Examining the Impact of the Covid-19 Pandemic on South African Air Travel

by

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DECLARATION

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ABSTRACT

The Covid-19 Pandemic halted national and international air-travel, causing the steepest decline in global air travel demand ever recorded. The purpose of this research study is to examine the impact that the Pandemic has and potentially will have on South African domestic and international air travel demand in the medium term.

The impact was evaluated in two parts. The first used historic data to forecast the growth of airline demand, had the Pandemic not occurred. This "counterfactual" model was then compared to the actual passenger numbers recorded between the period from March 2020 to September 2021 to quantify the decline of air travel demand caused by the Covid-19 Pandemic within this period. To construct the counterfactual model for both the domestic and international air travel demand, pre-Pandemic passenger data from Airport Company South Africa (ACSA) was used to fit a Seasonal Autoregressive Integrated Moving Average (SARIMA) model, type (2,1,0) x (1,0,0) 12. The model forecasts until the end of 2024, presenting a scenario of air travel demand which would have been expected in the absence of the Pandemic.

The second part forecasted the short-term recovery in passenger air travel demand by fitting the intervention (the demand shock caused by the Covid-19 Pandemic) to the SARIMA model. This model was compared to the counterfactual model, to predict the loss in air travel demand until December 2022. The recovery forecast was also later assessed against actual observations to evaluate the accuracy of the model and to comment on its suitability for use in future studies.

ACSA data showed that South African air demand dropped by 99% between March and April 2020. Between March 2020 and September 2021, the counterfactual model illustrates a total loss of between 42.5 million and 60.3 million domestic and international passengers.

The recovery forecast suggested that, based on a neutral recovery scenario, domestic air travel would reach 64.5% of 2019 levels by the end of 2022. International recovery was predicted to settle lower at 34% of 2019 levels by December 2022.

Furthermore, forecasting analysis found that South African passenger losses, for the period of March 2020 to June 2023, are expected to be 62.2 million for domestic and 30.2 million for international. Therefore, total losses for the period, attributed to the Covid-19 Pandemic and its associated effects on South African air travel demand, are expected to reach 92.4 million by June 2023.

The results of this study confirm long-term implications for South African airlines, airports and the air travel industry in general. Findings from this study provide quantifiable evidence of the harsh impact that the Covid-19 Pandemic has had on the air travel industry. Findings also have the potential to aid government officials and industry stakeholders in strategic planning and decision making within future demand shocks. It is recommended that future researchers take the model constructed for this paper as a prototypical proof test to build on and to improve the accuracy and forecasting range. Doing so opens up opportunities to use the model to forecast recovery of time-series data in future demand crises.

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ABBREVIATIONS AND TERMINOLOGY

ACI – Airports Council International

ACSA – Airports Company South Africa

CSC – Centre for Statistical Consultation

IATA – International Aviation Transport Association

ICAO – International Civil Aviation Organisation

IMF – International Monetary Fund

PAX - Passengers

RPK -Revenue Passenger Kilometres

SAA – South African Airlines

SARIMA – Seasonal Autoregressive Integrated Moving Average

YOY – Year-on-year

TABLE OF CONTENTS

DECLARATION ..... **ii**
ABSTRACT ..... **iii**
ACKNOWLEDGMENTS ..... **v**
ABBREVIATIONS AND TERMINOLOGY ..... **vi**
LIST OF FIGURES ..... **ix**
LIST OF TABLES ..... **xi**
CHAPTER 1: INTRODUCTION **1**
1.1 Introduction 1
1.2 Background 2
1.3 Significance of Study 5
1.4 Limitations 6
1.5 Research Focus 8
1.5.1 Problem Statement 8
1.5.2 Aim of Study 8
1.5.3 Research Objectives 9
1.5.4 Research Questions 9
1.6 Structure of Thesis 10
CHAPTER 2: LITERATURE REVIEW **12**
2.1 Introduction 12
2.2 The Effect of the Pandemic on Global Air Travel Demand 13
Summary of Findings 18
2.3 Pandemic Effect on South African Airports 19
Summary of Findings 20
2.4 Pandemic Effect on South african Airlines 21
2.4.1 South African Airlines (SAA) 21
2.4.2 Comair 24
2.4.3 LIFT Airlines 26
2.4.4 Airlink 27
2.4.5 FlySafair 29
2.5 Previous Air Travel Demand Crises 32
2.5.1 9/11 33

