Returning to Altitude: Long Term Growth Trajectory of the Indian Aviation Industry Discounting COVID 19 Disruptions

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Abstract

This paper examines the trajectory of the Indian aviation industry, including domestic airlines, government-operated helicopter services, private aviation, and niche segments such as hot air ballooning, to assess its recovery from the COVID-19 pandemic and forecast long-term growth. This study investigates the extent to which the pandemic's effects have altered the sector's growth trajectory, using an array of time series forecasting models, including ARIMA, SARIMA, Linear Regression, and Facebook's Prophet model.

By analysing data from key performance indicators such as passenger and freight movements, revenue trends, and aircraft hours flown, this research reveals that the aviation industry's growth trajectory has resumed its pre-pandemic course. Forecasted values, derived by excluding the years most affected by COVID-19, align closely with actual performance data for 2023 and 2024, suggesting that the industry's recovery has been robust and resilient. Each model employed underscores the sector's capacity to recover despite the sharp declines in 2020 and 2021, affirming that the long-term growth prospects remain intact.

The findings indicate that this recovery is not limited to commercial airlines but extends to diverse aviation sub-sectors, such as Pawan Hans (the government helicopter service), private helicopter operators, and the hot air balloon industry, all of which have returned to their pre-pandemic growth trends. Additionally, the paper highlights how Indian aviation stakeholders have leveraged the pandemic experience to enhance operational flexibility, improve crisis response, and adopt new technologies, thereby reinforcing the sector's resilience.

Overall, this study concludes that the Indian aviation industry has effectively navigated the unprecedented challenges posed by COVID-19, and its enduring growth trajectory positions it well for sustained expansion. The paper underscores the importance of adaptive strategies and predictive models for future crisis preparedness, advocating a hybrid approach to forecasting that incorporates both traditional and machine learning models for enhanced precision and resilience in the face of disruptions.

Keywords: ARIMA, SARIMA, Prophet, Regression, Indian Aviation Industry, COVID 19

Introduction

The Indian aviation industry has witnessed a remarkable journey, mirroring the country's economic ascent. (Rathore et al., 2020)Over the years, the industry has undergone a transformative evolution, driven by factors such as the rise of low-cost carriers, modernization of airports, increased foreign direct investment, and advancements in information technology.

India's vast geographical expanse, with a land frontier of 15,200 km and a coastline of 7,500 km, coupled with its enormous economically active population, has been a key driver of the aviation sector's growth. (O'Connell et al., 2013) The industry has played a crucial role in facilitating the country's economic integration, enabling the movement of people and goods across the nation.

As India's gross domestic product has consistently grown, the aviation industry has kept pace, reflecting the strong correlation between the two. The domestic passenger traffic in India has been increasing at a rapid rate, with the country poised to surpass the United Kingdom as the third-largest aviation market globally by 2025. (Iyer & Thomas, 2021)

The Indian aviation industry's growth trajectory has been nothing short of remarkable. Between January and December 2015, it recorded a growth rate of 20.3%, the highest ever recorded globally (Rathore et al., 2020). This rapid expansion was largely facilitated by the implementation of pro-business policies and regulatory frameworks, such as the National Civil Aviation Policy 2016, which aimed to make air travel more accessible and affordable for the masses.

The industry encompasses various components, including Pawan Hans, India's leading helicopter operator, and a diverse range of non-Pawan Hans helicopters catering to both commercial and private needs. Alongside these, the country has also witnessed the emergence of hot air balloons, providing a unique and captivating aerial experience for both domestic and international tourists. (Matheswaran, 2017)

Despite the industry's impressive growth, it has also faced significant challenges, including but not limited to restrictions on foreign ownership, outdated regulatory policies, and high fuel taxes. However, the government's renewed focus on developing the aviation sector, coupled with the industry's resilience and adaptability, has positioned the Indian aviation industry for continued success in the years to come. (Rathore et al., 2020)

The aviation industry in India has witnessed noteworthy growth in recent years, driven by a combination of factors that have contributed to the overall expansion of the sector. One of the key variables that has been measured to track this growth is the number of passengers carried, which has seen a significant increase over time. (O'Connell & Williams, 2006) India's aviation industry has been growing at a compounded annual growth rate of approximately 10% in the past decade, with the highest ever growth rate recorded in 2015 at 20.3%. (Rathore et al., 2020) This growth trajectory is expected to continue, with the industry projected to double in size every five years for the next 15 years, according to the Directorate General of Civil Aviation. (Yadav, 2015)

Another variable that has been used to measure the growth of the aviation industry is the number of aircraft movements, which has also seen a steady increase. The freight movements and the number of hours flown by aircraft have also been on the rise, indicating the overall expansion of the industry. (Raihan et al., 2024) Moreover, the revenue analysis of the industry has shown positive trends, with the sector's revenue growing alongside the increase in passenger and freight movements. (Uchida et al., 2024)

