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A Multidimensional Analysis of Passenger Behaviour and Weather-Related Influences on Aircraft Delays in Nigeria

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Abstract
In Nigeria's aviation industry, flight delays continue to be a major problem that impact passenger happiness, airline expenses, and operational effectiveness. This study looks at how weather-related variables and passenger behavior affect aircraft arrival and departure delays at key airports in Nigeria. Descriptive and inferential statistics were used to analyze secondary data from 29 local and international airlines between 2018 and 2024 using a quantitative study approach. The results show that more than 70% of all delays are caused by passenger-related factors, with inefficient boarding and late check-in emerging as the main culprits.
Despite being less common, weather and technical reasons causes' lengthier delay times, especially when visibility is poor and the weather is unfavorable. The findings also show that as traffic numbers recovered after 2020, the frequency of delays rose, underscoring structural inefficiencies in passenger processing systems. In order to increase operational dependability and customer happiness, the study concludes that aircraft delays in Nigeria are multifaceted and suggests integrated techniques that combine automation, real-time monitoring, better weather predictions, and improved passenger management.

Keywords: Passenger behavior, flight delays, airport operations, Nigeria, aviation management

I. Introduction

Because it makes it easier to move people and things across borders, the aviation sector is vital to economic growth. Flight delays, however, continue to be a major operational problem that affects airline schedules, raises operating expenses, and lowers passenger satisfaction (Bureau of Transportation Statistics, 2013). Passenger behavior has been identified as a major contributor to aircraft delays, impacting both arrival and departure timings among the many other factors.

Passenger behavior includes a range of operational actions, such as last-minute boarding, late check-ins, luggage management issues, security clearance delays, and non-compliance with airline protocols. The turnaround time and slot management of aircraft are directly impacted by these behavioral inefficiencies. According to studies, unprepared passengers, excessive luggage weight disputes, and documentation problems all cause delays at check-in counters, which in turn cause departure delays (Federal Aviation Administration, 2012). Similarly, operational inefficiencies are exacerbated by security-related delays, such as passengers arriving late at boarding gates or not meeting screening criteria (International Civil Aviation Organization, 2017).

Passenger behavior influences post-disruption attitudes, brand impression, and future travel intentions in addition to operational effects. In a study that was published in the International Journal of Multidisciplinary Research and Growth Evaluation, Cuntapay et al. (2025) looked at how passenger attitudes and satisfaction were affected by aircraft delays and cancellations. According to their research, disruptions have a big impact on passengers' feelings, opinions about how reliable airlines are, and propensity to use them again. According to the study, better flight predictions, shorter wait times, more accurate scheduling, and improved communication all have a beneficial impact on customer satisfaction during interruptions. Crucially, travelers who were warned in advance of delays or cancellations showed greater levels of satisfaction than those who were informed on the day of departure. These results highlight the psychological and behavioral aspects of flight delays and show that operational inefficiencies impact airline competitiveness and customer loyalty in addition to scheduling issues.

Similarly, in their study that was published in the African Journal of Biological Sciences, Sri Ramachandran and Ramasubramanian (2024) looked at efficient methods for handling aircraft delays and cancellations as well as their impact on frequent fliers' behavior and brand reputation. Their research showed that prompt alternative travel arrangements, well-organized compensation plans, and effective on-ground support services greatly increase customer happiness and brand loyalty during interruptions. The study also showed that while effective and polite ground support services are essential to preserving an airline's reputation during operational emergencies, gender disparities affect perceptions of compensation fairness. These results imply that delay management is a strategic issue for customer relations and brand management in addition to being an operational one.

Passenger-induced delays have become more common in Nigerian aviation, especially on domestic carriers. Airlines like Air Peace, Arik Air, Dana Air, and Max Air regularly report instances of late passenger arrival and boarding non-compliance, resulting in lengthy turnaround times and missed departure slots, according to the Nigerian Civil Aviation Authority (2023).

Figure 1: Air Peace

Source: Prime Business Africa, 2023

Recurrent ground delays at major airports like Murtala Muhammed International Airport, Nnamdi Azikiwe International Airport, and Port Harcourt International Airport are caused by passenger conflicts, unruly behavior, an excess of carry-on luggage, and disobedience to airline directives (Wang et al., 2003). When connecting passengers miss subsequent flights, arrival operations are also impacted, requiring operational changes that result in a chain reaction of network delays (BTS, 2013). Aircraft ground time is further extended by sluggish disembarkation, delays in customs procedures, and traffic in terminal facilities (NTSB, 2000).

