HOW TO REDUCE DELAYS ON PASSENGER AIRCRAFT: A STUDY OVER NON-WEATHER-RELATED ISSUES

By

Justice Isaac Amankwah

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Aviation Safety and Security Management

Middle Tennessee State University

August 2016

Thesis Committee:

Thesis Director – Dr. Wendy S. Beckman

Thesis Chairman – Dr. Paul A. Craig

ACKNOWLEDGEMENTS

I would like to reveal a deep sense of appreciation to the Almighty God and the following men and women who have had the greatest prestige on my education growth. In a consecutive order from their embryonic impact: my father, Kwame Amankwah; my mother, Akuah Asantewaa; my wife, Olivia A. Amankwah; Dr. Paul A. Craig; Mr. Gerald L. Hill; Dr. Andrea Georgiou; Mr. John R. Black; Mr. Chad L. Gehrke; Dr. Thomas J. Cheatham; Mrs. Mimi Thomas; Dr. Marva S. Lucas; Mrs. Gina E. Johnson; and Savanna Teague. My journey through the Middle Tennessee State University for the past five years has been a wonderful experience because of you. Without your support and tenderness, this thesis would not be feasible.

The thesis: How to reduce delays on passenger aircraft has been deeply leveraged by Dr. Paul A. Craig, Dr. Wendy Beckman and Dr. Andrea Georgiou. Thank you.

An exceptional words of gratitude to my pastor, Dr. David Jones for his spiritual endearment and compassion towards me and my family.

In memory of Nana Kofi Asibou I, my father in Law

1934-2015

ABSTRACT

Delays are contentious and a chronic issue that affects millions of air-travel passengers in the world. Delays have effects that can follow passengers from one airport to another on a multiple leg journey. Weather delays are different from airline arrival delays. It is obvious that weather delays are uncontrollable and unpredictable. Severe thunderstorms can force airline schedulers to cancel flights that may cause arrival delays for flight passengers. A collection of six years of flight delay data from Bureau of Transportation Statistics was used for three airlines, namely American Airlines, Delta Airlines, and Southwest Airlines, at four different airports (Hartsfield – Jackson Atlanta International Airport, O'Hare International Airport, Midway International Airport, and Nashville International Airport). The purpose of this study was to determine whether there is any correlation between "Hub-and-Spoke" and "Point-to-Point" systems that can be associated with arrival delays on travel passengers from the above airlines with regards to their associated hub airports.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF TABLES (Continued)

CHAPTER I: INTRODUCTION

Delays are contentious and a chronic issue that affects millions of air-travel passengers in the world. Delays have effects that can follow passengers from one airport to another on a multiple leg journey. Additionally, delays can be very disruptive to ground personnel such as ramp tower operators and air traffic controllers, whose timetables are made based on stringent performance. Some airline managers argue that the skills and characteristics necessary to mitigate flight arrival delays are beyond airlines' capabilities, and, therefore, the airlines should not compensate passengers for these delays. Other airline managers believe that the airlines have the tenacity and the power to reduce the frequency of arrival delays, and, therefore, the airlines should do something to improve the flight arrival delay problem (Sim, Koh, & Shetty, 2006). Delays that happen in the early part of the airline operations can have ripple effects on air-travel passengers, especially connecting flight passengers. Obviously, there are uncontrollable causes of delays, such as weather that disturb flying apart from the airline arrival delays.

Weather delays are different from airline arrival delays. It is obvious that weather delays are uncontrollable and unpredictable. Severe thunderstorms can force airline schedulers to cancel flights that may cause arrival delays for flight passengers. Bad weather, including storms and tornadoes, can also force airlines to reschedule their crew members and possibly use reserve crews in such emergencies. Severe hail can also force pilots to change the destination of an aircraft and make an emergency landing that will, in turn, impose arrival delays on air travel passengers. An aircraft does not make money unless it is in motion. According to the research study done by the University of California, Berkeley, domestic airlines delays cost a lot of money. Domestic flight arrival and departure delays cost $32.9 billion per year on air carriers. It is intriguing that half of such cost is endured by airline passengers, according to the study led by the UC Berkeley researchers. The calculation was based on passengers' lost time due to flight delays, cancellations, and missed connections (Guy, 2010).

With the available public data from the Bureau of Transportation Statistics (BTS), it is possible to assess flight delay data to establish the frequency and severity of arrival delays on air-travel passengers. A collection of six years of flight delay data from BTS will be used for three airlines, namely American Airlines, Delta Airlines, and Southwest Airlines, at four different airports (Hartsfield – Jackson Atlanta International Airport, O'Hare International Airport, Midway International Airport, and Nashville International Airport). The purpose of this study is to determine whether there is any correlation between "Hub-and-Spoke" and "Point-to-Point" systems that can be associated with arrival delays on travel passengers from the above airlines with their associated hub airports.

Literature Review

According to the United States' Airline Passenger Bill of Rights, if a passenger is delayed two to four hours from his or her original scheduled arrival time, the passenger is entitled to 200% of the one-way fare, up to $650 (Stockton, 2013). According to Stockton, if a passenger arrived more than four later than the scheduled arrival time, then the passenger is entitled to 400% of the one-way fare, up to $1300, from the airline. The passengers do get compensation (200%) under the two to four hours rule.

The European Union (EU) also requires flight compensation for flight passengers that governs all the European Community (EC), including England. For example, under the EC Regulation No 261/2004 should this happen; This information explains how to claim compensation or a refund or reimbursement under this law in respect of a flight operated by British Airways PLC or a British Airways franchisee operating BA flights in or into Europe, (British Airways, 2004). This indicates that anyone, who has been delayed by any of the European airlines has the right to file a claim for compensation. But, it is rather unfortunate that most of the people from developing countries have not been educated regarding their ability to claim these refunds from any European Airline.

In contrast to developing countries, most of the people in more developed countries, including United States and Canada, have the ability to read and write. Thus citizens of these countries can claim their refunds from any airline in the world which has wrongfully delayed them. According to the U.S. Department of Transportation, any passenger, who travels on an international itinerary, may be eligible to recover reimbursement under Article 19 of the Montreal Convention for expenses resulting from a delayed or canceled flight. It is passenger's right to file a claim with the airline. "If the claim is denied, you may pursue the matter in small claims court if you believe that the carrier did not take all measures that could reasonably be required to avoid the damages caused by the delay," (Department of Transportation, 2015 p.2). As has been indicated, the passenger does have the right to sue any air carrier, if he/she has been delayed for more than five hours without any reasonable cause or issue.

The arrival delays from the air carriers that can cause cancellations for air-travel passengers on their next leg can be controlled at various levels of air carrier operation. The circumstances that fall under the power of the air carriers are maintenance issues, fueling, crew problems, aircraft cleaning, and baggage loading. Again, some of the air carriers seem reluctant to solve issues whose resolutions may have long term benefits for the company. In fact, minimizing arrival delays on passengers will benefit the air carriers for their long term goals. “Intuitively, large delays which occur in the early part of the operating day are the most disruptive, while short delays have little or no propagation through the schedule,” (Beatty, Hsu, Berry & Rome, 1999, p. 265).

According to Beatty etal, large delays are the most disruptive. There are many reasons large delay may occur in an airline operation. It may start as a simple occurrence like a small light in the cockpit which indicates that the baggage door is open. The baggage door may in fact be closed, but the light is still activated in the cockpit. The affected light issue will not disrupt the performance of the airplane, so the pilot can utilize a Minimum Equipment List (MEL) to defer this light issue until the next leg. “The go/no-go decision is one of the most fundamental decisions that a pilot will make, and an integral part of that decision is determining the airworthiness of the aircraft,” (Wright, 2009, p.1). The aircraft may be grounded if the light problem become worse. For instance, a light that cannot be turned off may disturb pilots during a night flight. The technicians may take a few hours to fix it and that may cause arrival delays on the next leg for connecting passengers.

Weather delays can be experienced by the airlines at any time. Flight delays that involve heavy snow in the winter seasons are beyond anyone's control. For example, on January 22nd and 23rd, 2016, United States airlines cancelled more than 9,000 flights across the entire U.S. due to the monster snowstorm that killed eleven people in the nation (Associated Press, 2016, p.1). The unpredictability of weather can also be emphasized in the following incident. "On 7 August 2015, Delta Flight 1889 (an Airbus A320) made an emergency landing at Denver International Airport at 8:42 p.m. after the aircraft had encountered a severe hail storm in Nebraska near the Colorado border," (Mitchell, 2015, p. 1). According to the *Denver Post*, the hail storm damaged the front windshield of the airplane severely. The storm winds separated the nose cone from the fuselage of the airplane as well. This Delta flight was en route from Boston to Salt Lake City when unpredicted weather forced the pilot of the aircraft to divert from its route from Salt Lake City to Denver. The diversion of the aircraft caused arrival delays for Salt Lake City passengers. Most of the passengers were scared from the storm and decided not to fly from Denver to Salt Lake City, especially parents with children. Instead, they drove from Denver to Salt Lake City (Mitchell, 2015).

Another cause of air carrier delays are airline crew delays. "But beyond weather, mechanicals, catering issues, etc., the phrase, "crew illegalities" can strike fear into the most hardened frequent fliers," (Hough, 2012, p. 2). The "crew illegalities" can in part be effected by the crew-members' arrival time at the airport. This time starts counting as soon as pilots and cabin crew-members arrive at the airline gates. In other words, the crews' time starts ticking as soon as they arrive at the airport, whether the aircraft is ready or not. If the crew members are scheduled to fly eight hours and spend forty-five minutes at the airport waiting for the aircraft, their duty time could be over while they are en-route. "Federal Aviation Administration regulations for domestic flights generally limit pilots to eight hours of flight time during a 24-hour period. This limit may be extended provided the pilot receives additional rest at the end of the flight," (Duquette, 2010, p.1). As a result, the flight may be cancelled for the crew members, and this cancellation may cause delays for traveling passengers. When this happens crew scheduling will arrange for another crew member to come in and fly the delayed aircraft.