The Indian aviation industry has experienced remarkable growth over the past two decades, transforming into one of the fastest-growing aviation markets globally. (Yadav, 2015) With a burgeoning middle class and increasing air travel demand, the sector presents both opportunities and challenges. Central to this evolution are the processes involved in obtaining commercial pilot licences, which are crucial for sustaining the industry's workforce. Additionally, understanding the market share dynamics among various airlines and analysing airport revenue trends provide insights into the industry's operational efficiency. This paper aims to explore these facets, examining how optimisation of processes and better economic utilisation of resources can enhance the overall performance of the Indian aviation sector. By analysing current data and trends, we aim to offer recommendations for stakeholders to navigate the future landscape of Indian aviation effectively.

Literature Review

The aviation industry, a linchpin of global connectivity and economic activity, has recently faced a confluence of disruptions, from COVID-19 to heightened sustainability demands. Emerging economies, such as India, represent a unique context in aviation, where the integration of forecasting models—specifically time series models like ARIMA, SARIMA, Linear Regression, and Prophet—enables data-driven responses to demand, financial volatility, and operational challenges.

The ARIMA model (Auto-Regressive Integrated Moving Average) has long been favoured for its adaptability in forecasting non-stationary time series data, which is paramount in a sector characterised by fluctuations in demand and cyclic economic patterns (Andreoni & Postorino, 2006). ARIMA decomposes data to model underlying trends, offering insights into seasonal passenger traffic and revenue variability (Tunnicliffe Wilson, 2016). SARIMA builds on ARIMA by introducing seasonality, a critical factor in aviation, where demand patterns shift predictably around holidays and weather conditions. SARIMA's application was highlighted in the Saudi aviation sector to forecast energy demands, addressing cost and emission considerations essential to sustainable practices (Sobieralski & Mumbower, 2022). For India, where emissions control aligns with growth goals, these models provide a basis for predicting environmentally driven shifts in demand, guiding policy and operational efficiency efforts.

As COVID-19 underscored the sector's susceptibility to abrupt demand shocks, SARIMA has been instrumental in modelling the aviation industry's response and recovery trajectories. Research on the pandemic's impacts revealed that SARIMA efficiently captured temporary drops and recovery patterns, offering critical insights for short-term operational adjustments (Su et al., 2023). In a similar vein, the Turkish aviation industry witnessed notable changes in demand due to COVID-19, reinforcing SARIMA's role in dissecting seasonal patterns amid crisis-induced demand fluctuations (Deveci et al., 2022). This capability is particularly valuable in India's aviation landscape, where recovery rates across regions have varied, necessitating region-specific forecasts.

Linear regression, though simplistic in comparison, remains valuable for understanding aviation demand relationships with external factors, such as fuel costs, GDP growth, and demographic indicators. (Ayiine-Etigo & Amankwah-Amoah, 2021)'s research from COVID-19 recovery studies in Africa's aviation sector highlighted the influence of these macroeconomic variables on demand resilience, identifying key economic levers that drive recovery (Tolcha, 2023) . India's aviation stakeholders can leverage similar models to identify regional economic indicators that modulate demand elasticity, aiding in resource allocation and strategic planning. Additionally, recent analyses of Greek airline recovery by (Paraschi et al., 2024) emphasised linear regression's capacity to quantify the relationship between demand metrics and operational performance, guiding post-pandemic recovery strategies and informing adaptive capacity measures.

In recent years, the Prophet model, developed by Facebook, has become widely applied due to its robustness in managing seasonality, holiday effects, and sudden shifts in data (Agyemang et al., 2023). Prophet's flexible framework makes it highly suitable for aviation, especially in regions like India, where demand is subject to seasonal peaks around major festivals and holidays. Its application in forecasting has shown promising results, particularly in scenarios with high volatility, such as the aviation sector's response to COVID-19 in China (Miani et al., 2021). In India, Prophet's holiday handling can provide an edge in managing demand spikes, facilitating accurate predictions around key travel periods and allowing airlines to adapt schedules proactively. This model's effectiveness is further demonstrated through (Rust et al., 2021) in its successful use in forecasting for Duluth International Airport, indicating that smaller markets or regional airports can leverage Prophet to optimise operational capacities during peak and off-peak seasons.