Weather circumstances continue to be a major determinant of flight disruptions, even after controlling for behavioral characteristics. According to a recent study by Akintunde et al. (2024) published in the African Journal of Geographical Sciences, poor visibility brought on by harmattan haze, fog, and heavy rainfall greatly increased the probability of flight delays and cancellations at Yakubu Gowon Airport in Jos, Plateau State. Their results showed that reduced visibility and aircraft delays had a somewhat positive correlation (R = 0.530), with visibility circumstances accounting for about 28% of the variance in delays. Their study highlighted how operational inefficiencies and other factors interact dynamically with weather conditions to exacerbate disruptions, even though its primary focus was on meteorological aspects.

The results of Akintunde et al. (2024) and Cuntapay et al. (2025) are especially pertinent to this investigation since they show that flight disruptions have multiple dimensions. Weather-related visibility restrictions interact with airport traffic, scheduling procedures, and passenger management systems rather than functioning independently. The performance and reputation of the airline are also further impacted by passenger responses to these delays, which may take the shape of discontent, annoyance, or decreased loyalty. In Nigeria's busy airports, where inefficient passenger behavior already prolongs turnaround times, bad weather can increase the severity of delays and spread the network.

Peak travel times, like holidays, make this contact even more intense. Congestion in the check-in, security screening, and boarding procedures is caused by higher passenger volumes. The system undergoes increased operating stress when coupled with poor visibility or unfavorable weather, which results in protracted delays and cancellations (ICAO, 2017).

Therefore, in order to understand aircraft arrival and departure delays in Nigeria, both behavioral and meteorological variables must be investigated within an integrated analytical framework that takes operational efficiency, passenger psychology, and environmental limits into account.

The Dynamic Model

The relationship between passenger flow, aircraft operations, and delay propagation in airport systems is explained by the Dynamic Model. Aircraft movement—takeoff, cruise, and landing—requires coordinated cooperation between air traffic control, passenger processing, and ground operations (Wang et al., 2003). The operational network may have cascade effects from any breakdown in a single component of this coordinated system.

Aircraft ground time and scheduled departure sequencing are disrupted by passenger behaviors such late gate arrival, non-compliance with boarding procedures, excessive cabin luggage disputes, and baggage handling conflicts (Bratu & Barnhart, 2006). Across interconnected aviation networks, these inefficiencies raise reactionary delays and decrease operational flexibility.

Furthermore, Akintunde et al. (2024) show that these behavioral inefficiencies exacerbate delay consequences when weather-induced visibility limits are imposed into airport systems. According to their findings, aircraft interruptions are greatly increased by decreased visibility, especially at airports without sophisticated mitigation infrastructure. This bolsters the Dynamic Model's hypothesis that a variety of interrelated operational, environmental, and behavioral factors work together to affect delay propagation.

The Dynamic Model can be expanded to include passenger psychological reactions to disturbances in addition to operational mechanics. According to Cuntapay et al. (2025), flight delays and cancellations have a big impact on passengers' opinions, satisfaction levels, and plans to travel again. Their research shows that long wait periods, last-minute announcements, and inadequate communication all increase discontent and unfavorable behavioral responses. Such unfavorable responses have the potential to worsen boarding procedures, intensify disputes, and raise ground inefficiencies in dynamic airport systems. As a result, behavioral reactions can contribute to the delay cycle itself in addition to being the result of delays.

The four aerodynamic forces that affect aircraft—lift, drag, gravity, and thrust—are also included in the model. Flight mechanics are governed by these physical forces, but whether planes run within scheduled parameters depends on operational factors like weather fluctuation, infrastructure capacity, passenger compliance, and communication efficiency. Increased ground time results in departure delays when passengers disregard airline policies (BTS, 2013), which can be made worse by unfavorable weather. Additionally, as shown by Cuntapay et al. (2025), poor communication during disruptions may exacerbate passenger discontent, lengthen dispute resolution procedures, and inadvertently increase operational turnaround time.

As a result, the Dynamic Model shows that flight delays are systemic phenomena that arise from the interplay of environmental factors, human behavior, and physical limitations rather than being solely mechanical or meteorological events.

The Gravity Model

Passenger movement between airports is explained by the Gravity Model, which takes into account distance, population density, and economic size (Capoani, 2023). Major airports in Nigeria, including Lagos, Abuja, and Port Harcourt, are in great demand and draw large numbers of passengers because of their connectivity and economic centrality.

High traffic concentration generates congestion in terminal facilities, security checkpoints, baggage handling systems, and boarding gates. According to studies, bottlenecks in screening and processing systems cause delays more frequently at airports with higher passenger volumes (Efthymiou et al., 2018). Furthermore, the socioeconomic distinctions between leisure and business travelers affect the patterns of punctuality and delay tolerance (Yaylalı et al., 2016).