2.5.2 Financial Crisis ... 35
2.5.3 Previous Infectious Disease Outbreaks ... 36
2.6 Intervention Analysis ... 39
Summary of Findings ... 42
2.7 Recovery Predictions ... 42
Summary of Findings ... 52
2.8 Overall Summary of Literature Review ... 53
CHAPTER 3: DATA AND METHODOLOGY ... 55
3.1 Introduction ... 55
3.2 Ethical Clearance ... 60
3.3 Model Background and Justification ... 60
3.4 Model Design and Construction ... 63
3.5 Intervention Model Impact Pattern Selection ... 70
3.6 Assumptions and Limitations ... 71
CHAPTER 4: ANALYSIS AND DISCUSSION OF RESULTS ... 74
4.1 Introduction ... 74
4.2 Domestic Counterfactual Scenario ... 75
4.3 Comparison: Domestic Counterfactual vs Actual Observations ... 78
4.4 Domestic Recovery Forecast ... 81
4.5 Comparison: Domestic Counterfactual Versus Domestic Abrupt/Temporary Intervention Recovery Forecast ... 87
4.6 International Counterfactual Scenario ... 89
4.7 Comparison: International Counterfactual vs Actual Observations ... 92
4.8 International Recovery Forecast ... 95
4.9 Comparison: International Counterfactual vs International Abrupt/Permanent Intervention Recovery Forecast ... 102
4.10 Effect on Aircraft Movements ... 104
4.10.1 Domestic Aircraft Movements ... 104
4.10.2 International Aircraft Movements ... 109
4.11 Model Accuracy for the First nine Months of Intervention Forecast ... 113
CHAPTER 5: CONCLUSION AND RECOMMENDATIONS ... 119
CHAPTER 6: REFERENCES ... 127
Annexure A: Domestic model ... 145

LIST OF FIGURES

Figure 1: South African air passengers carried, 1970-2020 3

Figure 2: World air passenger travel evolution 1945-2021 16

Figure 3: Airlink route network 28

Figure 4: Previous demand shocks recoveries measured in RPKs, 14 months after start of Pandemic, indexed at start of shock 43

Figure 5: Previous demand shock recoveries measured in RPKs, 19 months after start of Pandemic, indexed at start of shock 44

Figure 6: Global economic recovery 45

Figure 7: Global passenger movement estimates (O-D) until 2030 46

Figure 8: Global air travel demand estimates Jan 2020-Oct 2023, as of September 2021 49

Figure 9:June 2022 predictions for air travel demand versus 2019 levels 50

Figure 10: ACSA airport locations by total annual passenger count in 2019 56

Figure 11: Domestic passenger movements April 2012 - September 2021 57

Figure 12: International passenger movements April 2012 – September 2021........ 59

Figure 13: Plot of pre-intervention international variables 63

Figure 14: Plot of differenced international series 65

Figure 15: Autocorrelation Function for international D (-1).................................... 66

Figure 16: Partial Autocorrelation Function for international D (-1) 67

Figure 17: Extended domestic passenger numbers baseline (counterfactual scenario) 76

Figure 18: Domestic counterfactual scenario versus actual observations 79

Figure 19: Domestic Abrupt/Temporary intervention forecast 84

Figure 20: Average domestic counterfactual and intervention forecast comparison 88

Figure 21: Extended International passenger numbers baseline 90

Figure 22: International counterfactual scenario versus actual observations 93

Figure 23: International Abrupt/Permanent intervention forecast 98

Figure 24: Average international counterfactual and intervention forecast comparison 103

Figure 25: Domestic aircraft movements April 2012 – December 2021 105

Figure 26: Domestic passengers per aircraft - April 2012 - December 2021.......... 107

Figure 27: International aircraft movements April 2012 – December 2021............ 109

Figure 28: International passengers per aircraft - April 2012 - December 2021 111

Figure 29: International recovery forecast vs actual observations October 2021 - June 2022 116

Figure 30: Domestic recovery forecast vs actual observations October 2021 - June 2022 117

LIST OF TABLES

Table 1: International and domestic passenger traffic, 2020, 2021 and 2022 versus 2019 17

Table 2: South African air passenger decline 2020 and 2021 vs. 2019 20

Table 3: ICAO international and domestic recovery forecast 2022 vs 2019 levels 47

Table 4: Parameter estimates for international D (-1) 68

Table 5: ACSA total domestic passenger movement growth between 2013-2019 77

Table 6: Forecasted counterfactual domestic passenger movements at ACSA airports for 2020-2024 78

Table 7: Domestic Abrupt/temporary intervention input parameters 81

Table 8: Domestic Abrupt/Temporary intervention model results October 2021 – December 2022 83

Table 9: Domestic intervention forecast compared to ICAO and Bain and Company Forecasts 2022 vs 2019 86

Table 10: ACSA total international passenger movement growth between 2013-2019 91

Table 11: Forecasted counterfactual international passenger movements and growth at ACSA airports for 2020-2024 92

Table 12: International Abrupt/permanent intervention input parameters 95

Table 13: International Abrupt/Permanent intervention model results October 2021 – December 2022 97

Table 14: International intervention forecast compared to ICAO and Bain and Company Forecasts 2022 vs 2019 100

Table 15: Bain and Company forecast vs intervention analysis results for June 2022 101

Table 16: ACSA average domestic passengers per aircraft recorded between 2012 to 2021 108

Table 17: ACSA average international passengers per aircraft recorded between 2012 to 2021 112

Table 18: Difference between international air passenger intervention forecast predictions and actual observations Oct 2021-Jun 2022 113

Table 19: Difference between domestic air passenger intervention forecast predictions and actual observations Oct 2021-Jun 2022 114

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

The Covid-19 Pandemic continues to have an unprecedented and severely negative impact on the global air travel industry (ACI, 2021; IATA, 2022b; World Economic Forum, 2022). The air travel industry is a notoriously competitive, volatile and fast changing industry. The nature of the industry makes it vulnerable to demand shocks and crises (Xuan *et al.*, 2021; Elliot, 2022). Any impact on the air transport industry is significant as the industry plays an important role in economic and social development (Baker, Merkert and Kamruzzaman, 2015; Florida, Mellander and Holgersson, 2015; InterVISTAS, 2015; Zhang and Graham, 2020).