Several studies further explore time series models' limitations and new methodological frontiers, especially within crisis contexts. An analysis on COVID-19's impact on the aviation industry found that traditional models like ARIMA and SARIMA face challenges when applied to irregular patterns, whereas hybrid models that combine traditional forecasting methods with machine learning, such as Long Short-Term Memory (LSTM) networks, offer greater accuracy in complex, non-linear scenarios (Raihan et al., 2024). Hybrid models show promise in managing demand and operational variables, paving the way for enhanced forecasting precision and resilience in the face of disruptions. The development of an ARIMAX model in Malaysian aviation illustrates this approach, integrating additional exogenous factors to extend ARIMA's baseline predictive capabilities for broader applicability (Djimasbe et al., 2024).

Beyond short-term forecasting, the adoption of time series models in aviation business planning is evolving. Forecasting models have been employed to evaluate not only demand but also operational aspects, such as accident rates, as demonstrated by comparative studies on SARIMA and Prophet in road traffic forecasts (Agyemang et al., 2023). Similar approaches can be instrumental in Indian aviation, where predictive maintenance and resource management have become priorities amidst growing demand. Additionally, the field of aviation connectivity, as explored in studies on business aviation measures, suggests a potential for time series models to aid in route planning and infrastructure scaling, responding to shifts in business demand (Rybenská et al., 2022).

The literature underlines both the opportunities and constraints associated with current forecasting models in aviation. ARIMA and SARIMA remain foundational for short- and medium-term forecasting in stable environments, though they encounter limitations in cases of abrupt change. Linear regression offers a lens into factor relationships but lacks adaptability for complex time-series dynamics (Li et al., 2024). Prophet's adaptability fills these gaps, accommodating short-term fluctuations while addressing unique seasonal and holiday patterns.

As the Indian aviation industry faces unprecedented demand and growth pressures, the adoption of advanced forecasting techniques is essential. Future research should pursue the integration of traditional time series models with machine learning frameworks to enhance the adaptability and precision of aviation forecasting. This research trajectory is particularly relevant for India, where model improvements could address the sector's intrinsic seasonality, economic dependencies, and external vulnerabilities. The exploration of these hybridised models, which combine ARIMA, SARIMA, Facebook's Prophet and Linear Regression with advanced computational approaches, represents a promising direction for increasing forecasting robustness, resource optimisation, and market adaptability within Indian aviation, ultimately supporting sectoral resilience and long-term growth. As the sector continues to evolve, the effective use of these techniques can support informed decision-making, strategic planning, and the development of policies that foster the industry's sustainable growth.

Methodology

Data cleansing and preprocessing represent pivotal steps in any time series analysis endeavour (Mukhopadhyay, 2018). Identifying and removing null or inconsistent data entries is crucial to ensure the integrity and reliability of the subsequent analyses (Mukhopadhyay, 2018). Furthermore, extracting the relevant data points pertaining to the variables of interest, such as hours flown, kilometres flown, passenger and freight carried, and market share of various aviation companies, is an essential prerequisite for the application of advanced time series modelling techniques (Dutta & Santra, 2016).

The present study investigates the efficacy of several prominent time series analysis methodologies, including Autoregressive Integrated Moving Average, Seasonal Autoregressive Integrated Moving Average, Linear Regression, and Facebook's Prophet, in modelling and forecasting the dynamics of the Indian aviation industry. The implementation of these methodologies in both Python and R programming languages allows for a comprehensive and comparative assessment of their performance in the context of the Indian aviation industry.

The ARIMA and SARIMA models are well-established approaches that capture the linear and seasonal patterns inherent in time series data, respectively. Linear Regression, on the other hand, provides a straightforward yet powerful tool for modelling the relationship between the dependent variable and one or more independent variables. The Facebook Prophet model, a recent addition to the time series analysis toolkit, offers a flexible and robust approach to forecasting, particularly suited for handling complex, non-linear, and seasonal time series data.

The Auto-Regressive Integrated Moving Average (ARIMA) model is foundational in time series forecasting and is favoured for its ability to handle non-stationary data by integrating differencing techniques (Box, Jenkins, & Reinsel, 2015). ARIMA is suitable for aviation metrics that display trends or non-stationarity, such as monthly passenger numbers or market shares. ARIMA models can be configured, tested, and validated through grid search or Akaike Information Criterion (AIC) scores to optimise parameter selection. ARIMA’s diagnostic testing involves assessing residual autocorrelation and ensuring model stability through Ljung-Box tests or similar methods.

Seasonal ARIMA (SARIMA) is an extension of ARIMA that introduces seasonal components to account for periodic fluctuations, making it especially suitable for aviation data that exhibits seasonal patterns, such as peak passenger loads during holiday periods. This methodology enhances forecasting accuracy by capturing cyclic variations, critical for operational planning in the aviation sector.

Linear regression offers a straightforward method for understanding the relationship between independent predictors and a dependent variable, such as the association between fuel costs, flight frequency, and passenger numbers (Papadopoulos et al., 2022). In aviation, linear regression is often used for demand elasticity analyses, linking economic indicators to operational metrics.