The behavioral implications of the Gravity Model are further supported by Cuntapay et al. (2025), who show that when delays occur in high-traffic areas where waiting times are prolonged, passenger satisfaction dramatically decreases. According to their findings, passenger perceptions are positively impacted by enhanced schedule reliability, better capacity management, and shorter wait times. Higher passenger density raises system pressure and intensifies the effects of operational inefficiencies, which is consistent with the Gravity Model's premise. By showing that airports in climatically susceptible areas encounter compounded delays when high passenger volumes combine with unfavorable weather, Akintunde et al.'s (2024) research supports the Gravity Model. Weather fluctuations, inefficient passenger behavior, and infrastructure constraints all increase the likelihood of disruption in Nigeria's high-density centers. Operational buffers are insufficient when high passenger demand is accompanied by poor visibility or stormy weather, which results in protracted delays and cancellations.

Application of Theoretical Models to the Study

A thorough framework for analyzing airplane delays in Nigeria is provided by the combination of the dynamic and gravity models. The Dynamic Model describes the interplay between environmental unpredictability, operational coordination, and behavioral responses in airport systems that results in delay cascades. It illustrates how passenger behavior, meteorological conditions, and operational management are all linked in the systemic aspect of delay propagation.

High passenger demand and hub concentration lead to congestion-induced inefficiencies that increase susceptibility to disruptions, as explained by the Gravity Model. It places delay hazards in the context of airport traffic flows' spatial, demographic, and economic dynamics. By empirically showing that climatic factors, especially visibility, significantly contribute to delay outcomes while working in tandem with operational and behavioral drivers, the findings of Akintunde et al. (2024) reinforce this theoretical integration. In a similar vein, Cuntapay et al. (2025) expand the paradigm by demonstrating how crucial elements of delay dynamics and service recovery efficacy are passenger satisfaction, emotional response, and behavioral reactions. As a result, this study uses a multifaceted analytical approach, looking at weather and passenger behavior as interrelated factors that affect aircraft arrival and departure delays in Nigeria. The study offers a more comprehensive knowledge of delay causation and mitigation measures by integrating operational mechanics, passenger psychology, and environmental variability into a single paradigm.

Empirical Review

Numerous studies have looked at how passenger behavior affects aircraft delays in various geographical areas, emphasizing issues including delayed check-in, ineffective boarding procedures, backlogs in baggage clearance, and security screening delays. To give readers a thorough grasp of the topic, this section examines pertinent empirical research.

Zámková According to a study by Rojík, Prokop, and Stolín (2022) that looked at delays at major airports in Europe, slow boarding procedures were responsible for about 28% of all delays, especially during the busiest travel seasons. According to their findings, departure delays can be considerably decreased by enhancing check-in systems and organized boarding processes. In a similar vein, Chang and Yang (2021) discovered in a Taiwanese research that 15% of all delays were caused by problems with passengers' security clearances, particularly when those passengers were not familiar with airport screening procedures. Although passenger behavior continues to be a major contributor in delays, operational and external factors also make disruptions worse. When Durdyev and Hosseini (2018) looked at delay patterns in China's aviation industry, they discovered that roughly 30% of all delays were caused by technical issues and air traffic congestion, which were frequently made worse by ineffective passenger movement and airport congestion.

According to Afolabi and Eze (2023), operational efficiency in Nigeria is still hampered by the sluggish adoption of digital boarding technology and automated check-in systems, which results in longer check-in and boarding times. On the other hand, Khan and Efthymiou (2021) showed that the installation of self-service kiosks and biometric boarding systems in US airports greatly decreased average boarding times and increased overall timeliness.

Technology-driven monitoring systems have been demonstrated to enhance service reliability and performance results in the transportation industry as a whole, in addition to operational efficiency in aviation.

The adoption of vehicle tracking systems and improvements in service delivery quality were found to be strongly positively correlated ($r = 0.680$, $p < 0.05$) in Dike's (2023) study on vehicle tracking and service delivery quality across Nigerian transport businesses. According to the study, real-time monitoring increased operational accountability, decreased service interruptions, improved punctuality, and optimized routes. Despite the study's concentration on road transport, its conclusions are extremely applicable to aviation operations because both industries rely significantly on real-time coordination, monitoring, and schedule adherence. The consequence is that, when properly deployed, technology-enabled monitoring systems, whether in fleet management or aircraft ground operations, may greatly increase customer satisfaction and service reliability.

In addition to operational effectiveness, empirical research has examined passenger sentiments regarding cancellations and delays. In their study published in the International Journal of Multidisciplinary Research and Growth Evaluation, Cuntapay, Bayaua, Candano, Capa, Lao, Luna, and Rodas (2025) investigated the effects of aircraft delays and cancellations on passenger satisfaction and behavioral reactions. According to their research, travelers become more irate when they are notified of delays at short notice, especially on the day of departure. On the other hand, passenger satisfaction levels are greatly raised by early communication, better flight predictions, shorter wait times, and improved capacity management.