The analysis of impacts and demand shocks, along with forecasting practices, are crucial within the air travel industry (ICAO, 2006; Airports Commision UK, 2013). Such procedures allow aviation industry stakeholders to calculate the consequences of current and future events, thereby aiding in planning and decision making. While some organisations have analysed the impact and created recovery forecasts for global air travel, no such study exists for South African air travel specifically. The full potential impact as well as the likely recovery of South African air travel is therefore unknown and needs to be investigated.

This research study will attempt to investigate the impact of the Covid-19 Pandemic on South African international and domestic passenger numbers between March 2020 and September 2021. Additionally, the study will also attempt to forecast the recovery of South African passenger demand for international and domestic air travel in the medium-term. This will quantify future potential losses in South African air travel demand. The forecasting model will function as a proof test for the use of similar models to predict time series recovery in future crises.

1.2 BACKGROUND

In April 2020, hard lockdowns caused global air travel demand to fall by 94% compared to the previous month. The global drop comprised declines of 98% and 87% for international and domestic air travel demand respectively (IATA Economics, 2020a). The negative trend continued throughout 2020, a year which saw annual global air travel demand fall 60% below 2019 levels, resulting in total revenue losses of $466 billion. In 2020, the industry suffered total passenger decreases of 2.7 billion and debt increases of $180 billion, more than half the total industry revenue for the same year. The disaster continued in 2021 with only small improvements in domestic air travel. Global air travel demand for 2021 was 49%, or 2.1 billion passengers, below 2019 levels and revenue losses totalled $324 billion (ICAO Aviation Bureau, 2022).

Like most global airline trends, South African air travel demand has grown consistently over the past 50 years, rising from 1.5 million air passengers carried in 1970 to 26,2 million in 2019. The positive long-term trend, followed by the sharp drop in demand in early 2020 caused by the Covid-19 Pandemic, is illustrated below in Figure 1.

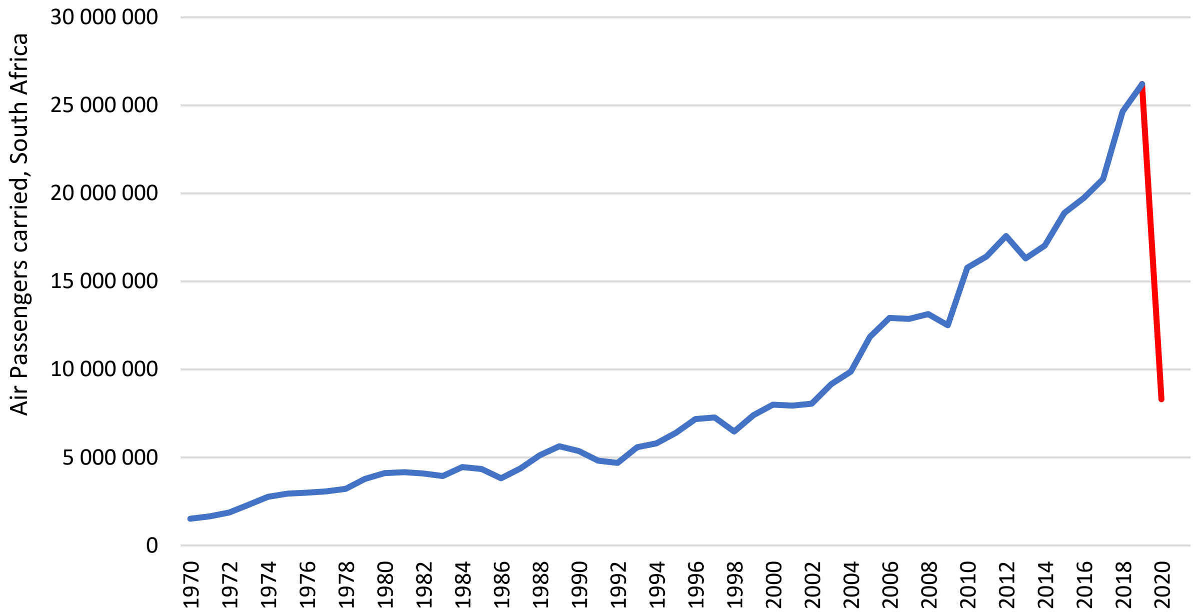

Figure 1: South African air passengers carried, 1970-2020 (Source: World Bank, 2022) (Own graph)

The scale of the impact that the Covid-19 Pandemic has had, and continues to have, on the South African air travel industry is not yet fully understood. The effect on the industry in general, however, cannot be underestimated. In April 2020, at the start of the Pandemic, South African air travel suffered an immediate drop in demand of 99%, 5% higher than the global average decline. In 2020, annual South African domestic air travel demand was 62% below 2019 figures, which was more severe than the global domestic decline. South African international air travel declines for 2020 (-75%) were on par with the global average of -74% (ACSA, 2022b).