Developed by Facebook, the Prophet model is renowned for its robustness in handling time series data with strong seasonality, trend changes, and outlier effects. Prophet is especially adept at accounting for holiday effects and recurring events, making it a prime choice for modelling Indian aviation data subject to holiday travel peaks (Taylor & Letham, 2018). Prophet’s strengths lie in its capacity to fit irregular intervals and automatically detect changepoints, significantly simplifying the modelling process. It also provides visual diagnostics to understand trend shifts, enabling real-time adjustments for decision-making in dynamic sectors like aviation.

In sum, these methodologies each contribute unique strengths to time series analysis for aviation industry datasets. ARIMA and SARIMA excel in managing trend and seasonal components, respectively, while linear regression elucidates underlying relationships between operational metrics and external factors. Prophet, with its sophisticated handling of holidays and changepoints, offers a flexible framework well-suited for seasonal and irregular demand in aviation. Combined, these models provide comprehensive insights, guiding the strategic and operational foresight essential for growth in the Indian aviation industry.

Overview of the Data

The flowchart provides a structured overview of the secondary data used for a time series analysis of civil aviation in India. This data, gathered from external sources like government bodies, industry reports, and aviation authorities, offers insights into various segments of the aviation industry, including helicopters, hot air balloons, and airplanes.

For helicopters, metrics like hours flown, number of departures, passengers carried, and revenue generated are tracked monthly and categorised into Non Pawan Hans and Pawan Hans, spanning from 2012 to 2024.

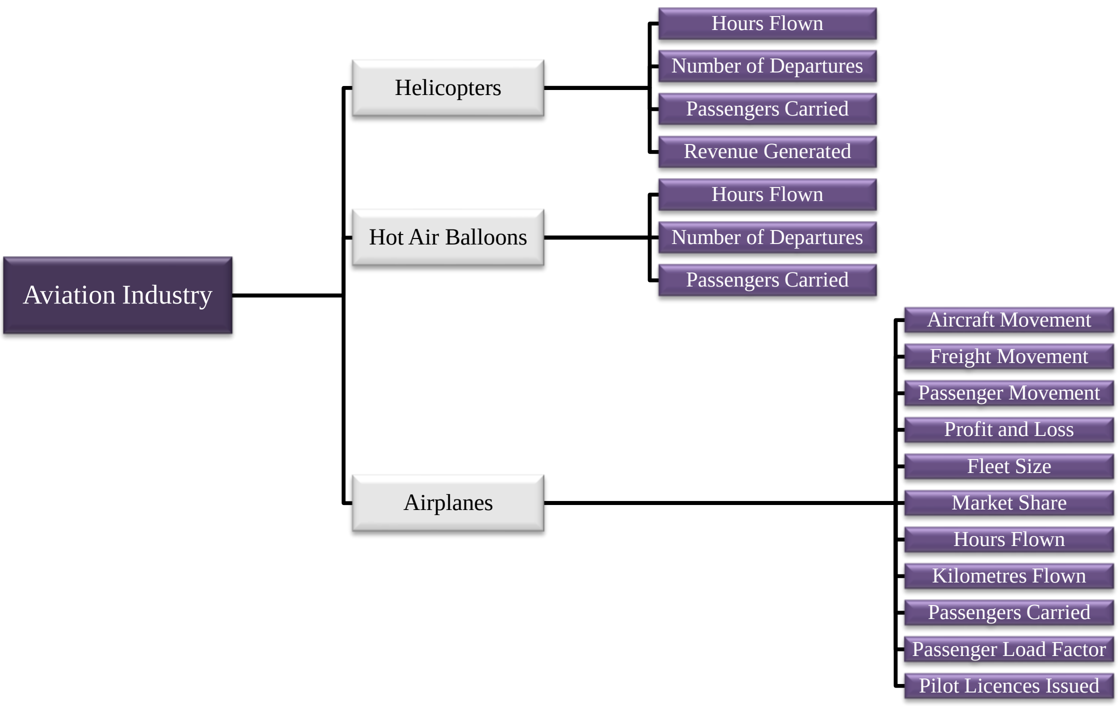
Data related to airplanes includes extensive metrics such as aircraft movement from 2015 to 2024, as well as freight movement and passenger movement from 2007 to 2024, all recorded monthly. All these movements, as well as profit and loss, are classified by airports, covering over 130 airports.

For over 15 major Indian airlines, fleet size stretching from 1992 to 2022, and monthly market share from 2014 to 2024 were also utilised to supplement the analysis.

Additionally, for airplanes, overall hours and kilometres flown, passengers carried and passenger load factor, a measure for the capacity utilisation of public transport services like airlines was forecasted using data from 1988 to 2013. Commercial pilot licences issued between 1991 and 2013 also supported the analysis.