Duty time can be defined as full duration of hours that pilots are on duty. It starts from the time they arrived to work to the moment they finished from all duties. Duty times are calculated to reflect the elapsed time. According to the Civil Aviation Safety Authority of Australia, the duty time is made up of flight duty period and any subsequent duty time before the off-duty period. Flight time refers to the time elapsed from the take-off moment from one airport until it comes to rest after landing at another airport. According to the Civil Aviation Safety Authority of Australia, flight duty period is part of duty period that includes both flight time, pre-and post-flight duties, and positioning or other duties at the beginning of the duty period, (Australian Civil Aviation, 2015). For example, it takes six hours to fly between Ghana and England, meaning six hours of flight time. Flight time extensions can be granted as "an increase in circumstances that are beyond the control of the program manager or flight crewmember (such as adverse weather) that are not known at the time of departure, that can prevent the flight crew from reaching the destination within the planned flight time," (Rising Up Aviation, 2011, p. 2).

Flight delays based on aircraft maintenance issues can be associated with unavailable parts. The aircraft whole seller, manufacturer, or distributer may not have all the required parts needed for the aircraft at that particular time. This is because different aircraft require different parts and popular demand for a particular part can impact its availability. "Aircraft maintenance activities form an essential part of airworthiness. The common objective of aircraft maintenance is to provide a fully serviceable aircraft when it is required by the operator at minimum cost," (Knotts, 1999, p. 337). Another avenue that presents delays for air-travel passengers is the unavailable parts in the airports maintenance warehouse. The maintenance warehouse of the airlines are often off site from the airport property. This means that the maintenance technicians have to travel back and forth for the needed parts of the airplane. In some cases, airports may have a limited space for the airlines maintenance facility. In view of this, popular parts are kept at the airports as compared to unpopular parts that are kept off site. If an unpopular part breaks on the aircraft, then the maintenance personnel have to remove the part, go to off-site place and bring the exact part for the work. "An airline manager may want to ensure that spare parts and maintenance skills are available in the small airports where delays might cause a bottleneck in down-stream operations," (Sachon, & Pate'-Cornell, 2000, p. 309). If the parts are not available at the warehouse, then the aircraft will have to wait for the seller to ship the parts. The fulfillment of an airplane part order may take a week or two. Maintenance managers often have these delays to face. According to Endsley and Robertson, "the most common problem in maintenance was an unavailability of parts and difficulty in determining when the proper parts would be available to the aircraft maintenance technician," (2000, p.305). In addition, sometimes the seller of the parts might send incorrect parts for the specific model and type of the aircraft.

The airline maintenance operations check-list, especially the Minimum Equipment List (MEL), can constitute a potential delay for flight passengers. MEL simply means an aircraft instrument or equipment is inoperative, but that it may not stop the operation of the aircraft. An aircraft is a complex machine that constitutes hundreds of components. It is inevitable that some of the aircraft components or instruments are going to stop working at some point in time, and need to be replaced. In some cases a pilot can continue to operate the aircraft with inoperative components for some appropriate length of time. MEL issues can pose a threat to flight delays, as pilots must spend time going through the list to determine if the aircraft can fly with the problem. These days many airlines use cockpit iPads as a replacement for manual MEL. In a news release from June 24, 2013, "American Airlines was the first major carrier to equip all its cockpits with these electronic flight bags (iPads), replacing more than 35 pounds of paper-based reference material MEL," (Business News, 2015, p.1).

Implementing an iPad, which is much lighter than bulky pounds of MEL papers, has helped pilots notify maintenance of mechanical issue more quickly. It has been estimated that the use of iPads in the cockpit as compared to bulky pounds of MEL papers has saved American Airlines 400,000 gallons of gas, or $1.2 million worth of fuel, (Hughes, 2013). In addition to the cost savings and a minimized environmental paper impact, the iPad implementation has helped to prevent back injuries for American

Airlines pilots who used to carry the heavy bags full of paper flight manuals (Hughes, 2013). Mechanical issues that would potentially disrupt flight schedules can be resolved due to iPad instant messaging. “Flight delays often occur because a problem detected in the previous flight needs to be fixed before the next take-off. Some of these problems are minor, others can affect flight safety and proper maintenance becomes critical,” (Sachon, & Pate’Cornell, 2000, p. 305). According to Sachon and Pate’Cornell, most of the flight problems that are detected by the en-route pilot need to be fixed before the next take off.

Prior to the iPad age, the pilots used to write notes regarding any problem that occurred in en-route with the aircraft, and leave it in the cockpit. As soon as the plane landed, maintenance personnel would go to the cockpit for such information in order to fix the problem. In some cases, the written communication channel between the pilots and the maintenance personnel turned to create some friction. In some cases, the maintenance personnel could not read the pilot’s hand writing. The iPad instant messaging has strengthened the smooth communication between pilots and maintenance personnel that has thereby increased the safety of the airline operations.

Another avenue that presents delays for air-travel passengers is the difficulty of finding the proper parts for aircraft repairs. This is a particular problem as the air carriers may own different aircraft that were purchased from different aircraft manufacturers, each with subtle differences among them. Small stores that supply aviation parts often do not have the correct parts due to these slight differences between the aircraft. “Related to this problem is the lack of critical parts. Critical parts are frequently not available when needed, leading to having an aircraft down for an extended period or necessitating expensive and time consuming rush procurements through the aircraft-on-ground organization," (Endsley, & Robertson, 2000, p. 310). As a result, the inventory technician in the maintenance workshop will spend more time remotely in every manufacturer's warehouse looking for ways to get the needed parts for the airplane as quickly as possible. In order to reduce flight delays because of unavailable parts, the inventory or procurement officer should make sure that the needed parts for the aircraft are available at all times to reduce delays on travel passengers.

According to the United States Department of Transportation, a flight is considered delayed if it arrived at (or departed) the gate fifteen minutes or more after the scheduled arrival or departure time (United States Department of Transportation, 2015). Most ramp tower operators struggle to push back an airplane from the gate within that fifteen minute grace period. One reason is because the seats of many aircraft are not large enough to handle particularly large passengers in the provided time. "Traveling with these big people, it is impossible for them to fit in the assigned seat. In most cases, the person in the front seat could not recline his or her seat at all," (Airline Obesity Policies, 2012, p.1). According to the policy, it is the customer's responsibility to communicate with the airlines at the time of booking about their seating needs in order for them to be well. More so, if a seat with the armrest down and with an extension seatbelt cannot fit a larger person, the airlines will charge the person for two seats or remove the person from the airplane. Often, seat arrangements have to be made to accommodate a large passenger while other passengers are looking for their seats numbers. In this case, more time is being spent on passenger seating, and the ramp tower operators cannot push back the aircraft on time.

Turnaround time has been a challenge for most airlines. It is the time allowed for airlines to do the following: de-plane the passengers, off-load the suitcases, restock the needed items, clean the inside of the fuselage, and reload the new passengers with their luggage. Most of the airlines find it difficult to meet their established turnaround times. "Delays in turnaround time can cause the potential loss of money to both airlines and passengers. These delays must be tackled at all critical paths like de-boarding, cleaning, fueling, and loading baggage" (Fricke, & Schultz, 2009, p. 1). The baggage reclaim at the airport is one of the major sources of delays that frustrate connecting flight passengers.

The passengers who use "Hub-and-Spoke" systems may miss their connecting flight because of few ground personnel unloading the baggage from the airplane. For example, passengers flying within one airline from London to United States have to claim their baggage at major airport, and re-check in their bags after customs, before reaching their destinations. Sometimes, the passengers wait too long for their suitcases to show up on the conveyer belt and other times their suitcases may not show up at all. "United Airlines troubles with lost luggage, delayed flights and chaotic baggage-claim area, with bags tossed everywhere, have gone on for weeks and are extending beyond the airline to color travelers' perceptions of the Denver Airport as a whole" (Keeney, 2015, p. 1). According to Keeney, several connecting flight passengers have decided to avoid United Airlines' through Denver Airport. This may affect the Denver Airport reputation. The problem may start with the airline personnel on the ground who handle the loading and unloading of the baggage for the airline. In some cases, passengers' bags did not get put on the outgoing flight on time, which may cause delays for connecting flight passengers. The problem can be caused from understaffing from the airline for baggage handlers with respect to the number of aircraft that have arrived at the airport. A shortage of ground personnel for any airline can result in a massive delay for flight connecting passengers.

Another path that creates delays for flight passengers is the janitorial personnel responsible for cleaning the airplane cabin during the turnaround time. The cleaners may take a while to finish cleaning the airplane cabin due to the size of the aircraft. Bigger aircraft like Boeing 747 will require more cleaners and proper cleaning materials to finish the work within the assigned turnaround time. Obviously, fewer cleaners and improper cleaning materials may results to unwilling workers as airplane cabin employees. "Striking airplane-cabin cleaners for a Delta Air Lines Inc. contractor at New York's LaGuardia Airport agreed to return to work after state officials said they would investigate complaints about working conditions" (Snyder, Sasso, 2014, p.3). Sometimes, cabin cleaners face health issues whiles doing their job. It was obvious that some passengers may travel with health issues without telling anyone in the cabin of the airplane. Recently, Thomas Eric Duncan, a passenger who flew from Liberia in Africa to Texas in the United States, carried a dangerous virus called Ebola in his blood. This man used the bathroom of the airplane during the transit, and his biological fluid contaminated the inside of the bathroom sink. The Ebola virus is very deadly to the human race, and is very contagious. In view of this, the cabin cleaners have the right to demand a better working environment for their own safety.

This strike from janitorial personnel caused more delays for connecting passengers because their airplane was not ready on time. Delta Airlines tried to address the problem by giving janitors the proper working equipment for cabin cleaning. In fact, "the profitability of the airline industry is not from the sale of aircraft, but from maintaining the aircraft for an anticipated thirty-plus year lifespan" (Lee, Thimm, & Verstraeten, 2008, p. 298). In other words, taking care of the airplane, both inside and outside, can ensure and guarantee the life expectancy of the airplane. The right chemical should be used in order to maintain the long life of the airplane when cleaning. Nevertheless, time is essential for flight operations and cabin cleaners' activities should not be interfere with ongoing travel of flight connected passengers.

A significant amount of money is being lost that can be associated with these domestic arrival delays, for both passengers and the airlines. "The $8.3 billion direct cost to airlines included increased expenses for crew, fuel and maintenance, among others. Nearly half of this cost is due to padded schedules, the hidden delays that are built into schedules because the airlines anticipated them," (Guy, 2010, p.1). In fact, airline delays not only cost both air passengers and airlines money, but their time, which cannot be replaced. Passengers who missed their connecting flights due to arrival delays are more likely to lose money on their business transactions. More so, passengers may miss out on very important occasions with respect to business due to arrival delays from the airlines.