In 2021, domestic air travel improved to 31% below 2019 figures, in line with the global domestic average of -30%. South Africa’s international air travel demand recovery for 2021 settled at 72% below 2019 figures, very close to the ICAO global international figure of -74% (ACSA, 2022b). While South African air travel has managed to catch up with the recovery rates highlighted around the world, the damages caused by the Pandemic in 2020 cannot be overlooked.

The emergence of new variants and inefficient vaccine rollout programs continued to lead to recurring lockdowns for the majority of 2021. While many other industries have adapted and even overcome the shock, the air travel industry continues to struggle to recover (ACI, 2021; Sun *et al.*, 2021). ICAO (2022) predicted that global passenger losses for 2022 would be 1.5 billion lower than 2019 levels while annual revenue losses could total $226 billion.

Air transportation is a crucial part of the global economy. Its derivative, air accessibility, is strongly linked to economic and social development (Florida, Mellander and Holgersson, 2015; InterVISTAS, 2015; Morphet and Bottini, 2015; Abate, Christidis and Purwanto, 2020). Air transport fosters trade, tourism, business, investment and commercial activities and sustains many direct and indirect jobs (Forsyth, Niemeier and Bremen, 2016; Baker, Merkert and Kamruzzaman, 2015).

South African air travel industry fosters jobs, tourism, investments and commercial activities. ACSA stated in their Social, Economic and Environmental report of 2017, that the company had generated R9.5 billion for the South African GDP. The report also stated that ACSA supported 14 950 direct and indirect jobs resulting in R2.8 billion in income (ACSA, 2017). According to Wuth (2017) the South African air transport sector supported 70 000 direct, 130 000 supply chain and 230 000 tourism linked jobs in 2014. The total direct and indirect impact of this was valued at 3.5% of the nation’s GDP, or $12.5 billion. It is imperative to study the effect that the Pandemic has had on the air travel industry to fully understand the damage which has been done and will be done in the future. To the author’s knowledge, no study has been conducted on the impact of the Pandemic on the South African air travel industry.

An in-depth review of the literature revealed that one of the most successful ways of analysing the impact of demand shocks on time series data is to perform intervention analysis. Many studies have successfully employed intervention analysis to examine the effects of external disasters on time series data from varying industries (Box and Tiao, 1975; Goh and Law, 2002; Lee, Oh and O'Leary, 2005; Gilmour *et al.*, 2006; Min *et al.*, 2011; Wadud, 2020). Consultation with the Stellenbosch Centre for Statistical Consultation (CSC) confirmed that a SARIMA intervention analysis would be best suited to examine the current and future impact of the Pandemic on South African domestic and international air travel demand.

This study attempts to examine the actual impact of the Pandemic on South African air travel passenger numbers and, further, attempts to predict a realistic air travel demand recovery for South Africa through the use of a parsimonious forecasting model which will serve as an experimental validation for similar future studies. The study will compare the actual passenger observations, recovery predictions and baseline counterfactual model results (as if the Pandemic did not take place) to determine the impact of the Coronavirus Pandemic on South African domestic and international air travel demand in terms of passenger number losses. Results will be compared to current recovery predictions created by various industry organisations and other nations.

1.3 SIGNIFICANCE OF STUDY

If the study achieves its desired aims, results will prove to be significant for international and South African aviation industry stakeholders and academic researchers alike.

Findings from this study could have the potential to assist airport and airline management and government officials in future strategic planning and management decisions. The study will help to calculate the potential effect that the Pandemic has had and will have on air travel demand from a South African perspective. An analysis of this type will therefore allow aviation stakeholders to be better prepared for future crises and exogenous demand shocks. Furthermore, industry experts as well as researchers can potentially improve and adapt the model constructed during this study to measure impacts and to predict recovery of time-series variables during future crises.

This study could prove to be significant in academic terms. Future research can build on the model to improve accuracy and forecasting range. This study serves as an early and experimental test for the accuracy and usefulness of the employment of a short-range, simple, parsimonious and univariate model during a crisis. The model can be updated with new data in the future.

From a national perspective, a study on the impact of the Pandemic on the all-important air transport industry is crucial. The South African economy is heavily reliant on a healthy air transport industry and therefore, an in-depth understanding of the damage done to the industry is pertinent. If the study is found to be successful, results will illustrate to officials the current and potential effect of the Pandemic on air travel in South Africa. Findings can be used by government in decision making relating to relief funding and aid within the local air transport industry.

1.4 LIMITATIONS

The unpredictable and volatile nature of the Pandemic and its evolving effects on the air travel industry means that the accuracy of the results of this study could change substantially. The relationship between air travel demand and traditional variables (GDP per capita, income, unemployment, etc.) has become very strained during the Pandemic, making them unusable in forecast models. To overcome this issue, it was decided that the simplest model approach, using univariate data, would be used in this research study. A univariate approach can mean that the model is robust, but it does result in a shorter forecast range.