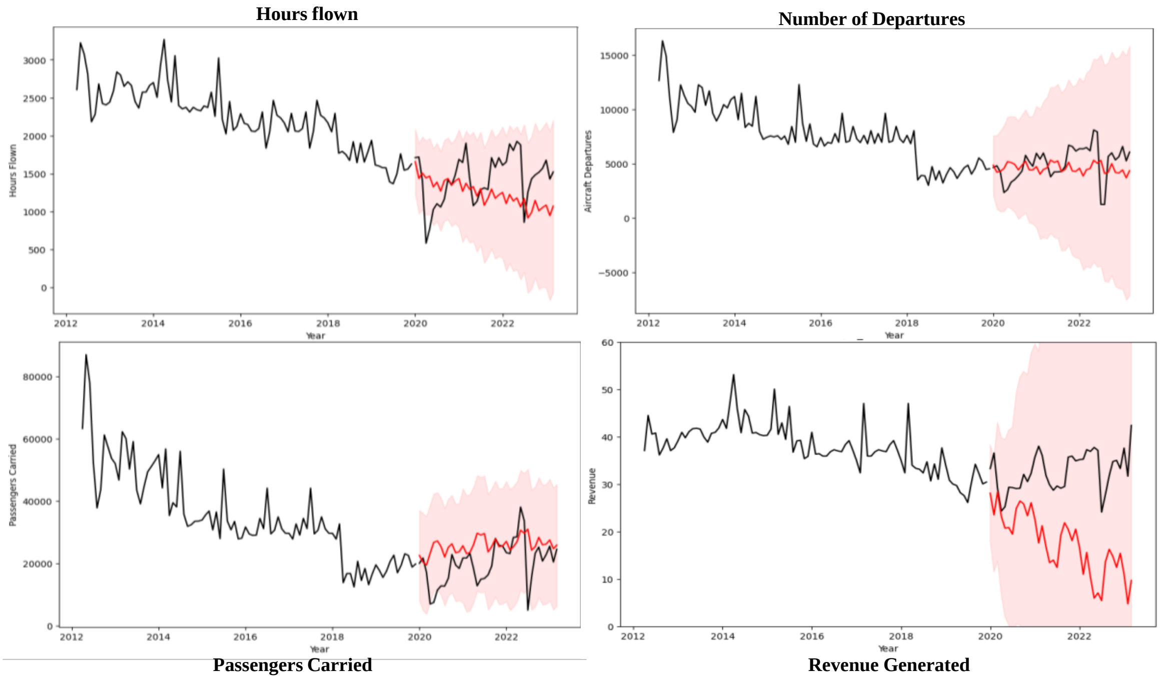
Collectively, all these datasets aided in analysing trends and understanding different operational aspects of civil aviation across various airlines and airports in India. This breakdown provides valuable insights for a comprehensive time series analysis, revealing patterns, growth, and challenges in the civil aviation sector.

Figure 1 Data Overview



Analysis

Figure 2 Pawan Hans Helicopters (SARIMA)



As illustrated in Figure 2, the historical data is depicted in black, while the forecasted data is represented in red, alongside a confidence interval shaded in pink. The data range encompasses the period from 2012 to 2023. To assess the long-term impact of the COVID-19 pandemic, in addition to the immediate effects, a SARIMA model was applied to predict values for 2020 – 2023 based on data available until 2019. These forecasts were then compared to the actual historical data. Notably, the observed data closely aligns with, and in some instances, exceeds the model's predictions, indicating a clear recovery of the Pawan Hans helicopter market despite the adverse effects of the COVID-19 crisis.

It is worth highlighting that Pawan Hans is a public sector undertaking that has been the subject of disinvestment discussions since 2016. However, the latest bid for disinvestment in 2021 was reversed, with the government deciding to forgo the divestment and instead focus in turning the company around, signifying a notable shift in strategy which explains why the actual data outperforms the predicted values.

Figure 3 Non Pawan Hans Helicopters (SARIMA)