Statement of the Problem

This study reviews the data of service based on hub-and-spoke systems versus point-to-point systems, with respect to delays for air travel passengers. Three carriers are utilized: two carries that uses hub-and-spoke systems, and one that uses the point-to-point systems. The purpose of the data collected was to review the impact of Delta, American, and Southwest Airlines' arrival delays on air travel passengers. Every airline chooses their hubs for several reasons. American Airlines chose O'Hare International Airport (ORD) as a hub in Chicago, despite the heavy snow in the winter seasons. Southwest Airlines has chosen Midway International Airport in Chicago area as a hub of operations. Chicago has lower taxes as compared to a city like New York. The house rentals are cheaper in Chicago, and the streets are always cleaned. "Chicago's airports, including O'Hare International Airport are easily accessible from the city, with 25 minutes straight shots from downtown for Midway and 45 minutes for O'Hare. With its convenient central location, passengers are a two hour flight from Colorado and New York, and only four hours from California," (Kittle, 2013, p. 1).

Southwest Airlines also uses Nashville International Airport (BNA) as one of their major hubs. Southwest Airlines is the largest air carrier in the Nashville International Airport, with about 86 daily departures that include nonstop services to Pittsburgh, PA, New York LaGuardia, NY, Newark, New Jersey, and Pensacola, FL (Nashville News & Media, 2015). According to the News & Media, the Nashville International Airport serves 390 daily flights from ten different airlines. In 2015, the airport set a new passenger record by serving more than 11.6 million passengers in the city of Nashville, using the "Point-to-Point" system proffered by Southwest Airlines. There is no personal income tax in the city of Nashville and the houses are affordable to many residents. Southwest Airlines chose Nashville International Airport because the airline wants to be part of the airport that serves as a major drive to the development of Nashville economy.

Delta Airlines chose Hartsfield – Jackson Atlanta International Airport as their main hub because of their global routes. Hartsfield – Jackson is the busiest airport in the world, and can accommodate more than 94 million passengers on both international services and domestic services. “Delta Airlines and its subsidiaries maintain a 70 percent share market at Hartsfield – Jackson Atlanta International Airport,” (Smith, 2006, p.1). Being the largest air carrier in the Atlanta Airport, Delta Airlines seeks to provide world-class customer service to its passengers in the fast-paced environment at Hartsfield – Jackson Atlanta International Airport.

As mention before, this study seeks to evaluate the relationship between “Point-to-Point” and “Hub-and-Spoke” systems of operation in the airline industry. Several reason for delays have been mentioned as passengers try to connect to their flights using the hub-and-spoke system. Also, an airline that makes use of direct flights for passengers with respect to point-to-point systems were briefly discussed. Through a series of data collected from the Bureau of Transportation Statistics (BTS), the major player in point-to-point systems in the airline industry (Southwest) and their methods of operation will be identified as compared to major players in hub-and-spoke systems (American and Delta). The primary questions to be address by this study are as follows:

Research Questions

1) What is the historical pattern of arrival delays for the six year period, as indicated by BTS, of American, Delta and Southwest Airlines’ into the Chicago area (O’Hare, Midway), Atlanta, and Nashville International Airports?
2) Based on the data analyzed in research question number one, does there appear to be any differences in arrival delays between airlines using the hub-and-spoke scheduling design as compared to an airline that uses a point-to-point design?

3) Are there any seasonal periods in the year that are more susceptible to flight arrival delays for Delta, American, and Southwest Airlines, with regards to Atlanta, O'Hare, Midway, and Nashville International Airports?

Potential Research Hypothesis

Based on the research questions, the hypothesis for question one can be described as the historical pattern of delays for the three mentioned airlines. The Null Hypothesis (*Ho*) is defined as, the historical pattern of the three airlines has no significant impact on flight arrival delays. Therefore, the Alternative Hypothesis (*Ha*) is formulated as: there are significant effects on flight arrival delays based on a historical pattern, associated with Delta, American, and Southwest Airlines. The second questions' hypothesis can be formulated as: there are differences in arrival delays among airlines that use hub-and-spoke schedule design as compared to airlines that use a point-to-point design. The Null Hypothesis (*Ho*) is formulated as: there are no significant arrival delays among airlines that use hub-and-spoke design schedules and airlines that use point-to-point designs. Therefore, the Alternative Hypothesis (*Ha*) is that there are significant arrival delays among airlines that use hub-and-spoke system design as compared to airlines that use point-to-point system design. Lastly, for the third question, are there any seasonal periods that are susceptible to higher arrival delays due to weather with regards to Delta, American, and Southwest Airlines flying to Atlanta, O'Hare, Midway, and Nashville International Airports. The Null Hypothesis (*Ho*) is: none of the seasons in a year are vulnerable to flight arrival delays. Therefore, the Alternative Hypothesis (*Ha*) is that some seasons within the year are more likely to experience arrival delays as compared to other seasons due to the snow or weather conditions in some states with respect to Atlanta, O'Hare, Midway, and Nashville International Airports.

The airlines are meeting their customers' demands and at the same time, making profit in the industry. In order for an airline to maintain on time performances, hub-and-spoke system and many other steps must be taken. The development with adaption of the point-to-point system should be a bigger piece of the equation.

CHAPTER II: METHODOLOGY

In order to determine if a relationship exists between airlines that use the "Hub-and-Spoke" system or a "Point-to-Point" system with regards to passenger delays, a comparative statistical method was pursued. This approach was perfect since numerical data was collected to answer all the three research questions. The data that was collected from the Bureau of Transportation Statistics (BTS) for this research also represents the airlines' public domain. The BTS is part of the United States Department of Transportation. Part of BTS's job is to compile data analysis and to make it accessible to the public. The database from the BTS website demonstrates air carrier arrival delays in the United States, including weather delays with respect to airports. The collected data was focused on flight arrival delays for Delta Airlines at Hartsfield – Jackson Atlanta International Airport, American Airlines at O'Hare International Airport, and Southwest Airlines at both Nashville and Midway International Airports. The BTS data information came from http://www.transtats.bts.gov/homedrillchart.asp.

The six years of airline data that was retrieved from BTS started from 2009 through 2014 for Delta, American, and Southwest Airlines. The collected data was used to compare the performance of these three airlines with respect to flight arrival delays. Six years of data evaluation for Delta Airlines and Southwest Airlines was utilized to determine which airline has the minimum arrival delays on passengers who flew from Nashville International Airport to Hartsfield – Jackson Atlanta International Airport or from the Atlanta airport to the Nashville airport. Another six years of data was collected for Delta Airlines and American Airlines to determine the arrival delays for passengers who flew from Hartsfield – Jackson Atlanta International Airport to O'Hare International Airport or from the O'Hare Airport to the Atlanta airport. In addition, six years of data evaluation was done for American Airlines and Southwest Airlines to establish the arrival delays for passengers who flew from Nashville International Airport to the Chicago area or from the Chicago area to the Nashville airport. It is important to know that Southwest Airlines flew to Midway International Airport in Chicago, whereas Delta Airlines and American Airlines operated at O'Hare International Airport.

Again, the collected data was used to establish correlations among the three airlines' delay patterns at the same airports. In other words, Delta, American, and Southwest Airlines all flew to Nashville, Atlanta, and Chicago using either the hub-and-spoke systems or a point-to-point system.

Participants

The collected data for these airlines with respect to hub-and-spoke system and point-to-point system started from January 2009 to December 2014 with regards to their prospective airports: Hartsfield – Jackson Atlanta International Airport for Delta, O'Hare International Airport for American, Nashville, and Midway International Airports for Southwest. American Airlines and Delta Airlines have been using hub-and-spoke systems since the deregulation of the airline industry (Bonsor, 2001). In the aviation field, a hub can be described as a primary airport for an airline where most of their flights are being dispatched, and a spoke is the path in which an airplane is being pulled out from the primary airport. An example for a hub-and-spoke system can be illustrated using Delta Airlines as follows: the main hub for Delta Airlines is at Hartfield-Jackson Atlanta

International Airport, where most of their airplanes are dispatched. The passengers flying from Charleston, SC, to Nashville, TN with Delta Airlines have to go through their main hub at the Atlanta airport in order to fill the airplane's empty seats before reaching to their destination or to connect the passengers with another aircraft from Hartsfield – Jackson Atlanta International Airport to Nashville International Airport. "The purpose of the hub-and-spoke system is to save airlines money and give passengers better routes to their destinations. Airplanes are airline's most valuable commodity, and every flight has certain set costs. Each seat on the airplane represents a portion of the total flight cost" (Bonsor, 2001, p. 1).

Southwest Airlines has been using the point-to-point system since the deregulation of the airline industry. The point-to-point system features the short haul, convenient flight time and low cost that generates more profit for the airline. "Southwest Airlines is one of the exceptions to the hub-and-spoke network system. Southwest uses the old-fashioned point-to-point system, hauling people in short distances with few connecting flights," (Bonsor, 2001, p. 1). An example for the point-to-point system can be illustrated as follows: Southwest Airlines offers nonstop flights from Nashville International Airport to LaGuardia Airport, New York. These direct (nonstop) flights help to reduce flight arrival delays for air travel passengers. In other words, there are no connected flights for passengers who use point-to-point system to their final destination. Hence, the arrival delays on passengers using point-to-point system is limited.

Instruments

The study utilized the data collection from the Bureau of Transportation Statistics (website previously mentioned), the researcher did not develop an instrument that was unique to this study. The tools used for this research included: graph pad scientific software and Microsoft Excel software to analyze the raw data. Microsoft Excel was used for the basic data arrangement and the analysis through a descriptive statistical function of the software. Using graph pad software, a two-tailed test (t-test) was used in the study to analyze the relationship of the three mentioned airlines by comparing the mean in each year. In this case, the t-test was performed first between Delta Airlines that uses the hub-and-spoke system and Southwest Airlines that use a point-to-point system. Then, another t-test was used to evaluate American Airlines that uses the hub-and-spoke system as compared to Southwest Airlines that uses a point-to-point system.

In order to determine any statistical value, the arrival delays data of the airlines in each year was copied and placed into a graph pad scientific table to generate the P-value, the Mean, and the Standard Deviation with respect to the number of sample size data. In this case, the sample size for all the data variables was twelve. The graph pad scientific software was also used to compare passengers' arrival delays data among Delta, American and Southwest Airlines. Six years of data from Delta Airlines and American Airlines were compared for arrival delays at the Atlanta airport and O'Hare Airport. More so, six years of data from Southwest Airlines and Delta Airlines were compared for arrival delays at the Nashville airport and the Atlanta airport. Lastly, six years of data from American Airlines and Southwest Airlines were compared for arrival delays at O'Hare airport and Nashville airport.