Air passenger and aircraft data sourced from ACSA dates back to April 2012. Post intervention data is limited for the model and its results to be presented in a timely manner. Data was collected until September 2021, just prior to the construction and analysis of the model. The data range serves the purpose of this paper's research objectives and allows the researcher to analyse the current and expected medium-term impact of the Covid-19 Pandemic on South African air travel demand. The limited post intervention observations only slightly hinder the forecasting component of the research, as the comparative analysis component is conducted on the actual observations and counterfactual model, which, by its nature, can only use pre-Covid-19 Pandemic data. Therefore, only the recovery predictions are subject to limited post observation data.

The research serves as a good platform for future researchers looking to build on the model or to explore the impact of the Pandemic. Assumptions and limitations of the data and model constructed for this research study are discussed further in Chapter 3.

1.5 RESEARCH FOCUS

1.5.1 Problem Statement

The South African air travel industry has been deeply affected by the Covid-19 Pandemic in terms of air travel demand, supply and revenue. Currently, the full extent of the air travel losses caused by the Pandemic and the possible effects on long-term South African air travel demand have not been analysed. To the author's knowledge, this will be the first South African study of its kind as there are no South African air travel recovery predictions readily available.

It is important to investigate the nature of the intervention to better understand its harmful effects on the South African air travel industry and its associated socioeconomic importance. Investigating the magnitude and duration of the shock will allow for better understanding of the impact on airline and airport revenue and operations. This will assist air transport industry stakeholders, government officials and policy makers in preparing and planning for potential future crises. If this air travel demand shock is not investigated, officials and stakeholders will be left ill prepared.

1.5.2 Aim of Study

This research study will attempt to examine the impact of the Pandemic on domestic and international South African air travel passenger numbers through the use of an intervention analysis model. The examination will include the analysis of actual and current air travel demand losses suffered so far, as well as the construction of a recovery forecast model to establish the full short-term predicted impact. Results and findings will be compared to analyses and forecasts conducted by international organizations and companies. Furthermore, the study will supplement the findings by investigating the impact that the Pandemic has had on aircraft movements.

1.5.3 Research Objectives

The aim of the research is refined into the following research objectives:

1. Investigate South African domestic and international air travel demand for the counterfactual scenario (baseline - had the Pandemic not occurred) by using a SARIMA model.

2. To create a simple and parsimonious air travel demand intervention analysis recovery model to forecast recovery, using univariate data.

3. Use the intervention analysis to examine likely recovery scenarios for South African domestic and international air travel demand.

4. Compare the baseline scenario to the actual recovery observations so far, as well as the predicted recovery scenario to determine the full potential impact of the Pandemic on South African domestic and international air travel demand and the industry.

5. Analyse the effect of the Pandemic on international and domestic aircraft movements and aircraft capacity in South Africa.

6. Investigate the model accuracy for the period from October 2020 to June 2022.

1.5.4 Research Questions

1. What would South African international and domestic air travel demand have looked like if the Pandemic had not occurred?

2. How many passenger movements have been and will be lost due to the Pandemic?

3. What is the predicted recovery of South African domestic and international air travel?

4. How did the Pandemic affect South African aircraft movements and average capacity?
5. How accurate is the low complexity univariate model?

1.6 STRUCTURE OF THESIS

This research study is comprised of six chapters. Chapter 1 introduces the overall topic and background, the significance, the limitations and the research focus of this study. The research focus provides an outline of the problem statement, research aim, objectives and questions.

Chapter 2 provides a review of the literature relating to the impact of the Covid-19 Pandemic on global air travel, South African airlines and airports, previous studies conducted on air travel demand shocks, intervention analysis studies and air travel recovery forecasts. The chapter concludes with a conceptual framework, designed to visualize and connect findings revealed in the literature review.

Chapter 3 discusses the data collected and methodology followed to analyse the impact of the Pandemic on South African air travel. The chapter starts by introducing the passenger data sourced from ACSA as well as details regarding successful ethical clearance that was granted for this study. The chapter then provides a background and justification for the model chosen followed by a presentation of the model's design. The impact pattern selection is then discussed as well as the assumptions and limitations of the model.

Chapter 4 presents a comparative analysis and discussion of findings. The chapter begins by introducing the domestic counterfactual scenario and then comparing it to the actual air travel observations. Following this the domestic recovery forecast is introduced and subsequently compared to the counterfactual scenario. The same steps are followed for the international air travel intervention analysis. The chapter additionally analyses the effect of the Pandemic on ACSA aircraft movements and concludes by evaluating the model accuracy for the months of October 2021 to January 2022.

Chapter 5 concludes this thesis with a discussion of the findings of this research study. The chapter also lists the fulfilled research objectives of this study as well as the contributions that the study has made to the knowledge pool. The chapter concludes with recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

A wide variety of literature was reviewed within this section. Firstly, the effect of the Pandemic on global air travel is studied to establish the immediate drop in passenger numbers as well as the total decline for the years of 2020 and 2021. This is achieved by reviewing reports from reputable aviation industry organisations such as the International Civil Aviation Organisation (ICAO), the International Air Transport Association (IATA) and McKinsey. Total industry revenue losses and debt accumulation as a result of the Pandemic are investigated. The impact of the Covid-19 Pandemic is shown to have been much larger than previous demand shocks that have affected the air travel industry in the past.

