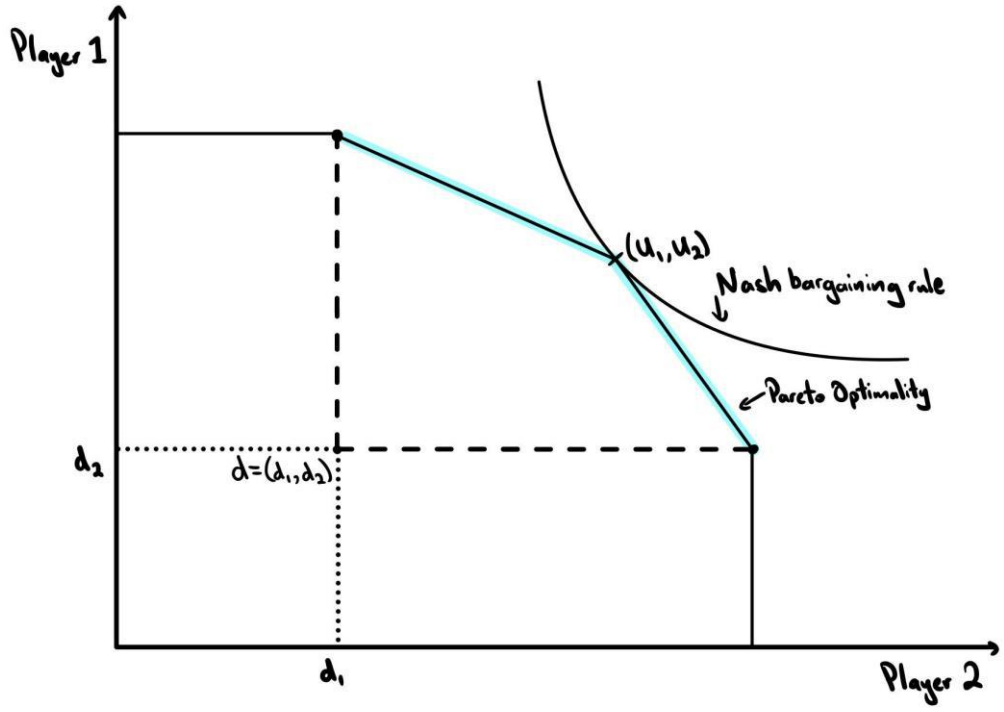

Fig. 2: Nash Bargaining Rule of Set F

Consider these axioms in the context of the aviation industry. Any collaboration between Air India and IndiGo will be formed through the Nash Bargaining Rule to ensure any decision reaches, or at least approaches, Pareto Optimality. Our model also considers the respective market share held by each entity, and we assume market share affects the utility derived by each player proportionally.

4. Experimental Results

This section discusses implementing the previously discussed theories and models to avoid the optimal strategy of minimising consumer disutility. To assess this, we first define sustainable development. The sustainable development function is a key performance metric in assessing consumer disutility. Thereafter, we break down each component in the function and attempt to optimise each function to obtain a best-case scenario for consumers and, if possible, for firms as well.

4.1 The Sustainable Development Function

To effectively map the consequences of the decisions of Indian air carriers, we work with a sustainable development function to measure a balance between economic, social, and environmental aims. This function is a modified version of a disutility function sourced from the paper 'Air traffic network equilibrium: Toward frequency, price, and slot priority analysis' (Sungwook Hong, Patrick T. Harker 1991). The function sums the vector characteristic of a given airline's service, being designed for a singular route yet can be aggregated to represent the airline as a whole. As the paper's purpose regards the industry as a whole, we assume that the variable type of aircraft flown, the travel pattern, and connection delays are negligible and exclude them from the equation. The overarching objective is to reduce each variable to minimise overall dissatisfaction.