Procedure

The first step was to open Microsoft Excel and download the raw data from the Bureau of Transportation Statistics website into an Excel spreadsheet. Once the data download was complete, some analyses were performed to answer the research questions. The table below demonstrates the raw data from the Bureau of Transportation Statistics without the summer and winter total at the bottom.

Table 1. *Raw Data from the Bureau of Transportation Statistics*

Bureau of Transportation & Statistics - TranStat

Month	Ontime Arrivals	Ontime (%)	Arrival Delays	Delayed (%)	Flights Cancelled	Cancelled (%)	Diverted	Flight Operations
January	3,889	73.24%	1,092	20.56%	316	5.95%	13	5,310
February	3,847	81.04%	737	15.53%	159	3.35%	4	4,747
March	4,168	78.60%	993	18.73%	128	2.41%	14	5,303
April	3,872	76.86%	1,032	20.48%	106	2.10%	28	5,038
May	4,244	82.07%	823	15.92%	83	1.61%	21	5,171
June	3,638	71.57%	1,258	24.75%	141	2.77%	46	5,083
July	4,184	80.09%	960	18.38%	73	1.40%	7	5,224
August	3,975	76.43%	1,142	21.96%	72	1.38%	12	5,201
September	4,362	90.50%	422	8.76%	23	0.48%	13	4,820
October	3,867	77.36%	1,095	21.90%	32	0.64%	5	4,999
November	4,328	91.95%	353	7.50%	20	0.42%	6	4,707
December	3,427	69.71%	1,340	27.26%	145	2.95%	4	4,916
Total	47,801	78.99%	11,247	18.58%	1298	2.14%	173	60,519
summer	24,275	79.49%	5,637	18.46%	498	1.63%	127	30,537
winter	23,526	78.47%	5,610	18.71%	800	2.67%	46	29,982
TOTAL	47,801	78.99%	11,247	18.58%	1,298	2.14%	173	60,519

Microsoft Excel software was used to arrange the raw data from the BTS website into workable data on a spreadsheet. The data was then arranged in a manner that allowed each airline to be compared with the others. The data contained flight information for the three airlines (Delta, American, and Southwest) and included the months of the year, on-time arrival, on-time percentage, arrival delays, delays percentage, flights cancelled, cancelled percentage, diverted, and flight operations. Again, the study only focused on Delta, American, and Southwest Airlines' arrival delays with respect to the number of flight operations for six consecutive years. The on-time arrival numbers were used to help in calculating the flight arrival delays with respect to flight operation numbers. The Microsoft Excel software was also used to generate six year of bar-charts and pie-charts for the three mentioned airlines. The delays percentage of flights in a month was calculated using the bar-chart. In this case, the highest delays of the season were reviewed in each year for each airline at the four different airports (Hartsfield – Jackson Atlanta International Airport, O'Hare International Airport, Midway International Airport, and Nashville International Airport). Below is the example of the 2009 delayed bar-chart.

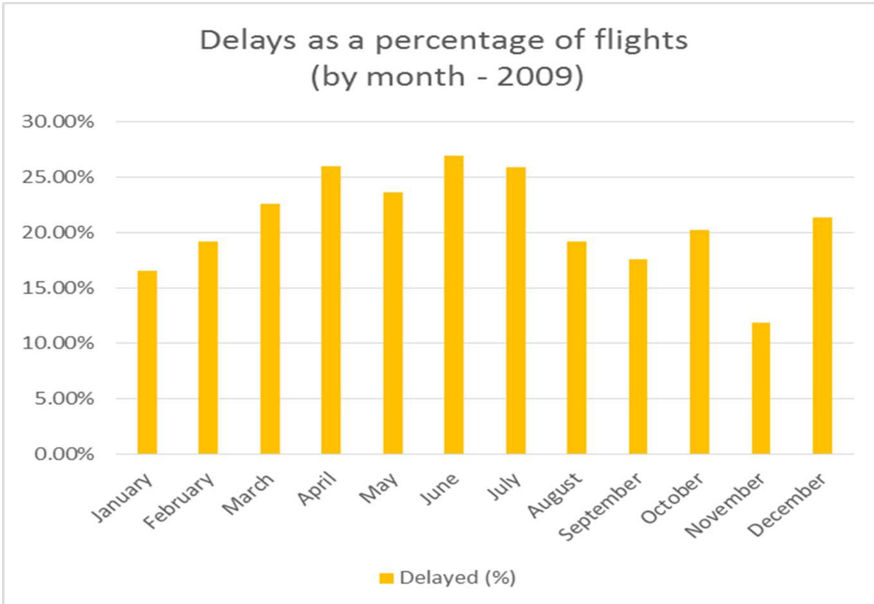


Figure 1. *2009 Delay Percentages for Delta Airlines.*

More so, the total number of delays over the aggregate number of flight operations was calculated to determine historical patterns among the three airlines with respect to delays.

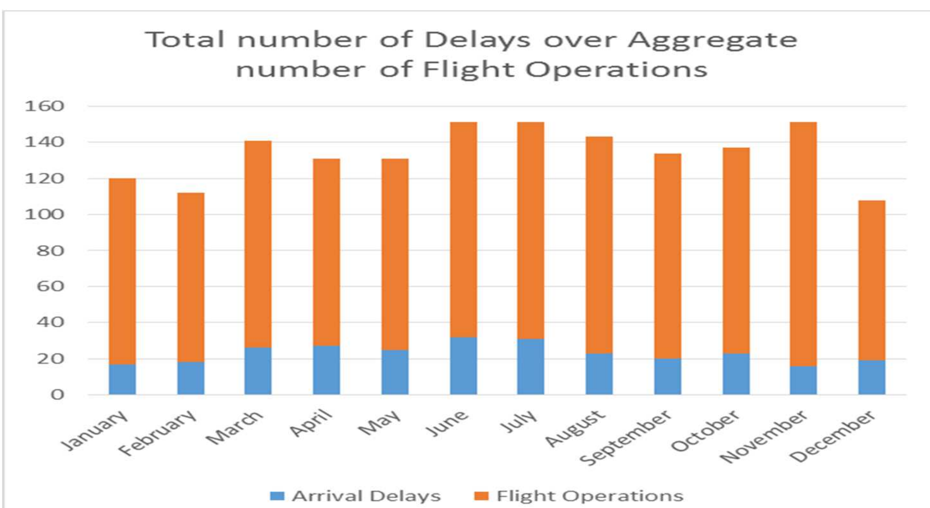
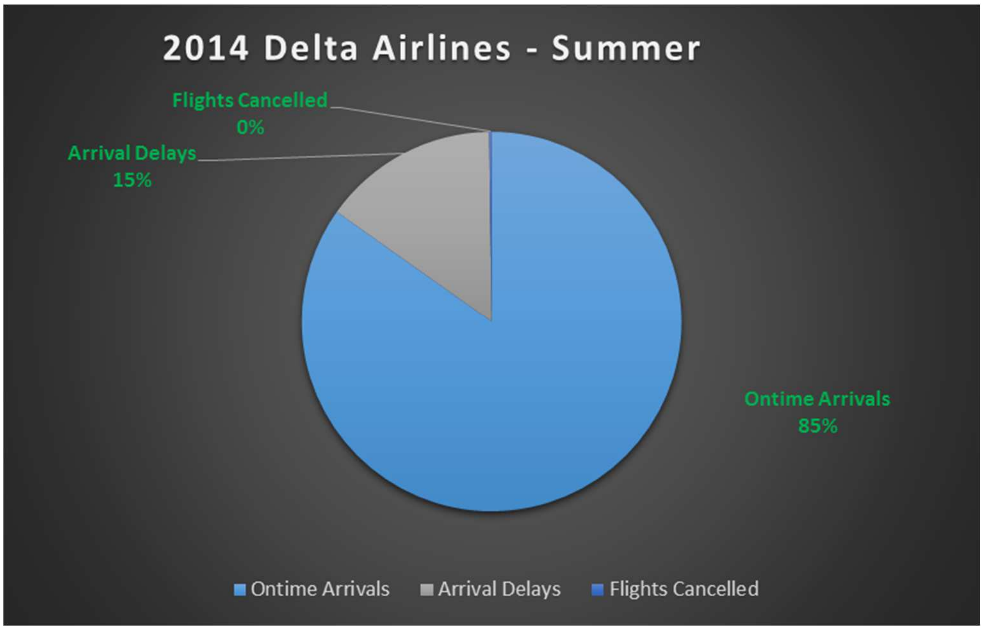


Figure 2. *2009 Delays over Aggregate Number of Flight Operations for Delta Airlines.*

The pie-charts were created to demonstrate the percentage of each airline during the summer seasons and the winter seasons on the Microsoft spreadsheet.



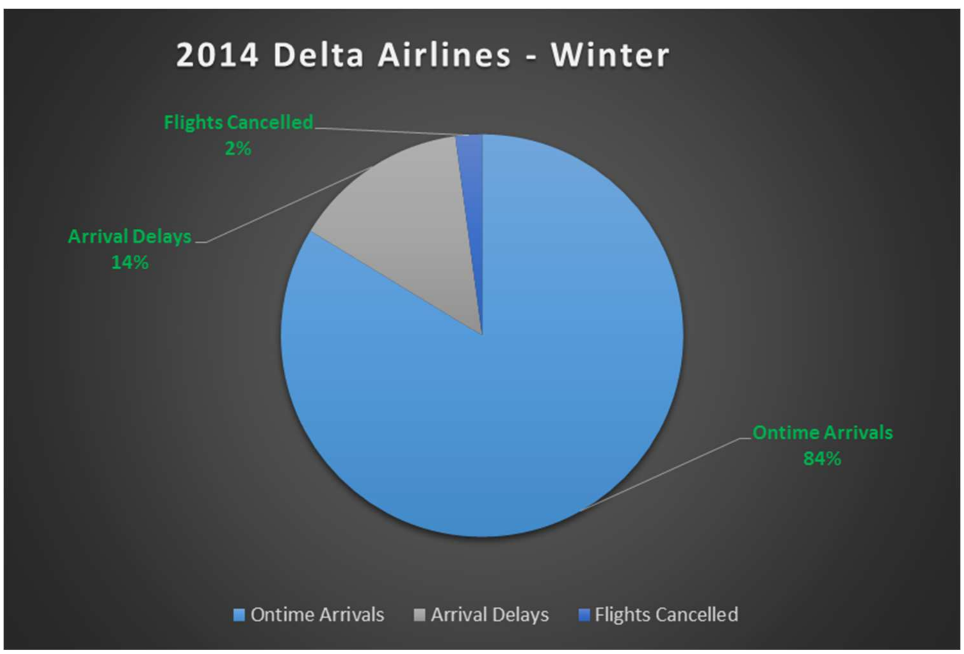


Figure 3. *2014 Delta Airlines Summer and Winter Seasons in Percentage*

The figures above show the calculated Delta Airlines summer and winter seasons in 2014 with respect to percentages of arrival delays, on-time arrivals, and flights cancelled.