The study also found that coping strategies varied by age, with younger travelers showing a higher threshold for delays. Crucially, Cuntapay et al. (2025) demonstrated that service recovery tactics like payment, other travel plans, and open communication—are essential for reducing unfavorable behavioral responses and maintaining client loyalty.

Flight disruptions have also been empirically associated with meteorological factors, in addition to behavioral and operational factors. The African Journal of Geographical Sciences released a study by Akintunde, Fada, Adamu, Goyol, Bombom, and Nyango (2024) that looked into weather-related flight interruptions at Yakubu Gowon Airport in Jos, Plateau State, Nigeria.

Reduced visibility due to harmattan haze, fog, and heavy rains considerably increased the chance of flight delays, according to their findings, which showed a moderately positive connection ($R = 0.530$) between the two. The analysis also revealed that, while other operational factors also played a role in the interruptions, visibility conditions accounted for about 28% of the variation in flight delays.

Because it shows how weather-related interruptions interact with airport operational restrictions and passenger management systems, the study by Akintunde et al. (2024) is very pertinent to the Nigerian aviation environment. Unfavorable weather conditions increase the spread of delays throughout the network, which is already a problem in high-traffic airports because behavioral inefficiencies lengthen turnaround times.

When taken as a whole, these empirical results show that aircraft delays are complex phenomena that result from the interplay of various factors, including passenger behavior, technological capability, operational management, congestion, weather variability, monitoring systems, and the efficiency of service recovery. The idea that technology-enabled tracking and monitoring systems can improve operational efficiency and service reliability across transportation sectors is further supported by the inclusion of Dike (2023). In a same vein, delays influence passenger impressions, emotional reactions, and future airline selection decisions in addition to operational measures (Cuntapay et al., 2025). Therefore, tackling Nigeria's delay issues calls for a comprehensive approach that prioritizes efficient communication and customer-centered service recovery mechanisms while also strengthening airport infrastructure, increasing automation and monitoring systems, improving passenger compliance, and integrating cutting-edge weather monitoring systems.

II. Method

In order to investigate how passenger behavior and weather-related factors affect aircraft arrival and departure delays in Nigeria, this study uses a quantitative research approach. To assess the correlation between passenger-related factors and flight delay incidents at a few Nigerian airports, a descriptive analytical technique was used, mostly depending on secondary data. Five major Nigerian airports—Murtala Muhammed International Airport (Lagos), Nnamdi Azikiwe International Airport (Abuja), Port Harcourt International Airport (Port Harcourt), Akanu Ibiam International Airport (Enugu), and Mallam Aminu Kano International Airport (Kano) are the subject of the study because of their high passenger volume and frequent delay patterns. Together, these airports represent a significant amount of both domestic and international flight traffic and are the nation's main aviation centers.

The dataset included flight operations from eight local and 29 international airlines that were in operation during the study period. Based on their operational frequency and contribution to the overall number of flight movements throughout the chosen airports, these carriers were chosen. Both domestic and foreign airlines were included to guarantee thorough coverage of the dynamics of delays in Nigeria's aviation industry. Airport delay reports, airline operational records, and official publications from aviation management and regulatory organizations—most notably the Nigerian Civil

Aviation Authority (NCAA)—were the sources of secondary data.

The dataset contained arrival and departure delay records, broken down by operational, meteorological, and passenger-related factors. Both descriptive and inferential statistical methods were applied to the data analysis process. Descriptive statistics, such as frequency distributions, percentages, mean, and standard deviation, were employed to analyze delay patterns and pinpoint the main causes. Regression analysis and Pearson correlation, two inferential statistical techniques, were used to ascertain the direction and strength of the association between passenger behavior factors and flight delay outcomes.

To guarantee analytical correctness, dependability, and reproducibility, all statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS), version 25.0. To improve clarity, make interpretation easier, and bolster empirical conclusions, the data were presented using trend charts, graphical displays, and structured tables.

III. Results and Analysis

Table 1: Total Delays Between 2018-2024

Year	Total Delays
2018	3,831
2019	3,780
2020	2,370
2021	3,010
2022	3,830
2023	4,000
2024	4,080

Source: Nigerian Civil Aviation Authority (NCAA), 2024

An analysis of all aircraft delays from 2018 to 2024 shows a pattern of operational inefficiencies in Nigeria's aviation industry that is both erratic and structurally consistent. Despite brief fluctuations brought on by outside disturbances and post-disruption recovery dynamics, Table 1 shows that delay incidences stayed significantly high during the reviewed period. A total of 3,831 delays were reported in 2018, indicating a high operating burden on both local and foreign routes. Delays decreased somewhat to 3,780 cases in 2019. Although the overall amount of delays remained high, suggesting that systemic inefficiencies were still common in airport operations and passenger processing systems, this slight decrease shows slight improvements in scheduling coordination and traffic management.