The function is defined as $V(p)$ where:

$$V(p) = \alpha ST_{p,k} + \gamma R_{p,k} + \delta F_{p,k} + \epsilon S_t + \eta$$

- $\alpha ST_{p,k}$: Travel time
- $\gamma R_{p,k}$: Ticket price
- $\delta F_{p,k}$: Frequency of flights
- ϵS_t: CO_2 emissions
- η: Constant / invariable disutility

4.2 Flight Duration

Flight duration is the flight duration of an aircraft from takeoff to landing on a particular route. It considers every iteration that the route was flown by any aircraft, with its variance being factors such as airport delays, air traffic congestion, and weather. These factors are all intrinsic and independent of actions taken by either Air India or Indigo and accept the assumption that the factors are present for both airlines simultaneously. For the paper's context, we view this as another negative factor, which we cannot accurately predict or model the nuance of how they might affect each air carrier, thereby excluding it as a factor from our discussions.

4.3 Ticket Prices

Ticket prices are the predominant determiner for the Indian leisure market, with price being virtually the sole factor between airlines for recreational travel. Indigo is a Low-Cost Carrier (LLC), while Air India is a High-Cost Carrier (HCC), which means that both firms play distinct roles in the market. Because of this extreme sensitivity to prices that exist in India (high PED), consumers are quick to respond. They will switch over to another

alternative or competitor that offers lower prices. However, we assume that despite Indians' sensitivity to price, they do not convert to alternative means of transport. Hence, while PED is high among air carriers, consumers will not substitute air travel for another means of transport as a whole. They will not substitute air tickets with train tickets but would consider different aviation firms) and not easily substitutable to a new market.

Firms have two choices: to raise or lower their ticket prices. Higher prices lead to higher revenue and, hence, profits, which means that the utility at a higher price will always be greater than at a lower price. This theory can be modelled when 'Lower Price' and Higher Price' are considered:

	AirIndia: LP	AirIndia: HP
Indigo: LP	$z_1, \quad y_1$	$(z_1 + \alpha), (y_1 - \alpha)$
Indigo: HP	$(z_1 - \alpha), \quad (y_1 + \alpha)$	$z_2, \quad y_2$

Table 2: Ticket Prices in Indian Aviation

Where:

- z_i: utility for Indigo at a given price
- y_i: utility for Air India at a given price
- $y_i < z_i$
- $z_1 < z_2$
- $y_1 < y_2$
- α : the demand fluctuation from price change

The use of α represents the utility gain from the firm's revenue from the influx of demand when they sell their goods at a lower price. We, additionally, view this model as asymmetric to represent the difference in market share between Indigo and Air India. Lastly, we understand that the utility of Air India and Indigo will be more significant when both charge higher prices. However, while the utility will increase, the extent of its increase is heavily dependent on the ability of the smaller air carriers, such as Akasa Air and SpiceJet, to meet the demand for lower airfare. This replacement of the primary air carrier is only feasible on a small scale on major, high-demand routes as smaller firms will not effectively supply more minor routes, possibly affecting the demographic who require low-cost airfare the most. As a result, high prices and collusion, while unlikely, may be disastrous in the long term.

The Nash Equilibrium of such a game would hence lie at the point where both firms have lowered their price. However, we know that both firms would want to enjoy higher utility, so we can logically argue why they would collude, at least in an implicit manner i.e. informally, and create a mutual agreement not to lower prices beyond a point. In this sense, while collusion would be optimal for the two players, it would not be optimal for consumers as higher prices increase their disutility.

To model such a situation while accounting for the potential of tacit collusion, we develop a Nash bargaining model. Price is not that simple, and firms can vary prices to an infinite extent (i.e., they have more than two options of price available). Further, to account for tacit collusion, the following Nash bargaining rule is considered as it meets all the Nash axioms:

$$argmax_{U_1,U_2}(U_1 - d_1)(U_2 - d_2)$$

Where:

- $U_1 \geq d_1$
- $U_2 \geq d_2$
- $U_1 + U_2 = S$

Where S is the total surplus.