Once the impact of the Pandemic on global air travel has been established, the effect on the South African air travel industry is investigated. This is accomplished by reviewing the effects of the Pandemic on South African airports as well as 5 South African airlines – South African Airways (SAA), Comair, Lift, Airlink and FlySafair. Reviewal of the impact is conducted by studying ACSA sourced data and airline media releases.

Focus then shifts to reviewing studies on previous air travel demand crises such as 9/11, the Financial Crisis of 2008 and the Severe Acute Respiratory Syndrome (SARS) Pandemic. Results of the various studies are carefully analysed to determine what type of effect each shock had on air travel. Most importantly, this part of the literature attempts to determine what methods researchers used to study the demand shocks and if the shocks were permanent or temporary in nature.

Numerous studies which employed intervention analysis are also reviewed. The objective of this is to determine how successful other studies, which conducted intervention analysis, have been. The reviewal of these studies aids in identifying limitations of such an analysis as well as potential pitfalls to avoid. Literature reviewal of previous intervention analyses helps determine that the method is suited to the unique characteristics of this study.

Finally, the literature review chapter concludes with the reviewal of recovery predictions created by various reputable companies and organisations within the air travel industry, such as Bain and Company, IATA and ICAO. The predictions and forecasts constructed are analysed to be used as a comparison to this study's own recovery forecast.

2.2 THE EFFECT OF THE PANDEMIC ON GLOBAL AIR TRAVEL DEMAND

The rapid spread of the Coronavirus at the beginning of 2020 led to national lockdowns, air travel restrictions and passenger behaviour changes on a scale never witnessed before. By the end of 2020 world GDP had shrunk by around 3.2%, and tourism receipts declined by 86%, or US$1.3 trillion (IMF, 2021; UNWTO, 2021). The Pandemic and its subsequent lockdowns created the perfect crisis for the international air travel industry. By the first week of April 2020, 75% of all countries monitored by IATA had completely banned entry into their respective countries (IATA Economics, 2020a).

According to an IATA market analysis report, the immediate ensuing drop in year-on-year air travel demand, in terms of Revenue Passenger Kilometres (RPKs) for April 2020, was recorded at 94% (IATA Economics, 2020a). The same report calculated that RPKs for domestic markets recorded a decline of 86.9% while international markets fell by an unparalleled 98.4%. By August 2020 RPKs were still down 75% versus the previous year. The decrease in passenger volumes is regarded as the worst in history for the industry. Similarly, the analysis found that seasonally adjusted RPK volumes had fallen to a level last seen 30 years ago.

The revenue losses recorded by the air travel industry are simply unimaginable. In 2020, the commercial airline industry revenue totalled $372 billion, a revenue loss of 55% compared to the $838 billion recorded in 2019 (Statistica, 2021). The revenue recorded in 2020 is therefore, in nominal value, equal to revenue figures recorded in 2004.

The long-term effects of the Pandemic on the air travel industry are starting to emerge and cannot be underestimated in terms of severity. A publication by McKinsey (2021) states that the Pandemic's effects on air travel are far more extreme than caused by the 2008 financial crisis. While the financial crisis weakened economic conditions and consumer spending power, the Covid-19 Pandemic changed passenger behaviour and possibly altered the entire airline industry irreparably. Furthermore, the Pandemic also caused similar economic damage.

The same publication reported that another issue looms for the airline industry in its fight to return to pre-Pandemic levels. The industry in 2020, in order to survive the turmoil, was forced to turn to state credit and emergency funds, resulting in the accumulation of $180 billion in debt. This staggering figure is half of the total industry revenue generated in 2020 stated in the Mckinsey report. The reports conclude that the financial burden of the repayment of these loans will inevitably lead to higher ticket prices, inhibiting demand growth.

To gather a better understanding of the current situation, a report by ICAO is reviewed. The ICAO economic impact analysis (2021) provides regularly updated figures relating to the effect of the Pandemic on the air travel industry. As illustrated in *Figure* 2, there was a 60% decline in total passenger volumes for the year of 2020. This figure improved slightly as the decline in total passenger numbers for 2021 vs 2019 grew to -49%. It must also be noted how small the passenger volume drop offs are for previous crises relative to the Pandemic. It is expected that 2022 passenger numbers will be between 27% and 32% below 2019 figures.

ICAO compared 2020 total global (domestic and international) scheduled airline passenger traffic to 2019 figures and found that there was a reduction of 50% in airline seat capacity, a decrease of 2,7 billion passengers and $371 billion losses in gross passenger operating revenues. Furthermore, the report also compared 2021 to 2019 world traffic levels and found a reduction of 40% of seats available, a decrease of 2,1 million passengers and gross passenger operating revenue losses of between $313 billion and $324 billion.