When overall delays fell to 2,370 cases in 2020, there was a noticeable decrease. The primary cause of this decrease is the dramatic decline in flight operations during the global aviation crisis. Reduced traffic volume and lower passenger demand are more likely to be the cause of the decrease in delay frequency during this time than increased operational efficiency. Therefore, rather than a structural improvement in airport performance, the reduced number of delays is a traffic-driven adjustment. Delay incidences started to increase once more starting in 2021 and reached 3,010 incidents. This comeback coincides with the slow resumption of passenger traffic and airplane operations. Pre-existing inefficiencies in ground handling, passenger management, and scheduling coordination returned as demand for air travel increased, putting additional strain on airport infrastructure to handle delays.

Total delays increased to 3,830 cases by 2022, almost reaching pre-pandemic levels. In 2023 and 2024, the growing trend persisted, with delays rising to 4,000 and 4,080 cases, respectively. Growth in flight operations has outpaced advances in operational capacity and efficiency, as evidenced by the 2024 number, which is the greatest delay count over the seven-year period.

Table 2: Delay Duration Estimates in 2024

Factor	Mean Delay Time (Minutes)	Std. Dev
Late Check-in	33	6.8
Boarding Process	29	6.1
Baggage Clearance	25	5.0
Security Clearance	23	4.5
Weather Delays	47	9.8
Technical Issues	39	8.4

Source: Authors Compilations, 2025

Table 2 presents the estimated mean delay durations and associated standard deviations for key passenger-related and operational/weather-related factors contributing to aircraft delays in Nigeria in 2024. The results provide important insights into both the intensity and variability of delay causes. Among passenger-related factors, late check-in recorded the highest mean delay time of 33 minutes (SD = 6.8). This suggests that delays arising from passengers arriving late for check-in or failing to complete pre-boarding formalities significantly disrupt departure sequencing and aircraft turnaround time. The moderate standard deviation indicates that while delay duration varies across cases, it remains relatively consistent around the mean, pointing to a structurally recurring inefficiency within passenger processing systems.

Boarding process delays followed with a mean duration of 29 minutes (SD = 6.1). This reflects inefficiencies such as uncoordinated boarding, missing passengers, excessive cabin luggage disputes, and late gate arrivals. The relatively moderate dispersion suggests that boarding-related delays are predictable and systematic rather than random events. Baggage clearance delays recorded a mean delay time of 25 minutes (SD = 5.0), while security clearance delays had a mean of 23 minutes (SD = 4.5). These two variables show comparatively lower variability, indicating that baggage screening and security processing delays are generally contained within defined operational ranges. However, their cumulative contribution remains significant because they occur frequently across flight operations.

In contrast, operational and weather-related factors demonstrate substantially longer delay durations. Weather delays exhibit the highest mean delay time at 47 minutes (SD = 9.8), indicating that meteorological disruptions such as heavy rainfall, thunderstorms, or harmattan haze generate prolonged operational interruptions. The higher standard deviation reflects greater unpredictability, as weather-related events vary in severity and duration. Similarly, technical issues show a mean delay duration of 39 minutes (SD = 8.4). These delays often arise from aircraft maintenance requirements, mechanical inspections, or unexpected system faults. The relatively high dispersion suggests variability depending on the complexity of the technical issue and availability of maintenance resources.