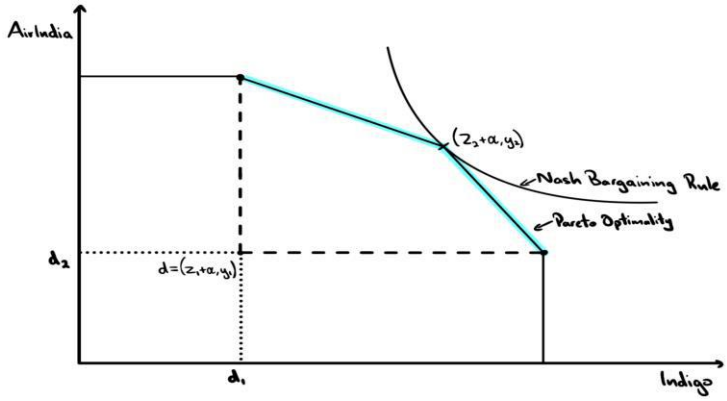

Fig 2: Nash Bargaining Rule in Indian Aviation

4.4 Flight Frequency

By comparing Nash equilibrium strategies through numerical illustrations, Davendra et al. showed that collusion leads to lower revenue losses and, hence, a more significant surplus. This was modelled as such:

Expected Revenue (Firm 1)	Expected Revenue (Firm 2)	% Revenue Loss
5	14	11.44
6	13	14.02
7	12	11.17
8	11	9.10
9	10	5.50
9.5	9.5	3.80

Table 3: Nash Equilibrium Flight Frequency in Indian Aviation with varying revenue models

Table 3 (Davendra et al.) includes two major ideas. Firstly, the data outlines the positive correlation between market dominance and net revenue loss when there are restrictions to fly low-demand routes. While one company succeeds similarly to the other, both can share a greater surplus; hence, the system must form an oligopoly to collaborate and share the burden of both frequency of high demand and low demand routes. Cooperation forces supply to low-demand routes. To achieve this, firms generate similar revenue levels and accept the mutually decided cooperation point, ensuring that the system does not revert to the disagreement point.

This understanding can be extended to government intervention within the Indian case. Flight frequency on low demand is essential to connecting all Indian airports. The government should, therefore, consider the surplus losses that may be faced by the duopoly relative to this when applying future policies for India. When setting policies regarding cooperation, the aim should be to share the burden of flying low-demand routes between Air India and IndiGo to ensure that IndiGo supplies greater low-demand routes due to its greater fleet capacity. IndiGo has a fleet of nearly 300, while Air India has only a fleet of approximately 120 (excluding its fleets in Vistara and Air India Express), allowing IndiGo greater flexibility to use select aircraft exclusively for low-demand routes. In the same context, Air India will also require deploying Air India Express aircraft onto these low-demand routes. If the opposite case occurred and Air India received the burden of flying low-demand routes, there would be severe grievances in meeting high-demand routes in the market, which may lead to a price surge on these popular routes.

Alternatively, the system could still mutually agree without government intervention to a point where the burden of servicing low-demand routes is done entirely by one air carrier. The carrier would perform this with the greater fleet size, IndiGo in the India case, allowing for minimised revenue loss. This scenario would be the ideal case for the entire system; however, it is difficult to achieve as IndiGo will be required to lose profits by forfeiting their scheduled slots on high-demand routes to supply greater low-demand routes. However, this cooperative equilibrium point would lead to the least revenue loss and allow for the greatest net surplus for air carriers and consumers due to their increased flight frequency.

4.5 CO_2 Emissions

CO_2 emissions, possibly less relevant to other factors, remain a determining factor in consumers' decision to choose one airline over another for new-age consumers and investors. Despite the new CO_2 emission guidelines to abide by, firms may take one step further and be mindful of future consequences by reducing their emissions beyond the required amount.

Sustainable Aviation Fuels (SAF) are a practice that allows firms to reduce emissions. SAFs work by deriving biofuels from sustainable sources such as waste oil, fats, and agricultural residues rather than traditional fossil fuels – possibly reducing carbon emissions by 80%.