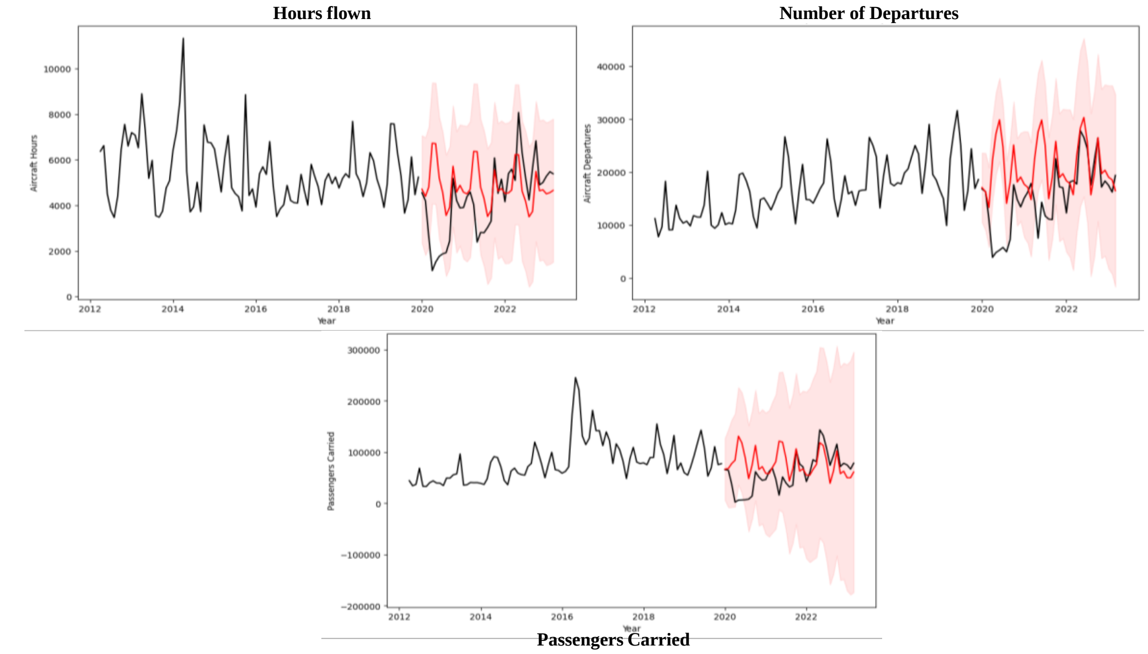
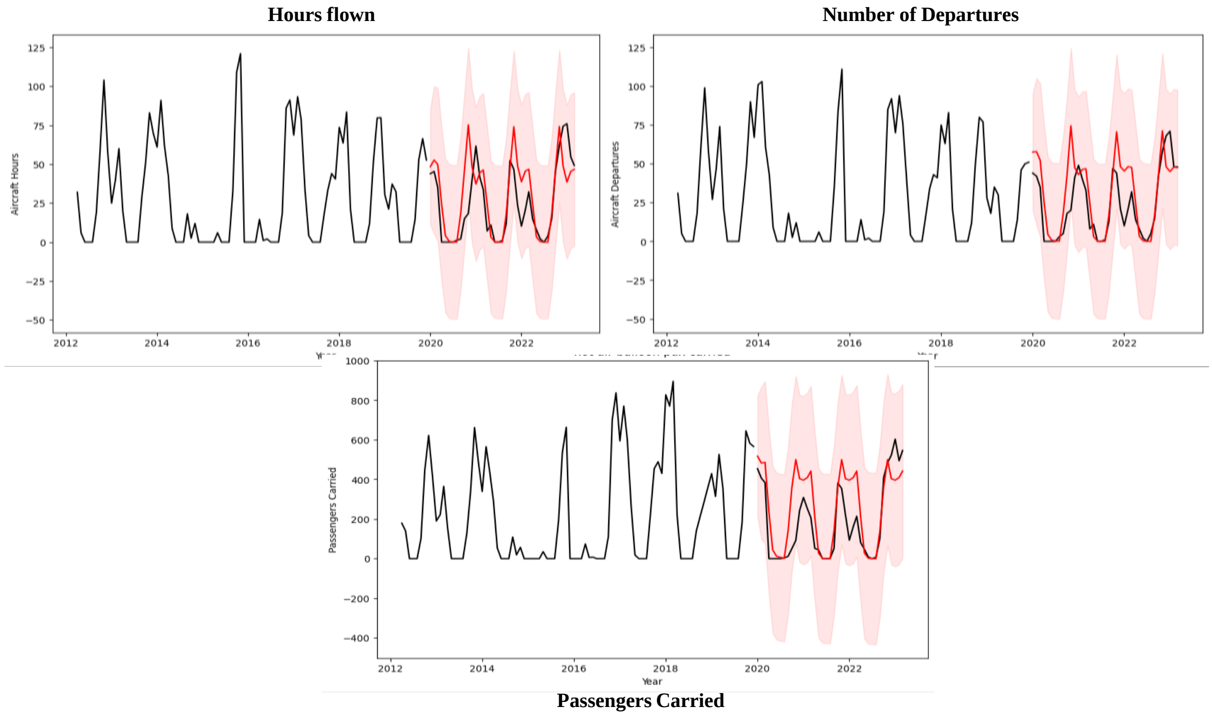