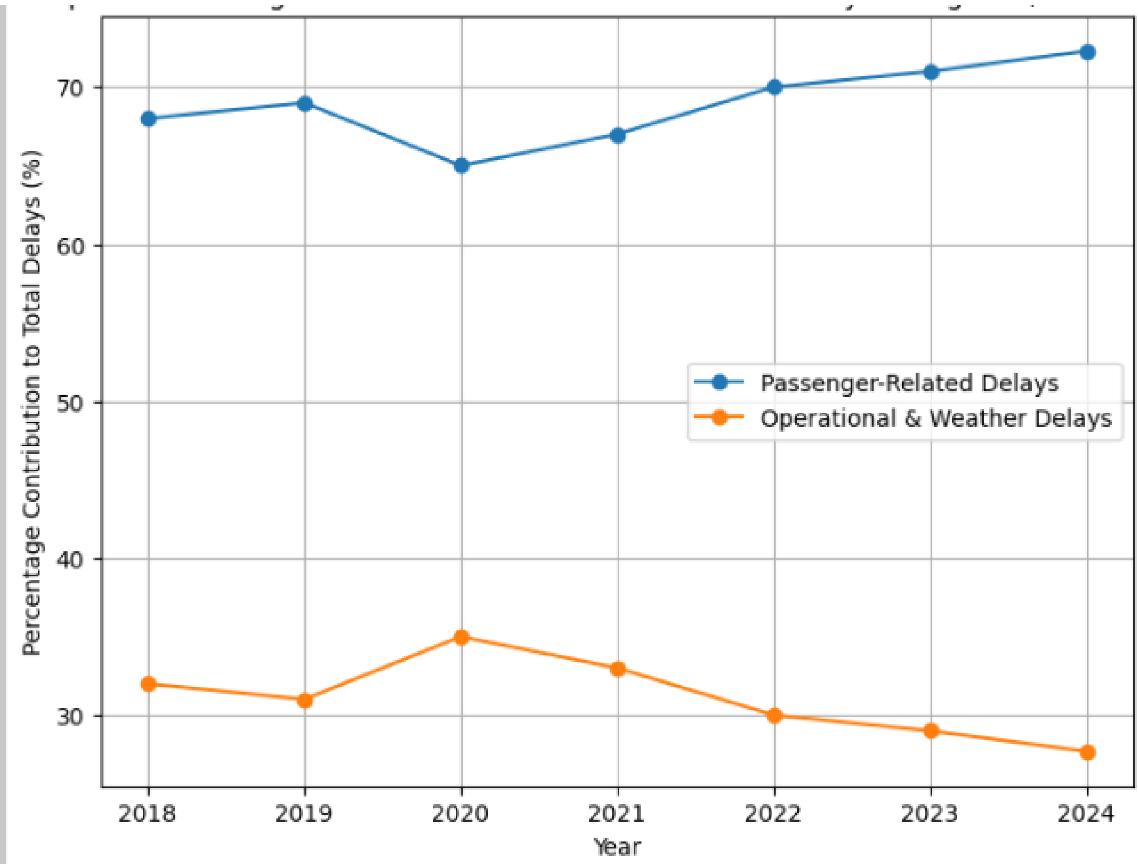

Figure 1: Trend of Passenger-Related vs Operational/Weather Delay Causes (2018–2024).
Source: Authors Compilations, 2025

Figure 1 illustrates the comparative percentage contribution of passenger-related delays and operational/weather-related delays to total aircraft disruptions in Nigeria between 2018 and 2024. The trend demonstrates a clear structural shift in delay causation over the seven-year period. From 2018 to 2019, passenger-related delays accounted for approximately 68–69% of total delays, while operational and weather-related factors contributed roughly 31–32%. This distribution indicates that behavioural and ground-processing inefficiencies were already the dominant contributors to delay occurrence prior to the 2020 operational downturn. In 2020, a noticeable deviation occurred. Passenger-related delays declined to approximately 65%, while operational and weather-related delays increased to 35%. This temporary shift reflects the disruption of normal aviation activity during the global contraction in air traffic. Reduced passenger volume likely minimized behavioural inefficiencies, while operational uncertainties and weather-related constraints assumed relatively greater proportional influence. Beginning in 2021, the trend reversed. Passenger-related delays resumed their upward trajectory, increasing from 67% in 2021 to 70% in 2022. By 2023 and 2024, passenger-related factors reached approximately 71% and 72.3%, respectively, representing the highest proportion recorded during the study period. Conversely, operational and weather-related delays steadily declined to 27.7% by 2024.

The widening gap between the two categories suggests that as flight operations recovered and traffic volumes expanded, behavioural inefficiencies increasingly dominated the delay ecosystem. This pattern implies that infrastructural capacity and technological improvements may have moderately reduced operational and weather-related disruptions, while passenger management systems did not experience proportional efficiency gains.

Figure 1 also demonstrates structural persistence in passenger-induced delays. Unlike weather events, which fluctuate seasonally and operationally, passenger behaviour represents a recurring, systemic variable embedded within airport ground processes. The upward trend indicates that increased passenger traffic intensifies congestion in check-in, boarding, and security screening procedures, thereby amplifying delay propagation.