Air India and Indigo are negotiating potential future partnerships with fuel companies and research institutes to integrate SAF into their operations. The Indian government is also working on policies such as subsidies to support the usage of SAF and hopefully reduce the carbon footprint inside Indian aviation. The only drawbacks are the limited supply and the rise in costs. SAFs cannot entirely replace traditional fuel sources due to the continuously

growing demand within the industry and may only substitute a minute portion of the fuel used. Furthermore, SAF is more expensive than traditional fuel sources, with an overreliance on its surcharging airfare to cover any rises in cost.

This situation can be modelled in two possible ways. Firstly, if both firms decide to make the same move and implement or not implement such a technology, they will have equal payoffs. Despite SAF fuels incurring higher costs on the firms, this would not be negligible in the long run due to economies of scale. Hence, considering the options 'Implement Technology' (IT) and 'Don't Implement Technology' (DIT) we can say the following:

	AirIndia: IT	AirIndia: DIT
Indigo: IT	$-\gamma + b, -\gamma + b$	$(-\gamma + \alpha), (\gamma - \alpha)$
Indigo: DIT	$(\gamma - \alpha), \quad (-\gamma + \alpha)$	γ, γ

Table 4: CO_2 Emissions in Indian aviation assuming no capital investment

- γ: cost of implementation of SAF
- a: utility upon sole implementation of SAF
- b: utility upon mutual implementation of SAF
- a > γ
- a > b

This model views the system as a symmetric overview of the implementation of CO_2 emission reduction methods in Indian Aviation. As the impact of utility is independent of market share, we view both parties to gain equal benefit or loss from all decisions. As these decisions aid the firm, the resultant utility of SAF implementation is greater than not implementing it. However, if both are implemented, we cannot accurately determine if the consequent would be a gain or a loss for each air carrier. Those factors would depend on how effective SAF is in reducing emissions and the extent to which emission reduction sways consumers and creates efficiency in operations.

This model primarily assumes that some consumers are sensitive about which airline is better for the environment but are indifferent when both take the same action – the case of a zero-sum game. In this case, consumers' sensitivity towards the firm's better for the environment is represented by $\alpha$the change in utility (caused by a change in demand) that each firm incurs, given that they implement or do not implement SAF. If one acts and implements SAF, it becomes superior in the eyes of the consumer, thereby increasing demand for the firm that implemented SAF and shifting it away from the alternative firm. However, if both firms did or did not implement SAF, the market dynamics remain unchanged.

However, this model ignores portfolio and capital investments due to sustainability improvements. The second potential scenario, therefore, considers when investors invest based on sustainable practices for the environment.

Investors would increase investments in the firm that implemented SAF if both implemented SAF; however, investors (and the government) would equally support both firms to a larger extent. This can be shown by:

	AirIndia: IT	AirIndia: DIT
Indigo: IT	$-\gamma + b + \beta, -\gamma + b + \beta$	$(-\gamma + \alpha + \beta), (\gamma - \alpha)$
Indigo: DIT	$(\gamma - \alpha), \quad (-\gamma + \alpha + \beta)$	γ, γ

Table 5: CO_2 Emissions in Indian aviation assuming some capital investment

Where:

- β: additional capital investment caused by SAF
- γ: cost of implementation of SAF
- a: utility upon sole implementation of SAF
- b: utility upon mutual implementation of SAF
- a > γ
- a > b

Along the same lines, we view the system as symmetric, though we consider the possibility of additional capital investment outside the system. The system in this is an assumption on the principle that investors will solely be swayed by the decision to implement SAF, though they may be swayed by factors such as expansion projects and market share. The variable's value would depend on investors' focus on sustainability and ESG. Any improvement, innovation, or act of sustainability will improve the shareholder's view of the firm and increase its share price. The only variance is how much investors spend on Air India or IndiGo. When considering the possibility of implementing SAF to similar levels, we assume that new investors, especially ESG-focused investors, may begin investing further into the two firms.