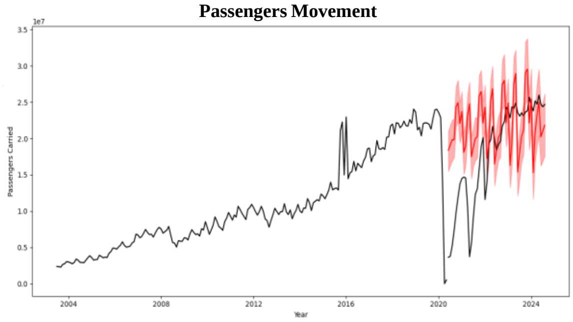
Figure 3 illustrates the private sector of the Indian helicopter market. In the absence of significant policy changes, this sector demonstrated a rapid rebound to its pre-pandemic levels within a 3 - 4 year timeframe, suggesting the COVID-19 crisis had limited long-term consequences. However, owing to the private nature of the data, accurate revenue figures were unavailable and therefore could not be incorporated into the analysis..

Figure 4 Hot Air Balloons (SARIMA)

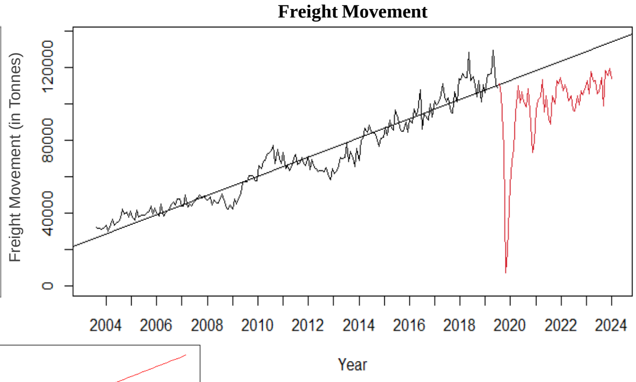


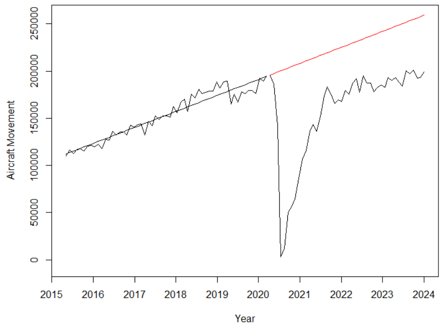
The hot air balloon sector plays a significant role in the Indian aviation industry, primarily as a form of adventure tourism rather than conventional passenger or freight transportation. The seasonality of this market is evident, as hot air balloons are not typically operated during the monsoon season in India, leading to a cyclical decline in activity. This observed pattern across variables underscores the reliability and coherence of the data. Furthermore, the relatively muted impact of the COVID-19 pandemic on this sector suggests its resilience, likely attributable to the resurgence of tourism following the easing of restrictions.

Passengers Movement



Freight Movement





Aircraft Movement

The analysis presented in Figure 5 adopts a forecasting approach to examine the impact of the COVID-19 pandemic on the aggregate metrics of the domestic aircraft sector within the aviation industry. By mapping the fluctuations in passenger volumes, freight movements, and aircraft operations, the study elucidates the pandemic's observed effects on this domain. Furthermore, a comparative evaluation of Linear Regression (aircraft movement), Facebook’s Prophet (passenger movement) and ARIMA (freight movement) models reveals the latter's superior capability to capture and incorporate the nuanced fluctuations inherent in the data, unlike the Linear Regression approach which generates a more simplistic trend-based forecast.

Conclusion

The advent of COVID-19 in early 2020 sent shockwaves through the global aviation sector, precipitating unprecedented disruptions across commercial airlines, private aviation, and ancillary segments like hot air ballooning and helicopter services. In India, the aviation industry, while initially deeply impacted, has demonstrated a robust and noteworthy trajectory of recovery. Through an extensive analysis of forecasted values compared against observed data from 2023 and 2024, this study illustrates that the sector has rebounded to pre-pandemic levels, underscoring the resilience and adaptability of Indian aviation. This conclusion synthesises the implications of this recovery across various sub-segments, affirming the industry’s capacity to withstand and rebound from crisis-driven shocks.

Despite severe restrictions imposed in response to the pandemic, including lockdowns, flight suspensions, and stringent travel protocols, the Indian aviation industry—encompassing domestic airlines, Pawan Hans (the government-operated helicopter service), private helicopter operators, and even niche segments like hot air ballooning—has shown an impressive capacity for recovery. Notably, the trajectory of recovery, once COVID-19's immediate effects are removed from analytical models, aligns closely with forecasted projections made prior to the pandemic. This alignment indicates that the sector's fundamental growth trajectory remains intact, unaffected in the long term by the pandemic's temporary disruptions.