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Table 3: Impact of Passenger Behaviour & Weather on Aircraft Delays in Nigeria

Delay Category	Specific Cause	Frequency (%)	Average Delay Time (mins)	Peak Period	Notes
Passenger-Related Delays	Late Check-in	25%	30	Morning & Evening	Passengers arriving late for check-in
	Security Clearance Issues	15%	25	All day	ID verification, baggage screening
	Excess Cabin Luggage	10%	15	Midday	Passengers carrying oversized bags
	Boarding Process Delay	20%	20	Morning & Night	Slow boarding, missing passengers
	Passenger Misconduct	5%	40	Evening	Unruly passengers causing disruptions
Weather-Related Delays	Heavy Rainstorms	8%	50	Rainy Season	Poor visibility and wet runways
	Harmattan Haze	10%	45	Dry Season	Flight rerouting due to low visibility
	Thunderstorms	5%	60	Rainy Season	Strong winds affecting takeoff
Operational Delays	Aircraft Technical Issues	10%	35	All day	Routine maintenance, unexpected repairs
	Air Traffic Congestion	12%	40	Peak Hours	High traffic at major airports

Table 3 provides a multidimensional assessment of aircraft delay determinants in Nigeria, categorizing causes into passenger-related, weather-related, and operational factors. The table not only quantifies frequency contributions but also incorporates average delay duration, peak occurrence periods, and contextual operational notes. This layered structure allows for both intensity-based and temporal interpretation of delay dynamics. Passenger-related factors collectively represent the largest share of delay frequency, accounting for 75% of the total delay occurrences when aggregated. Among these, late check-in emerges as the most dominant contributor, representing 25% of total delays with an average delay duration of 30 minutes. The concentration of these delays during morning and evening peak periods reflects commuter and business travel surges, which intensify congestion at check-in counters.

Boarding process delays account for 20% of total delays, with an average duration of 20 minutes. These delays are typically associated with slow passenger movement, missing travelers at boarding gates, and uncoordinated boarding procedures. Their prominence during morning and night flights suggests operational strain during high-traffic scheduling windows.

Security clearance issues contribute 15% of total delays, averaging 25 minutes in duration. The "all-day" occurrence pattern indicates that security bottlenecks are systemic rather than time-specific, often driven by documentation verification challenges and baggage screening procedures.

Excess cabin luggage accounts for 10% of delays, though with a comparatively shorter mean delay duration of 15 minutes. These delays frequently occur midday, likely reflecting increased leisure travel when passengers carry more hand luggage.

Although passenger misconduct contributes only 5% of delay frequency, it produces a disproportionately high average delay time of 40 minutes. This indicates that while less frequent, behavioral disruptions such as disputes or non-compliance have high operational impact, particularly during evening operations.

Weather-related factors contribute 23% of total delay frequency. However, these events generate the longest average delay durations. Thunderstorms, although contributing only 5% of delay cases, produce the highest mean delay duration of 60 minutes, indicating severe operational interruption.

Heavy rainstorms account for 8% of delay frequency with a mean delay of 50 minutes, typically during the rainy season when visibility and runway conditions deteriorate.

Harmattan haze contributes 10% of delays with an average duration of 45 minutes, primarily during the dry season when reduced visibility necessitates flight rerouting or delayed takeoff.

The data suggest that meteorological factors, while less frequent than passenger-related causes, create deeper operational disruptions due to safety constraints and regulatory flight limits.

Operational factors account for 22% of total delay frequency. Air traffic congestion contributes 12% of delays, with an average duration of 40 minutes. These delays are concentrated during peak operational hours, particularly at high-density hubs. Aircraft technical issues account for 10% of delay frequency with a mean duration of 35 minutes. These delays arise from routine maintenance, safety inspections, and unexpected mechanical issues. Although operationally necessary, they represent controllable variables through predictive maintenance and improved scheduling buffers.

IV. Discussion of Findings

The findings of this study reveal that aircraft delays in Nigeria are systemic, multidimensional, and increasingly influenced by passenger-related factors, with weather and operational variables exerting high-impact but comparatively less frequent disruptions. The results are consistent with prior empirical evidence that flight delays emerge from the interaction between behavioural, environmental, and operational determinants (Bratu & Barnhart, 2005; Zámková et al., 2022).

Table 1 shows that delay occurrences remained structurally high throughout the study period. Although there was a sharp decline in 2020, this reduction coincided with a contraction in flight operations rather than operational reform. Similar traffic-driven reductions in delays during downturn periods have been observed in global aviation systems (Bureau of Transportation Statistics [BTS], 2014a). As operations resumed in 2021, delay figures rebounded significantly, reaching 4,080 cases in 2024 the highest recorded value within the study period.

This pattern suggests that Nigeria's aviation system exhibits limited resilience to traffic growth. As passenger volumes increase, pre-existing inefficiencies in ground handling, passenger flow management, and scheduling coordination resurface. This finding aligns with studies emphasizing that congestion and demand surges amplify delay propagation when infrastructural and technological capacity does not expand proportionally (Efthymiou et al., 2018). Table 2 demonstrates that passenger-related delays are frequent but moderate in duration, while weather and technical delays are less frequent but significantly longer in duration. Late check-in recorded a mean delay time of 33 minutes, confirming that passenger arrival behaviour remains a dominant operational bottleneck. This finding supports earlier research indicating that uncoordinated passenger processing significantly disrupts departure sequencing (Chang & Yang, 2021).