5. Optimal Operational Policies

5.1 Maximising Consumer Benefit

As represented by our sustainable development function, flight duration plays a key component in the disutility of consumers. However, this depends on the route and is largely a constant in this function. While subsidising the training of pilots to increase choice and skill in the labour market holds potential, the route is still the main deciding factor. There is also an opportunity cost in doing such, which must also be considered. Overall, we will neglect the limited effect such policies could have on travel time due to the unpredictable nature of such a variable due to factors such as weather and will consider it a constant based on the route being taken.

Our model indicates that collusion negatively affects consumer utility. The game is a standard asymmetric company dilemma (≈ 60 - 40), and the strongly dominant strategy in a strictly competitive environment (or Nash equilibrium) leads to both firms setting lower prices. On the other hand, the Nash bargaining rule we developed proposes a solution at which both firms can agree to set higher prices and enjoy utility maximisation, which lies

above this disagreement point. Negotiations benefit both firms proportionately, so it is reasonable to assume that tacit collusion could lead to this point.

Hence, from the perspective of consumers, and to avoid market power abuse, we would want to develop policies that strictly deregulate collusion. There has been no evidence of collusion between Air India and Indigo. Regulation can be enforced through fines to ensure that no tacit collusion takes place. This can also help generate additional government revenue, although it must often be significantly high until firms change decisions. Simultaneously, governments should also focus on protecting suppliers and employees, especially wage cuts, which should be closely monitored to avoid exploitation as firms aim to maximise profit.

Another feasible solution would be a price ceiling. This solution may be viable if the various other benefits of collusion are to be gained to help reduce ticket pricing. However, it would alter the equilibrium point and result in a shortage, reducing the efficient nature of free markets.

Our model indicated that when both firms have a roughly equal flight frequency, the surplus in the market is maximised (i.e., revenue loss is minimised). However, we know that Indigo and Air India have an asymmetric dynamic where Indigo is larger in revenue and market share than Indigo. As discussed, they also consequently run more flights due to significantly more fleets.

While the government could encourage collusion, this would have some unwanted side effects, primarily lowered competition, higher barriers to entry, and eventually higher prices. Hence, unless flight frequency significantly hinders the surplus gained by firms and, by extension, the workers and employees, this should not be implemented as a policy despite there being potential solutions to these unwanted policy effects.

5.2 Ensuring Sustainability Operations

We devise two potential models for the emissions in the aviation market. The technology we adopt is sustainable aviation fuels (SAF). Subsidising this technology has already been done and is highly effective. Lowering costs can also help increase efficiency in the long run and motivate Indigo and India to implement this fuel in their jets.

However, this may take a while and occur in the long run. In the short run, regulating a maximum emissions limit on both firms would have more immediate effects. This could also lead to the development of a carbon credits market in India. This way, firms will be incentivized to innovate instead and improve their environmental efficiency by using such fuel to help their emissions and meet their targets annually.

Summary and Conclusions

The main limitation of our findings was our assumption of only two players in the market, AirIndia and Indigo. Models become much more complicated and tangled without this assumption, although they would also achieve greater accuracy.

Further, rational human behaviour and utility function estimates are also often extremely difficult to model. Rational human behaviour entails a lot of limitations, such as bounded self-control, rationality, information, etc., and these assumptions can hinder the validity of our findings.

Policies can help move the market to a more desirable equilibrium. However, they are only effective to an extent and can usually disturb the efficient workings of a free market, leaving the root problem unsolved. All policies also include unwanted side effects, such as extra government spending, which means that each policy inherently has an opportunity cost.

Future research should consider removing the assumption of two players in the market to make models more detailed, as well as developing quantitative models of the market to help gain a more precise understanding of the dynamics between Air and Indigo and other competitors. Crucially, we assume that demand is constant despite price variations, ignoring the possibility of consumers unwilling to travel from high prices or switching to alternative means of transport entirely. The models also contained smaller assumptions that were carried forth due to the lack of pre-existing information or data to derive aspects such as firm relationships, market dynamics from market share differences, and the ignorance of variations in fixed costs and flight duration differences. Economic and psychological theory can also outline potential policy frameworks that would be optimal given the situation.

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