The graph pad scientific calculator software was used to perform the comparisons among the three airlines flying to the same airport and to determine if the connections existed. Again, the graph pad scientific software was used to determine if a statistical correlation existed between two absolute numbers (variables) of the airlines with respect to arrival delays. The graph pad calculator was useful when comparing two groups of data. The graph pad calculator takes two data variables at the same time to produce their mean, the p-value, the t-test value, standard deviation and more, whereas Microsoft Excel takes only one data set at a time to generate the mean, p-value, and more. The graph pad software was more helpful when calculating the t-test values using the means of the two data variables at the same time. For example, in 2011, the mean value for Delta Airlines' data variable was 2576.42 whereas the mean value for American Airlines was 898.00. Using the graph pad calculator, a t-test value of 8.3349 was produced between the two means of Delta and American Airlines. Microsoft Excel can generate one t-test value with regards to one data variable, and it cannot produced t-test values with respect to two data variables at the same time. Therefore, the graph pad calculator was more useful for statistical values as compared to Microsoft Excel.

In addition, the data was utilized to demonstrate the significant differences between the summer seasons (April through September) and the winter seasons (October through March) in the form of operations for each airline in order to determine the cause of flight arrival delays at each airport. It is obvious that more delays may occur during the winter seasons as compared to the summer seasons due to the heavy snow. According to the data, some of the bar charts on the Microsoft spreadsheet show that Delta, American, and Southwest Airlines experienced more flight arrival delays during the summer seasons as compared to the winter seasons when flying to the same airport. The bar-charts for each year for Delta, American, and Southwest Airlines were compared for arrival delays at the same airport. More so, the bar-charts also indicated that each airline experienced more flight summer delays when flying to their separate hub airports as compared to the winter seasons. In other words, Delta Airlines experienced more summer delays when flying from the Nashville airport to the Atlanta airport or from O'Hare Airport to the Atlanta airport. American Airlines experienced summer season delays when flying from the Nashville airport to O'Hare Airport or from the Atlanta airport to O'Hare Airport. Southwest Airlines experienced less arrival delays in both summer and winter seasons according to the bar-charts at the Nashville airport when flying from the Atlanta airport or Midway Airport. The comparative statistical method used in this research yielded interesting outcomes that are going to be discussed in subsequent chapters.

CHAPTER III: DATA ANALYSIS

The collected data was utilized to determine if there were significant differences between the summer seasons and the winter seasons based on the flight arrival delays for Delta, American, and Southwest Airlines at the Atlanta, Nashville, Midway, and O'Hare International Airports. The collected data was also used to determine the difference in passenger arrival delays with respect to point-to-point systems of operations and hub-and-spoke systems. A comparative statistical data analysis was utilized for the three mentioned airlines using the data average approach. The average by season was calculated to determine which month is subject to the highest delays for the three airlines at the Atlanta's Hartsfield-Jackson, Nashville, Midway, and O'Hare International Airports. The summer season was defined as April through September, while the winter season was defined as October through March.

The arrival delay data for Delta Airlines from 2009-2014, as seen in Table 2 below, indicates that the airline experienced summer season delays especially in May and June at O'Hare International Airport. The average by month section of the data indicates that the highest passenger arrival delays happened in June with 28.98%, which is in the summer season. The average summer season for Delta Airlines flights into O'Hare was 23.79%, whiles the average winter season was 19.21%. The resulting average percentage range between the summer and winter seasons for Delta flights into O'Hare airport was 4.58%.

Table 2. *Delay Percentage by Month for Delta Airlines at O'Hare Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	19.82%	18.96%	26.02%	16.38%	13.76%	31.60%	21.09%
February	14.51%	23.98%	22.10%	11.93%	20.79%	25.06%	19.73%
March	28.64%	17.05%	22.37%	20.21%	15.40%	20.35%	20.67%
April	21.94%	25.53%	30.47%	11.89%	24.41%	21.68%	22.65%
May	23.56%	41.77%	25.58%	21.98%	23.21%	24.70%	26.80%
June	28.13%	44.10%	24.96%	14.73%	30.29%	31.65%	28.98%
July	21.09%	38.79%	23.18%	27.21%	22.99%	14.59%	24.64%
August	21.28%	26.54%	22.65%	16.47%	19.19%	31.09%	22.87%
September	15.45%	20.47%	14.92%	13.05%	11.38%	25.59%	16.81%
October	24.56%	15.90%	8.44%	21.20%	11.84%	32.63%	19.10%
November	5.05%	20.48%	21.68%	9.43%	14.92%	15.97%	14.59%
December	23.08%	35.16%	14.80%	13.04%	26.06%	8.26%	20.07%

Table 3 shows the data for the six years of arrival delays for Delta Airlines flights into Nashville International Airport. The data indicates that the airline experienced summer season delays especially in June and July at the Nashville International Airport. The average by month section of the data also indicates that the highest passenger arrival delays happened in July with 24.03%, which is in the summer season. The average summer season delays for Delta Airlines flights into the Nashville airport was 17.94%, while the average winter season delays were 14.94%. The average delay percentage range between the summer and winter seasons for Delta flights into the Nashville airport was 3%.

Table 3. *Delay Percentage by Month for Delta Airlines at Nashville Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	16.50%	14.38%	17.17%	12.50%	9.09%	27.48%	16.19%
February	19.15%	20.00%	20.53%	9.91%	10.86%	13.29%	15.62%
March	22.61%	16.45%	23.93%	12.84%	8.39%	13.48%	16.28%
April	25.96%	10.96%	17.52%	9.34%	11.26%	11.73%	14.46%
May	23.58%	20.81%	12.81%	15.21%	10.86%	16.26%	16.59%
June	26.89%	29.26%	23.10%	13.06%	23.26%	19.81%	22.56%
July	25.83%	28.86%	21.45%	25.74%	29.69%	12.61%	24.03%
August	19.17%	19.88%	16.51%	14.38%	15.02%	17.53%	17.08%
September	17.54%	14.99%	9.70%	10.10%	7.62%	17.37%	12.89%
October	20.18%	17.85%	6.85%	10.57%	5.82%	14.99%	12.71%
November	11.85%	17.33%	10.03%	7.89%	12.50%	13.45%	12.18%
December	21.35%	27.37%	12.88%	11.60%	16.77%	10.05%	16.67%

The six years of delay data that was collected for Delta Airlines at Hartsfield-Jackson International Airport, as seen in Table 4, indicates that the airline experienced summer season delays especially in June and July. The average by month section of the data also indicates that the highest passenger arrival delays happened in July with

21.62%, which is in the summer season. The average summer season delays for Delta Airlines flights into Atlanta airport were 17.91%, while the average winter season delays were 15.55% respectively. The average percentage range between summer and winter seasons for Delta flights into the Atlanta airport was 2.36%.

Table 4. *Delay Percentage by Month for Delta Airlines at Atlanta Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	22.27%	15.15%	16.39%	14.25%	12.24%	23.57%	17.31%
February	16.68%	18.75%	17.27%	10.41%	12.92%	15.52%	15.26%
March	26.22%	19.79%	20.62%	14.75%	13.22%	15.55%	18.36%
April	23.53%	12.59%	18.36%	9.15%	13.46%	14.98%	15.35%
May	26.82%	22.72%	15.24%	13.21%	13.39%	14.48%	17.64%
June	19.76%	26.38%	21.35%	13.32%	24.22%	17.79%	20.47%
July	23.02%	26.33%	20.69%	19.76%	28.25%	11.67%	21.62%
August	22.97%	22.66%	15.52%	16.13%	17.07%	13.84%	18.03%
September	21.01%	14.89%	12.57%	10.59%	10.12%	16.98%	14.36%
October	22.99%	14.53%	10.74%	13.94%	7.91%	12.82%	13.82%
November	15.09%	16.70%	10.69%	8.46%	12.56%	10.32%	12.30%
December	24.05%	20.39%	12.65%	12.97%	19.18%	8.38%	16.27%

Six years of combined delays were next collected for American Airlines. The arrival delay data for American Airlines into O’Hare International Airport from 2009-2014, as seen in Table 5, indicates that the airline experienced more delays summer season, especially in May and June. The average by month section of the data indicates that the highest passenger arrival delays happened in June with 25.45%, which is in the summer season. The average summer season delays for American Airlines flights into O'Hare Airport were 21.77%, while the average winter season delays were 18.48%. The resulting average percentage range between summer and winter seasons delays for American flights into the O'Hare Airport was 3.29%. It is interesting to note that the heavy snow in the Chicago area from November through February of each year did not disturb American Airlines with regards to passengers' arrival delays in the winter seasons.

Table 5. *Delay Percentage by Month for American Airlines at O'Hare Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	20.56%	14.25%	16.67%	11.23%	17.60%	25.26%	17.60%
February	15.53%	21.21%	23.74%	10.59%	22.83%	18.48%	18.73%
March	18.73%	22.12%	17.09%	18.09%	16.18%	17.86%	18.35%
April	20.48%	19.14%	28.83%	12.20%	27.36%	18.97%	21.16%
May	15.92%	27.37%	24.98%	16.73%	22.06%	25.24%	22.05%
June	24.75%	29.52%	20.43%	14.99%	28.46%	34.53%	25.45%
July	18.38%	21.25%	23.56%	20.01%	20.53%	23.74%	21.25%
August	21.96%	18.92%	18.81%	20.46%	16.53%	34.50%	21.86%
September	8.76%	14.14%	17.23%	36.84%	12.25%	23.94%	18.86%
October	21.90%	12.66%	13.49%	29.50%	15.62%	36.80%	21.66%
November	7.50%	14.35%	21.05%	15.59%	15.89%	16.71%	15.18%
December	27.26%	18.99%	12.67%	17.15%	22.39%	17.87%	19.39%

Table 6 below shows the data for the six years of arrival delays for American Airlines flights into Nashville International Airport. The data indicates that the airline experienced summer season delays especially in June and July. The average by month section of the data also indicates that the highest passenger arrival delays happened in June with 24.20%, which is in the summer season. The average summer season delays for American Airlines flights into Nashville airport were 21.52%, while the average winter season delays were 18.14%. The resulting average percentage range between summer and winter seasons delays for American flights into the Nashville airport was 3.38%.