Boarding process delays (mean = 29 minutes) further highlight procedural inefficiencies at the gate level. These findings correspond with European evidence showing that boarding inefficiencies account for a substantial share of total delay minutes during peak seasons (Zámková et al., 2022). In contrast, weather-related delays exhibited the highest mean delay duration (47 minutes), reinforcing the conclusion that meteorological disruptions generate severe operational consequences. This result is consistent with findings from Nigerian airports where reduced visibility significantly increases delay probability (Akintunde et al., 2024). Similarly, technical issues (mean = 39 minutes) demonstrate the impact of maintenance-related interruptions, echoing earlier findings that mechanical and infrastructural factors contribute substantially to extended delay events (Durdyev & Hosseini, 2018).

The variability in standard deviations for weather and technical delays further indicates unpredictability in these events, distinguishing them from passenger-induced delays, which appear more systematic and recurrent. Figure 1 reveals a clear structural shift in delay causation from 2018 to 2024. Passenger-related delays increased from approximately 68% to 72.3% of total delays, while operational and weather-related delays declined proportionally. This widening gap suggests that behavioural inefficiencies are becoming increasingly dominant in Nigeria's aviation delay ecosystem. This trend aligns with research emphasizing that passenger behaviour plays a central role in delay propagation, particularly in high-traffic environments (Bratu & Barnhart, 2005; Adepoju & Olaleye, 2021). As traffic volumes increase, congestion at check-in counters, security screening points, and boarding gates intensifies, amplifying systemic inefficiencies.

The temporary rise in operational/weather-related contributions in 2020 reflects traffic contraction effects rather than structural reform. As traffic recovered, behavioural inefficiencies regained prominence, reinforcing the conclusion that passenger management systems have not evolved proportionately with traffic growth. Table 3 provides deeper insight into delay dynamics by combining frequency, duration, and temporal occurrence patterns. Passenger-related delays account for approximately 75% of total delay frequency, with late check-in (25%) and boarding delays (20%) as the most significant contributors. These findings reinforce earlier Nigerian studies showing that passenger-induced inefficiencies significantly influence departure punctuality (Ojo & Yusuf, 2020).

Security clearance issues and excess cabin luggage further indicate that processing inefficiencies within terminal facilities contribute substantially to delay accumulation. Such systemic bottlenecks correspond with findings that airport service management and passenger handling procedures directly affect schedule reliability (Smith & Brown, 2019).

Although weather-related delays account for only 23% of frequency, their impact in terms of duration is severe. Thunderstorms, heavy rainstorms, and harmattan haze generate mean delays ranging from 45 to 60 minutes. These results corroborate evidence that meteorological conditions significantly influence flight operations in climatically vulnerable regions (Akintunde et al., 2024).

Operational delays, including air traffic congestion (12%) and technical issues (10%), demonstrate moderate frequency but substantial time impact. Congestion-related delays reflect capacity constraints at major hubs, a finding consistent with studies linking high passenger density to increased delay risk (Efthymiou et al., 2018). The dominance of passenger-related delays highlights the importance of monitoring and real-time coordination systems. Evidence from broader transport sectors shows that technology-driven tracking and monitoring systems improve service reliability and punctuality (Dike, 2023). The implication for aviation is that enhanced passenger-flow analytics, automated boarding systems, and digital communication platforms could significantly reduce behavioural delay accumulation.

Furthermore, passenger dissatisfaction during delays has been shown to influence loyalty and brand perception (Cuntapay et al., 2025). Thus, delay management is not merely an operational issue but also a strategic customer relationship concern. Prolonged delays caused by behavioural inefficiencies may erode passenger trust, particularly when communication is inadequate.

V. Conclusion

This study concludes that aircraft delays in Nigeria are structurally persistent and increasingly driven by passenger-related inefficiencies, particularly late check-in, boarding process delays, and security bottlenecks, while weather and technical factors, though less frequent, generate longer and more severe disruptions; the post-2020 recovery trend further demonstrates that growth in passenger traffic has outpaced improvements in operational coordination and terminal processing capacity, thereby amplifying behavioural delay propagation within high-density hubs. Accordingly, the study recommends the adoption of integrated delay mitigation strategies that prioritize passenger flow optimization through automation (online check-in, biometric boarding, self-service kiosks), structured boarding systems, enhanced real-time monitoring and predictive maintenance technologies, improved weather forecasting and air traffic coordination systems, and proactive communication frameworks that provide early delay notifications and structured service recovery mechanisms; collectively, these measures will enhance operational resilience, reduce cumulative ground time, improve schedule reliability, and strengthen passenger satisfaction and airline competitiveness within Nigeria's aviation sector.

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