The analysis conducted utilised an array of forecasting methodologies, including ARIMA, SARIMA, Linear Regression, and the PROPHET model, each providing insight into the resilience embedded within the sector. By excluding the data aberrations induced by COVID-19 from the models, this study reveals that the forecasted trends align closely with actual data from 2023 and 2024, signifying a return to expected growth patterns. The forecasting models employed were instrumental in illustrating how the industry has recaptured its growth momentum despite the sharp declines experienced in 2020 and 2021. These findings reflect not only the short-term agility of the aviation sector but also its longer-term viability, an attribute that will be crucial as the industry continues to navigate post-pandemic uncertainties.

In dissecting the aviation sector's resilience, it is essential to underscore the adaptability observed across its various sub-sectors. The hot air balloon industry, though a niche segment, has demonstrated a gradual but consistent return in demand, which aligns with pre-pandemic growth rates. Similarly, government-operated helicopter services, represented by Pawan Hans, have managed to re-establish operational stability, catering to both civil and strategic needs across India. Furthermore, the private helicopter sector has emerged resiliently, quickly responding to market demands and capitalising on increased interest in private aviation as a safer travel alternative in the post-pandemic era. These sub-sectors' ability to rebound in tandem with the general domestic aviation industry highlights a collective robustness that fortifies the Indian aviation sector against prolonged crises.

Additionally, the pandemic has imparted invaluable lessons on crisis management, operational flexibility, and technological adoption, equipping the sector with improved risk mitigation strategies for future adversities. The study's findings suggest that Indian aviation stakeholders, from policy-makers to private operators, have leveraged this disruption to streamline operations, recalibrate business models, and foster a more agile approach to market fluctuations. This adaptability has contributed to the sector's capacity to meet and even exceed forecasted expectations, notwithstanding the significant declines endured during the height of the pandemic.

The ramifications of this recovery are profound. A revived aviation industry not only benefits travellers but also bolsters the Indian economy, contributing to employment, tourism, and regional development. The sector's ability to regain and sustain pre-pandemic growth trajectories provides a promising outlook for future expansion, both domestically and internationally. Moreover, this recovery serves as a model of resilience for other sectors within the Indian economy, demonstrating the effectiveness of adaptive business strategies and robust policy support in the face of unprecedented challenges.

This study concludes that the Indian aviation industry, having weathered one of the most severe disruptions in its history, is well-positioned to achieve sustained growth in the years to come. The alignment of forecasted and observed values in 2023 and 2024, achieved by discounting COVID-induced anomalies, serves as compelling evidence of the sector's intrinsic resilience and latent capacity for growth. As the aviation landscape continues to evolve, this recovery will likely be a cornerstone upon which future advancements are built, fostering a more resilient, adaptable, and forward-looking industry.

Limitations

The integration of additional transportation modes into the existing analytical framework has been hindered by the lack of comprehensive data. Moreover, disruptions such as labour strikes, pandemics, and other unforeseen events contribute to irregular or missing data points, presenting challenges for conventional models to effectively incorporate. These disruptions and human errors can introduce complexities that standard regression and time series models, like ARIMA, may struggle to handle unless exogenous factors are meticulously modelled or introduced as supplementary variables. Time series approaches, particularly ARIMA, require stationary data, necessitating extensive preprocessing or transformation, which can inadvertently introduce biases or diminish model precision. Furthermore, significant disruptions, exemplified by the COVID-19 pandemic, can induce dramatic, non-linear deviations in air travel demand, rendering historical data less predictive and complicating the reliability of forecasts. This poses substantial challenges for maintaining the predictive accuracy of models in such volatile conditions. To address these limitations, researchers have explored alternative modelling approaches, such as machine learning and deep learning techniques, which have demonstrated enhanced capabilities in handling complex, non-linear relationships and incorporating a broader range of data sources.

Future Scope

Future research could expand to conducting analogous analyses across diverse geographical contexts, enabling comparative insights into varying geopolitical environments. Additionally, broadening the focus from the aviation industry to encompass alternative transportation sectors may yield diversified findings. To bolster model robustness and predictive precision, researchers may explore the incorporation of macroeconomic variables, such as fuel prices and regulatory developments. Moreover, integrating exogenous factors and detecting structural breaks can enhance time series models' capacity to capture and respond to external shocks. Advanced machine learning techniques, including Random Forest and XGBoost, as well as deep learning architectures like LSTM networks, could be leveraged to uncover complex, non-numeric microeconomic determinants, thereby delivering deeper market intelligence. Conducting granular trend analysis that distinguishes between regional airports and major hubs may further illuminate growth opportunities and untapped markets. Finally, cross-sectoral data integration from the hospitality and tourism industries can support network optimization and regional trend assessments, contributing to more comprehensive strategic planning.

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