Table 6. *Delay Percentage by Month for American Airlines at Nashville Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	20.77%	13.89%	17.50%	17.70%	15.29%	20.37%	17.59%
February	13.60%	21.10%	22.77%	15.71%	12.16%	17.81%	17.19%
March	17.70%	25.00%	18.13%	23.33%	9.15%	8.05%	16.89%
April	22.19%	14.04%	26.65%	15.46%	24.22%	13.14%	19.28%
May	22.28%	22.38%	22.22%	22.48%	25.08%	20.85%	22.55%
June	28.13%	22.70%	17.30%	17.53%	27.55%	32.01%	24.20%
July	23.60%	22.00%	18.32%	26.71%	23.12%	26.87%	23.44%
August	21.03%	18.94%	20.90%	20.65%	16.87%	26.35%	20.79%
September	12.32%	15.94%	16.28%	41.14%	11.94%	15.57%	18.87%
October	19.34%	14.57%	12.27%	29.08%	14.15%	22.48%	18.65%
November	15.45%	15.79%	13.79%	21.90%	14.33%	24.77%	17.67%
December	18.49%	17.13%	17.52%	19.50%	23.13%	29.22%	20.83%

Six years of combined delays were next collected for American Airlines flights into Atlanta. The arrival delay data for American Airlines from 2009-2014 as seen in Table 7 below indicates that the airline experienced more delays in summer season, especially in June and July, at the Atlanta Hartsfield-Jackson International Airport. The average by month section of the data indicates that the highest passenger arrival delays happened in June with 28.15%. The average summer season delays for American Airlines flights into the Atlanta airport were 24.62%, while the average of the winter season delays were 18.78%. The percentage range of the average delays between the summer and winter seasons for American flights into the Atlanta airport was 5.84%.

Table 7. *Delay Percentage by Month for American Airlines at Atlanta Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	24.15%	14.31%	14.06%	14.14%	23.23%	16.71%	17.77%
February	15.66%	19.54%	16.92%	12.59%	13.38%	18.28%	16.06%
March	27.06%	23.23%	17.22%	18.97%	12.81%	18.25%	19.59%
April	27.15%	18.93%	26.41%	15.10%	22.53%	18.59%	21.45%
May	29.50%	25.24%	22.08%	23.96%	23.40%	21.23%	24.24%
June	29.26%	25.73%	25.73%	20.40%	34.09%	33.66%	28.15%
July	31.20%	24.22%	23.21%	28.28%	32.37%	28.06%	27.89%
August	24.74%	24.18%	23.46%	24.94%	16.06%	27.95%	23.56%
September	15.93%	15.20%	16.94%	39.18%	19.19%	28.13%	22.43%
October	27.63%	13.44%	15.16%	29.72%	13.18%	23.97%	20.52%
November	18.01%	13.70%	13.78%	18.62%	14.97%	23.14%	17.04%
December	30.46%	13.93%	16.52%	18.41%	21.48%	29.41%	21.70%

Next, six years of delayed data was gathered for Southwest Airlines flights into Chicago Midway International Airport, as seen in Table 8 below. The arrival delay data for Southwest Airlines from 2009-2014 indicates that the airline experienced summer delays at the Midway International Airport. The average summer season delays for Southwest Airlines flights into Midway Airport were 18.25%, and the average delays for the winter season were 17.39%. The percentage range between the average delays for the summer and winter seasons for Southwest flights into Midway Airport was 0.86%. Although the average by month section of the data indicates that the highest passenger arrival delays happened in December with 23.76%, which is part of the winter season, the airline also experienced some summer flight delays into Midway International Airport.

Table 8. *Delay Percentage by Month for Southwest Airlines at Midway Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	16.16%	19.15%	23.27%	10.31%	15.78%	28.24%	18.82%
February	9.44%	13.96%	17.83%	8.42%	13.69%	23.25%	14.43%
March	12.89%	16.99%	15.51%	13.72%	18.54%	22.24%	16.65%
April	12.26%	12.96%	21.36%	10.75%	19.56%	22.28%	16.53%
May	13.20%	16.91%	21.33%	14.77%	20.67%	25.59%	18.75%
June	17.48%	23.69%	18.25%	18.24%	27.55%	26.81%	22.00%
July	15.38%	19.99%	13.77%	21.93%	22.62%	21.58%	19.21%
August	17.03%	15.38%	15.26%	17.06%	24.56%	22.76%	18.68%
September	10.49%	11.55%	15.48%	9.67%	19.34%	19.48%	14.34%
October	16.53%	19.46%	10.52%	14.33%	19.22%	24.45%	17.42%
November	7.47%	15.52%	8.71%	12.90%	20.71%	14.17%	13.25%
December	27.03%	26.52%	10.03%	19.98%	41.51%	17.51%	23.76%

Six years of combined delays were next collected for Southwest Airlines flights into Nashville International Airport, as seen in Table 9 below. The average delays in the summer season for Southwest Airlines flights into Nashville Airport was 17.60%, and the average for the winter season was 17.30%. The percentage range between the average delays in the summer and winter seasons for Southwest flights into Nashville Airport was 0.30%, indicating that the airline was subject to both winter and summer seasonal delays. The average by month section of the data indicates that the highest passenger arrival delays happened in December with 23.83%. The small difference in average delayed percentage between summer and the winter seasons indicates that Southwest Airlines has similar summer and winter delays at the Nashville International Airport.

Table 9. *Delay Percentage by Month for Southwest Airlines at Nashville Airport 2009-2014*

	2009	2010	2011	2012	2013	2014	**AVERAGE**
January	14.79%	17.92%	23.86%	9.07%	12.96%	34.47%	18.85%
February	7.01%	16.76%	18.94%	8.39%	13.27%	23.78%	14.69%
March	14.17%	16.44%	15.61%	12.84%	18.86%	22.99%	16.82%
April	15.46%	12.79%	20.99%	10.07%	17.22%	23.41%	16.66%
May	15.14%	18.47%	17.20%	14.67%	18.78%	26.43%	18.45%
June	18.40%	21.07%	17.08%	15.33%	22.47%	27.64%	20.33%
July	17.52%	19.30%	14.94%	19.99%	19.16%	25.30%	19.37%
August	16.20%	16.28%	15.56%	16.35%	21.70%	18.86%	17.49%
September	12.00%	10.52%	14.76%	9.65%	18.43%	14.32%	13.28%
October	17.91%	19.50%	11.89%	12.83%	17.34%	17.60%	16.18%
November	7.21%	16.93%	9.57%	12.30%	18.80%	15.92%	13.46%
December	22.82%	26.60%	11.19%	21.40%	39.80%	21.18%	23.83%

Next, three years of delay data was gathered for Southwest Airlines flights into Atlanta's Hartsfield-Jackson International Airport, as seen in Table 10 below. It is interesting to note that Southwest Airlines did not start a point-to-point system of operations into Hartsfield-Jackson International Airport until February 2012, according to the data. The average percentage of delays for the summer season for Southwest Airlines flights into Atlanta airport was 22.6%, and the average for the winter season was 20.6%. The resulting average percentage range between summer and winter seasons for Southwest flights into Atlanta airport was 2.0%. The average by month section of the data indicates that the highest passenger arrival delays happened in December with 28.5%.

Table 10. *Delay Percentage by Month for Southwest Airlines at Atlanta Airport 2012-2014*

	2012	2013	2014	**AVERAGE**
January		16.63%	31.18%	23.9%
February	9.77%	15.13%	19.73%	14.9%
March	17.23%	18.87%	23.94%	20.0%
April	16.73%	22.80%	23.05%	20.9%
May	22.15%	21.22%	22.49%	22.0%
June	20.39%	29.79%	25.88%	25.4%
July	27.98%	31.00%	25.34%	28.1%
August	22.81%	22.24%	20.63%	21.9%
September	11.13%	19.76%	20.59%	17.2%
October	14.69%	21.90%	17.75%	18.1%
November	15.30%	22.99%	16.90%	18.4%
December	23.21%	36.86%	25.39%	28.5%

Comparison of Airlines Flights into Airports

The resulting average percentage delays for Delta, American, and Southwest Airlines were utilized to compare to each other at the Atlanta, Nashville, and Chicago airports which were Midway and O'Hare International Airports. Microsoft Excel and Graph-pad software were utilized to review the calculated mean (average) delay percentage for each of the three airlines. These averages came as a sum of twelve months of arrival delays divided by the total number of flights dispatched by the airlines in a year. To determine which airline (Delta, American and Southwest Airlines) had statistically significant flight arrival delays on passengers, a graph pad scientific calculator was used to compare the airlines average percentages as seen above. The graph pad analysis was used to determine a t-test value difference between Delta and American Airlines, which use hub-and-spoke systems' as compared to Southwest Airlines, which uses a point-to-point system. A t-test was also utilized to determine if there was a statistical difference in delays between Delta Airlines and Southwest Airlines, or Southwest and American Airlines, with regards to Atlanta, O'Hare, Nashville, and Midway International Airports.

When a t-test value is large, it indicates that the mean (average) of the data are statistically different from each other and the null hypothesis is rejected. The larger the t-test value, the stronger the rejection of the null hypothesis. The subsequent pages show the t-test values comparing Delta, American, and Southwest Airlines examined in this study. In each case, the null hypothesis is that there is no difference between the airlines in terms of delays.

Table 11 below shows the results of the t-test comparing Delta Airlines and American Airlines average percentage delays at Atlanta's Hartsfield-Jackson International Airport. The results, with $p = 0.0015$, indicated there was statistically significant difference between the two airlines, with Delta having significantly more delays than American in Atlanta airport.