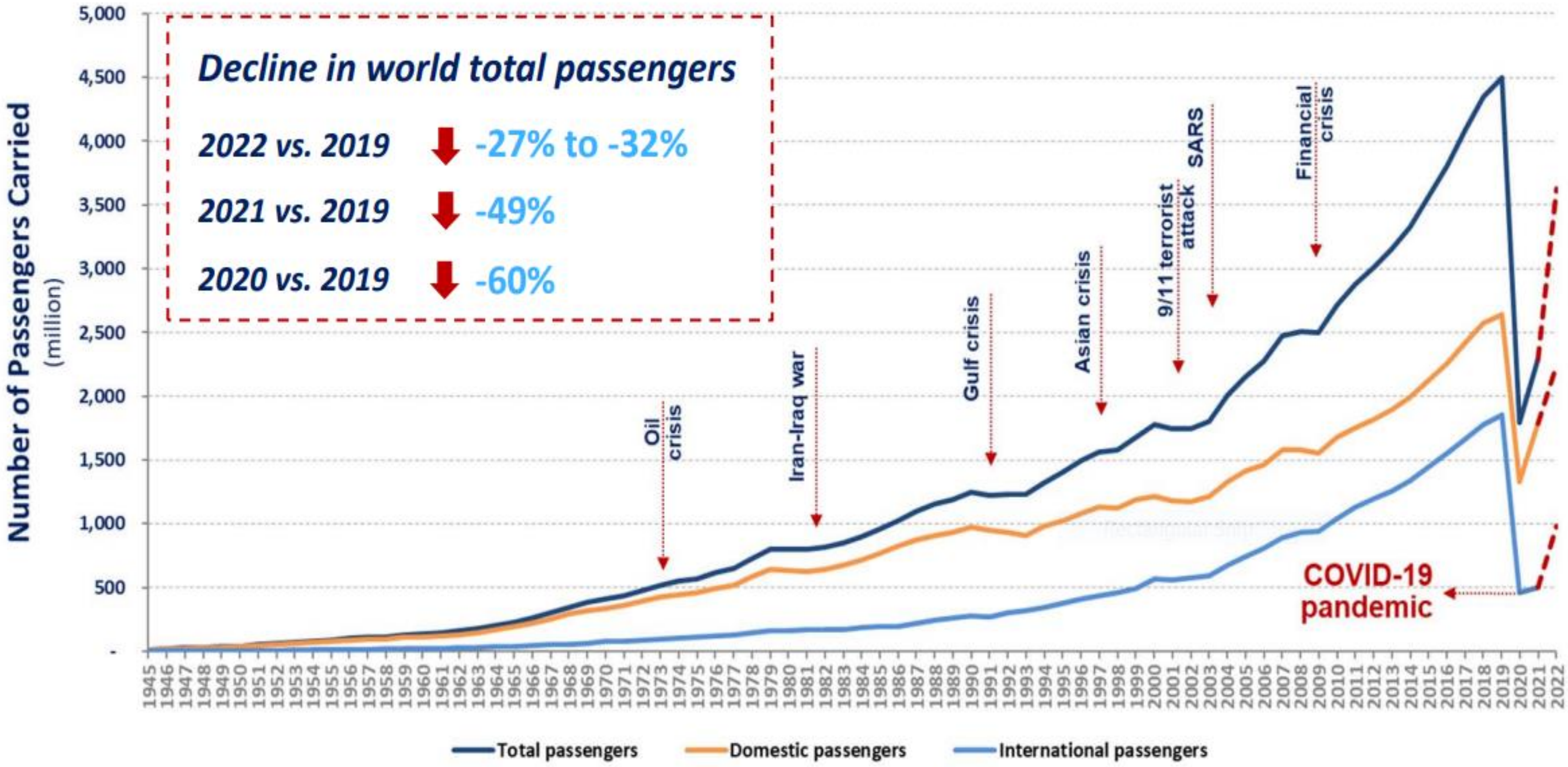

Figure 2: World air passenger travel evolution 1945-2021* (Source: ICAO Aviation Bureau, 2022)

Table 1, below, compares 2020, 2021 and expected 2022 domestic and international air travel figures to 2019 levels.

Table 1: International and domestic passenger traffic, 2020, 2021 and 2022 versus 2019 (Source: ICAO Aviation Bureau, 2022)

	2020 VS 2019		2021 VS 2019		2022 VS 2019	
	Domestic	**International**	**Domestic**	**International**	**Domestic**	**International**
Pax numbers decline	-1.32 billion	- 1.37 billion	-801 to - 838 million	-.32 to - 1.36 billion	-468 to - 563 million	-837 to - 935 million
Pax numbers % decline	-50%	-74%	-30% to - 32%	- 72% to - 74%	-18% to - 21%	-45% to - 50%
Revenue losses ($)	-120 billion	-250 billion	-66 to - 69 billion	-248 to - 255 billion	-38 to - 46 billion	-163 billion to -180 billion

The report highlights that international air travel was more severely affected than domestic air travel. The analysis recorded a 74% decline in 2020 international passenger volumes versus 2019, while domestic volumes only fell by 50%. The losses in revenue followed a similar path with international gross operating revenues losses totalling $250 billion while domestic losses were $120 billion.

While 2021 saw no improvements for international air travel, there was steady recovery for domestic air travel. International air travel remained low at 72%-74% below 2019 levels while domestic passenger decreases sank to between 30%-32% below 2019 numbers. International passenger revenue losses were between $248 billion and $255 billion ($250 billion in 2020) and between $66 billion and $69 billion for domestic air travel ($120 billion in 2020).