Table 11. *Delta Airlines Verses American Airlines Average Results in Atlanta Airport*

Airline	**Delta**	**American**
Mean	16.73%	21.70%
SD	2.7203	3.8758
SEM	0.7853	1.1188
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.0015, t = 3.6341, df = 22

By conventional criteria, this difference is considered to be very statistically significant.

Table 12 below shows the results of the t-test comparing Delta Airlines and Southwest Airlines average percentage delays at Atlanta's Hartsfield-Jackson International Airport. The results with p = 0.0030, indicated there was statistically significant difference between the two airlines with Delta having significantly more delays than Southwest in Atlanta.

Table 12. *Delta Airlines Verses Southwest Airlines Average Results in Atlanta Airport*

Airline	Delta	Southwest
Mean	16.73%	21.60%
SD	2.7203	4.2601
SEM	0.7853	1.2298
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.0030, t =3.3417, df = 22

By conventional criteria, this difference is considered to be very statistically significant.

Table 13 below shows the results of the t-test comparing American Airlines and Southwest Airlines average percentage delays at Atlanta's Hartsfield-Jackson International Airport. The results with p = 0.9565, indicated there was not a statistically significant difference between the two airlines.

Table 13. *American Airlines Verses Southwest Airlines Average Results in Atlanta Airport*

Airline	American	Southwest
Mean	21.70%	21.60%
SD	3.8758	4.2601
SEM	1.1188	1.2298
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.9565, t = 0.0551, df = 22

By conventional criteria, this difference is considered to not be statistically significant.

Next, an analysis of Southwest, Delta and American Airlines flights into the Nashville Airport was performed. Table 14 below shows the results of the t-test comparing Southwest Airlines and American Airlines average percentage delays at Nashville International Airport. The results with $p = 0.0470$, indicated there was statistically significant difference between the two airlines, with American having significantly more delays than Southwest in Nashville.

Table 14. *Southwest Airlines Verses American Airlines Average Results in Nashville Airport*

Airline	Southwest	American
Mean	17.45%	19.82%
SD	3.0031	2.5111
SEM	0.8669	0.7249
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.0470, t = 2.1046, df = 22

By conventional criteria, this difference is considered to be statistically significant.

Table 15 below shows the results of the t-test comparing Southwest Airlines and Delta Airlines average percentage delays at Nashville International Airport. The results with p = 0.4644, indicated there was not statistically significant difference between the two airlines.

Table 15. *Southwest Airlines Verses Delta Airlines Average Results in Nashville Airport*

Airline	Delta	Southwest
Mean	16.43%	17.45%
SD	3.6293	3.0031
SEM	1.0477	0.8669
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.4644, t = 0.7446, df = 22

By conventional criteria, this difference is considered to not be statistically significant.

Table 16 below shows the results of the t-test comparing American Airlines and Delta Airlines average percentage delays at Nashville International Airport. The results with p = 0.3167, indicated there was not statistically significant difference between the two airlines.

Table 16. *American Airlines Verses Delta Airlines Average Results in Nashville Airport*

Airline	Delta	American
Mean	16.43%	16.50%
SD	3.6293	54.3139
SEM	1.0477	15.5829
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.3167, t = 1.0246, df = 22

By conventional criteria, this difference is considered to not be statistically significant.

Finally, a comparison of Southwest, Delta and American Airlines flights into the Chicago area airports (Midway and O'Hare International Airports) was performed. Table 17 below shows the results of the t-test comparing Southwest Airlines (Midway) and Delta Airlines (O'Hare) average percentage delays into the Chicago area. The results with p = 0.0203, indicated there was a statistically significant difference between the two airlines, with Delta having significantly more delays than Southwest in Chicago area.

Table 17. *Southwest Airlines Verses Delta Airlines Average Results in Chicago Area*

Airline	Delta	Southwest
Mean	21.44%	17.82%
SD	3.9483	3.0892
SEM	1.1398	0.8918
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.0203, t = 2.5014, df = 22

By conventional criteria, this difference is considered to be statistically significant.

Table 18 below shows the results of the t-test comparing Southwest Airlines (Midway) and American Airlines (O'Hare) average percentage delays into the Chicago area. The results with p = 0.0626, indicated there was not a statistically significant difference between the two airlines.

Table 18. *Southwest Airlines Verses American Airlines Average Results in Chicago Area*

Airline	American	Southwest
Mean	20.12%	17.82%
SD	2.6600	3.0892
SEM	0.7679	0.8918
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.0626, t = 1.9615, df = 22

By conventional criteria, this difference is considered to be not quite statistically significant.

Table 19 below shows the results of the t-test comparing Delta Airlines and American Airlines average percentage flights delays into the O'Hare International Airport. The results with p = 0.3502, indicated there was no statistically significant difference between the two airlines.

Table 19. *Delta Airlines Verses American Airlines Average Results in O'Hare Airport*

Airlines	Delta Air	American Air
Mean	21.44%	20.12%
SD	3.9483	2.6600
SEM	1.1398	0.7679
N	12	12

P value and statistical significance:

The two-tailed P value equals 0.3502, t = 0.9544, df = 22

By conventional criteria, this difference is considered to be not statistically significant.

CHAPTER IV: DISCUSSION

The paramount objective of this research, as established by the three research questions stated in Chapter I, was to determine whether there was a relationship between hub-and-spoke systems and point-to-point systems associated with passenger traveling delays from Delta Airlines, American Airlines, and Southwest Airlines with respect to their associated airports (Hartsfield – Jackson Atlanta International Airport, O'Hare International Airport, Midway International Airport and Nashville International Airport). The focus was also to ascertain whether the summer seasons and winter seasons impact passenger flight arrival delays. The answer to research question one, the historical pattern of arrival delays for the six-year period, as indicated by the BTS, of American, Delta and Southwest Airlines into the Chicago area (O'Hare, Midway), Atlanta, and Nashville International Airports, demonstrated that there were significant flight delays for operation into the four airports. For American and Delta flights into Atlanta, Delta had significantly more delays than American. For Delta and Southwest flights into Atlanta, Delta had significantly more delays than Southwest Airlines. For American and Southwest flights into Atlanta, the results were not considered to be significantly different. For Southwest and American into Nashville, American had significantly more delays than Southwest Airlines. The average results for Southwest and Delta into Nashville were considered not to be significant. For American and Delta flights into Nashville, the results were considered insignificant. For Delta and Southwest flights into Chicago area (Midway and O'Hare), the average results were significant. This indicates that Delta had significantly more delays than Southwest did in the Chicago area. The average results for Southwest and American flights into Chicago area were considered to not be significant. For Delta and American flights into O'Hare, the average results were also considered not to be significant.

The second research question asked, "Based on the data analyzed in the primary question number one, does there appear to be any differences in arrival delays between airlines using the hub-and-spoke scheduling design as compared to an airline that uses a point-to-point design?" The answer remains mixed, as the six-year data analysis has some differences in arrival delays between airlines that use the hub-and-spoke systems as compared to an airline that uses point-to-point systems. Delta Airlines which uses a hub-and-spoke system, and Southwest Airlines which use a point-to-point system were compared, and the results of the t-test comparing Delta and Southwest Airlines average percentage delays at Atlanta Airport was statistically significant. This indicates that Southwest had fewer delays while Delta had substantially more delays. The t-test value of Delta and Southwest was large enough to reject the null hypothesis. American Airlines which uses a hub-and-spoke system, had significantly more delays as compared to Southwest Airlines, with a point-to-point system, as seen in the average percentage delays at Atlanta Airport. American Airlines had significantly more delays as compared to Southwest Airlines in the average percentage delays at the Nashville Airport. The results of comparing the Delta and Southwest Airlines average percentage delays at the Nashville Airport was not statistically significant. Delta had significantly more delays than Southwest Airlines as seen in average percentage delays at Chicago area airports (O'Hare and Midway International Airport), and this was considered to be statistically significant. The American and Southwest Airlines average percentage delays at Chicago airports (O'Hare and Midway International Airport) was not statistically significant.

The results indicated that there is a mixed bag of significant differences between a point-to-point system and a hub-and-spoke system of operations in the airline industry. The six years of data analysis for this study has demonstrated why each airline utilizes their system of operation. Southwest Airlines has been using the point-to-point system since the deregulation of the airline industry. The point-to-point system features short haul, convenient flight times and low cost that generates more profit for the airline. “Southwest Airlines is one of the exceptions to the hub-and-spoke network system. Southwest uses the old-fashioned point-to-point system, hauling people in short distances with few connecting flights” (Bonsor, 2001, p.1). For example, Southwest Airlines offers nonstop flights from Nashville International Airport to LaGuardia Airport, New York. These direct (nonstop) flights help to reduce flight arrival delays on air travel passengers. In other words, there are no connecting flights for passengers who use a point-to-point system to their final destination. Hence, the arrival delays on passengers using point-to-point system are limited. Inevitably, a point-to-point system of operations may have the tendency to be the future preferred way of air transportation. Frequent flyer, like the researcher, can testify to the benefits of point-to-point system of operations. The researcher has flown several times between the United States, England, Germany, and Ghana, because most of his family members live in those countries. A point-to-point system is a workable system for both traveling passengers and the airlines like Southwest Airlines. The operational benefits of a point-to-point system is starting to spread into other airlines like Frontier Airlines that now offers a nonstop service from Nashville International Airport to Orlando, O’Hare, and Philadelphia International Airports. In addition, West Jet Airlines has announced its seasonal, nonstop flights from Nashville

International Airport to Toronto Pearson International Airport, starting in June 2016 (Nashville News & Media, 2016).

In contrast, American Airlines and Delta Airlines have been using hub-and-spoke systems since the deregulation of the airline industry. A hub-and-spoke system of operation is a feature of long haul carriers that may be convenient for international passengers. “The purpose of the hub-and-spoke system is to save airlines money and give passengers better routes to their destinations. Airplanes are airlines’ most valuable commodity and each seat on the airplane represents a portion of the total flight cost” (Bonsor, 2001, p.1). Each airline company chooses their routes very carefully in order to support their customers, their fleets, and make a profit as well. The hub-and-spoke systems have benefited many airlines both locally and internationally. The mix-match of significance between the hub-and-spoke system and point-to-point system indicates that there is no clear distinction which favors one system of operation with respect to money making.

The third research question asked – “Are there any seasonal periods in the year that are more susceptible to flight arrival delays for Delta, American, and Southwest Airlines with regards to Atlanta, O’Hare, Midway, and Nashville International Airports?” The answer is Yes, the six years of data analysis for Delta, American, and Southwest Airlines has proven that more of the flight arrival delays happened in summer months as compared to the winter months at the four mentioned airports (Hartsfield – Jackson Atlanta International Airport, O’Hare International Airport, Midway International Airport, and Nashville International Airport). The resulting average percentage delays range for Southwest Airlines indicated that the airline is more susceptible to summer month's delays at Midway, as compared to winter month's delays. The average percentage range delays for Southwest Airlines at Nashville Airport indicated that the airline has more summer months' delays as compared to winter delays. In Atlanta, the resulting average percentage range delays of Southwest Airlines indicated that the airline is more susceptible to summer month's delays at Hartsfield-Jackson International Airport, as compared to winter month's delays.

For American Airlines into O'Hare, the average percentage range delays indicated that the American Airlines is more subject to summer month's delays as compared to winter month's delays at O'Hare International Airport. The resulting average percentage range delays of American Airlines flights into Nashville indicated that the airline was more susceptible to summer month's delays at the Nashville Airport, as compare to winter month's delays. For American into Atlanta, the average percentage range delays indicated that American Airlines is more subject to summer month's delays as compared to winter month's delays at Hartsfield-Jackson International Airport.

Delta Airlines, which uses a hub-and-spoke system, was also subject to summer months' delays as compared to winter months' delays. The resulting average percentage range delays for Delta Airlines at O'Hare Airport indicated that the airline was more susceptible to summer month's delays at O'Hare, as compare to winter month's delays. The resulting average percentage range delays of Delta Airlines flights into Nashville indicated that the airline was more susceptible to summer month's delays at Nashville Airport, as compared to winter month's delays. Lastly, the resulting average percentage range delays of Delta Airlines flights into Atlanta indicated that the airline was more susceptible to summer month's delays at Hartsfield-Jackson International Airport, as compared to winter month's delays. Therefore, arrival delays from the three airlines happened more frequently to passengers during the summer months as compared to winter months at all four airports examined in this study.

Limitations

While this research showed a mix of the significance in the arrival delays for passengers who use the hub-and-spoke system as compared to the point-to-point system, the findings did have some limitations. This study tested for t-test values between Delta and Southwest Airlines, Southwest and American Airlines, and Delta and American Airlines to reveal the statistical evidence using a comparison analysis. Some of the t-test values revealed in this study were statistically significant, and some were not statistically significant. More detailed analysis may have proved more conclusive.

The data for this research only represents three of the United States' airlines and not the entire selection of airlines in the world. Therefore, the data analyses for this research were limited to the general aspects of flight operations for Delta, American, and Southwest Airlines concerning a point-to-point system and hub-and-spoke system. And, only these three carries were utilized with respect to the four airports in this study. Using different airlines and other different airports may change the results significantly.

It is paramount to realize that the relationship does not correspond to causation. In other words, research is not concluding that a point-to-point system of operation is the most definite way to influence flight delays for passengers. It is rather concluding that there is a slight impact of flight arrival delays for passengers who flew with airlines that use a point-to-point system as compared to hub-and-spoke system. Therefore, a point-to-point system can be re-confirmed as a slight predictor of getting airline passengers to their destinations as quickly as possible.

Future Research

The research has opened up potential for future studies to investigate the topic matter. Since flight delays are common to frequent flying passengers, a future study should be conducted with ten years of flight arrival delays instead of six years of flight arrival delays. Airlines use either a point-to-point system or hub-and-spoke system as their daily flight operations. Further studies would be beneficial as to which flight operations system would have greater impact on flight arrival delays for passengers.

Another related future study could look at the hidden delay cost because a significant amount of money is being lost that can be associated with arrival flight delays for both passengers and the airlines. In fact, airline delays not only cost both air passengers and airlines money, but it costs them their time, which cannot be replaced. Passengers who missed their connecting flights due to flight arrival delays are more likely to lose their business transactions. More so, passengers who missed their connecting flights due to flight arrival delays are more likely to switch to a different airline with less flight arrival delays. Therefore, the further studies should look for actual cost in arrival delays that can be beneficial to both passengers and the airlines.

REFERENCES

Associated Press. (2016). At least 11 killed in snowstorm-related deaths. *ABC News*. Retrieved from http://www.abcnews.go.com/us/wirestory/killed-snowstorm-related-deaths-36465874

Beatty, R., Hsu, R., Berry, L., & Rome, J. (1999). Preliminary evaluation of flight delay propagation through an airline schedule. *Air Traffic Control Quarterly*, *7*(4), 259-270.

Bonsor, K. (2001). How airlines work. *HowStuffWorks.com*. Retrieved from https://science.howstuffworks.com/transport/flight/modern/airlines3.htm

British Airways. (2012). Flight cancellation and long delays: notification of rights under EC Regulation No 261/2004 (as required by Article 14.2). *British Airways*. Retrieved from http://www.britishairways.com/en-us/information/legal/flight-cancellation-compensation

Business News. (2015). Travelers scramble after iPad issues delay American Airlines flights. *Business News*. Retrieved from http://business-news.biz/travelers-scramble-after-ipad-issues-delay-american-airlines-flights/

Civil Aviation Safety Authority. (2015). Duty time, flight time and flight duty period. *Civil Aviation Safety Authory.* Retrieved from https://www.casa.gov.au/standard-page/duty-time-flight-time-and-flight-duty-period

Duquette, A. (2010). Fact sheet – pilot flight time, rest, and fatigue. *Federal Aviation Authority*. Retrieved from https://www.faa.gov/news/fact_sheets/news_story.cfm?newsld=6762

Endsley, M. R., & Robertson, M. (2000). Situation awareness in aircraft maintenance teams. *International Journal of Industrial Ergonomics*, *26*(2), 301-325.

Flight Search. (2016). Flight from Charleston SC to Nashville TN. *Google News*. Retrieved from https://www.google.com/flights/#search;f=CHS;t=BNA;q=flight+from+charleston+sc+to+nashville+tn

Fricke, H., & Schultz, M. (2009). Delay impacts onto turnaround performance. In ATM Seminar.

GraphPad Software (2015). *Quick Calcs*. Retrieved from http://www.graphpad.com/quickcalcs/ttest1.cfm

Guy, A., B. (2010). Flight delays cost $32.9 billion, passengers foot half the bill. *University of California at Berkeley.* Retrieved from http://news.berkeley.edu/2010/10/18/flight_delays/

Hough, J. (2012). Two of the most dreaded words in airline delays – "crew illegalities." *Consumer Traveler.* Retrieved from http://consumertraveler.com/today/two-of-the-worst-words-in-airline-delays-crew-illegalities/

Hughes, N. (2013). Apple's iPad now in use in all American Airlines cockpits. *Apple Insider.* Retrieved from http://appleinsider.com/articles/13/06/24/apples-ipad-now-in-use-in-all-american-airlines-cockpits

Independent Traveler. (2016). Airline obesity policies. *Independent Traveler.* Retrieved from https://www.independenttraveler.com/travel-tips/none/airline-obesity-policies

Institutional Review Board. (2016). *American Public University System*. Retrieved from http://www.apus.edu/community-scholars/institutional-review-board/

Jarrah, A. I., Yu, G., Krishnamurthy, N., & Rakshit, A. (1993). A decision support framework for airline flight cancellations and delays. *Transportation Science*, *27*(3), 266-280.

Keeney, L. (2015). United's baggage woes start to affect Denver Airport's reputation. *The Denver Post*. Retrieved from https://www.denverpost.com/business/ci_27270086/uniteds-baggage-woes-start-affect-denver-airport-reputation

Kittle, C. (2013). 25 reasons why Chicago is the most underrated city in America. *Business Insider.* Retrieved from www.businessinsider.com/25-reasons-why-chicago-is-the-best-city-in-america-for-young-professionals-2013-6

Knotts, R. M. (1999). Civil aircraft maintenance and support fault diagnosis from a business perspective. *Journal of Quality in Maintenance Engineering*, *5*(4), 335-348.

Lee, S. G., Ma, Y. S., Thimm, G. L., & Verstraeten, J. (2008). Product lifecycle management in aviation maintenance, repair and overhaul. *Computers in Industry*, *59*(2), 296-303.

Mitchell, K., (2015). Delta flight from Boston makes emergency landing in Denver. *The Denver Post*. Retrieved from http://www.denverpost.com/news/ci_28607221/delta-flight-from-boston-makes-emergency-landing-denver

Nashville News & Media. (2015). Nashville International Airport surpasses 11.6 million passengers in 2015. *FlyNashville.com*. Retrieved from https://flynashville.com/news-and-media/press-releases/Pages/2015numbers.aspx

Nashville News & Media. (2016). Nashville International Airport welcomes new airline and additional international service. *FlyNashville.com*. Retrieved from https://www.flynashville.com/news-and-media/press-releases/Pages/WestJet.aspx

Rising Up Aviation. (2011). Flight, duty and rest time requirements: All crewmembers. *RisingUp.com.* Retrieved from http://www.risingup.com/fars/info/part91-1057-FAR.shtml

Sachon, M., & Pate'-Cornell, E. (2000). Delays and safety in airline maintenance. *Reliability Engineering & System Safety*, *67*(3), 301-309.

Sim, K. L., Koh, H. C., & Shetty, S. (2006). Some potential issues of service quality reporting for airlines. *Journal of Air Transport Management*, *12*(6), 293-299.

Snyder, J., Sasso, M. (2014). Airplane cabin cleaners end LaGuardia strike over ebola. *Bloomberg.* Retrieved from http://www.bloomberg.com/news/2014-10-09/ebola-fears-drive-laguardia-s-airplane-cleaners-to-strike.html

Stockton, H. (2013). Airline passenger Bill of Rights – What are flyers' rights? *Traverlsort.com.* Retrieved from: travelsort.com/blog/airline-passenger-bill-of-rights-what-are-flyers-rights

Sullivan, M. III (2011). *Fundamentals of statistics* (3rd ed.). Boston, MA: Pearson Education, Inc.

United States Department of Transportation (2015). *Bureau of transportation statistics*. *Transtats.* Retrieved from https://www.transtats.bts.gov/homedrillchart.asp

United States Department of Transportation (2015). Plane talk: Coping with flight delays. *Transportation.gov*. Retrieved from http://www.transportation.gov/airconsumer/plane-talk-coping-flight-delays