The ICAO report suggests that 2022 will see newfound recovery for international air travel and continued recovery for domestic air travel. Preliminary estimates for 2022 international passenger volumes are expected to be between 35% and 37% lower than 2019 levels. 2022 domestic volumes were expected to continue to recover at a faster rate with estimated levels of between 22% and 24% lower than 2019 levels. International and domestic gross passenger revenue losses were predicted to be $123-128 billion and $49-53 billion respectively.

SUMMARY OF FINDINGS

1. Following the initial lockdowns and restrictions, global RPKs in April 2020 were down 94% compared to April 2019.

2. In August of 2020, RPKs were down 75% year on year, dispelling the hopes of a quick recovery and signalling that a slow recovery of air travel is more likely.

3. The global commercial airline industry recorded revenue losses in 2020 of $466 billion, down 55% compared to 2019

4. Data proved that the Pandemic poses a far larger threat to the aviation industry than the financial collapse of 2008

5. Airlines around the globe accumulated $180 billion in debt

6. It was established that there was a 60% reduction in total air travel demand for the year of 2020 compared to 2019.

7. International air travel demand suffered more than domestic air travel demand. International air travel demand declined by 74% in 2020 while domestic only declined by 50%. Revenue losses for international air travel amounted to $250 million while domestic losses equalled $120 billion.

8. Air travel figures for 2021, while much improved for domestic, are still devastating for international air travel. International air travel demand remained

between 72% and 74% lower than 2019 levels with revenue losses of between $248 and $255 billion. Domestic air travel demand gained traction and settled 30%-32% lower than 2019 figures while suffering revenue losses of $66 to $69 billion.

9. The ICAO forecast predicts that 2022 international air travel will recover to levels 35%-37% lower than 2019 figures (up from 72% to 74% of 2019 levels in 2021).

10. 2022 domestic air travel is expected to recover to 22%-24% lower than 2019 levels (up from 30%-32% of 2019 levels recorded in 2021).

11. Revenue losses for 2022 are expected to total between $123 and 128 billion for international air travel and between $49 and $53 billion for domestic.

2.3 PANDEMIC EFFECT ON SOUTH AFRICAN AIRPORTS

The South African air passenger travel industry has suffered profoundly at the hands of the Pandemic. In line with the rest of the world, Airports Company South Africa (ACSA), a partially government-owned operator of South Africa's nine largest airports, has reported large reductions in air traveller demand as well as revenue losses of R2.6 billion (SABC, 2021). This is only the second time that the company has made a revenue loss in 28 years.

Total air travel demand in April 2020 was 20 091, 99% below the April 2019 figures of 3 600 379. For the months from May 2020 – September 2020, total passenger movements at ACSA airports were only 1 461 127. Table 2 below, illustrates the impact on domestic and international annual passenger numbers in South Africa.

Table 2: South African air passenger decline 2020 and 2021 vs. 2019 (Source: ACSA, 2022)

	DOMESTIC ICAO	DOMESTIC SOUTH AFRICA	INTERNATIONAL ICAO	INTERNATIONAL SOUTH AFRICA
2020 VS 2019	-50%	-62%	-74%	-75.2%
2021 VS 2019	-30%	-30.8%	-72% TO -74%	-72.4%

Annual domestic passenger demand for 2020 was 62.02% below 2019 figures. This is 12% worse than ICAO's report showing domestic passenger decline of 50%. Domestic air travel in South Africa recovered to -30.8% below 2019 for 2021, on par with ICAO's global domestic average report findings of -30% for 2021 versus 2019.

South Africa's international air travel is also more severely affected than ICAO's suggested international average. South African international passenger demand for 2020 was down 75.2%, while ICAO found global averages to be 74%. International air travel demand for 2021 was 72.4% below 2019 levels, in line with the 72-74% decline ICAO reported for 2021.

Comparison between the South African and International reports suggest similar negative impact patterns for South Africa and the global air travel industry in 2021. The impact in 2020 seems to have been more severe for South Africa than it was for the global air travel industry.

SUMMARY OF FINDINGS

1. South African air travel industry demand decline was larger than the world average in 2020 but on par in 2021.
2. ACSA reported revenue losses of R2.6 billion.
3. From 2020 to 2021, domestic air travel in South Africa improved from 62% to 30.8% lower than 2019 levels.

4. From 2020 to 2021, international air travel in South Africa did not improve significantly at all.

2.4 PANDEMIC EFFECT ON SOUTH AFRICAN AIRLINES

The South African airline industry was harshly affected by the Pandemic, witnessing the collapse of four airlines, SAA, its subsidiary, Mango Airlines, British Airways (operated by Comair) and Kulula (owned by Comair) (Dube, 2021).

The Pandemic did, however, reduce start-up costs and open up opportunities for new airlines. While four airlines went into business rescue, the start-up airline, LIFT, and the refurbished Airlink, emerged to capitalize on the vacuum left behind by the abovementioned airlines. The Pandemic also offered the commercial airline, FlySafair, pause to plan strategic expansions in its route network and fleet.

2.4.1 South African Airlines (SAA)

SAA, the flagship carrier of South Africa, had sustained many years of profit losses due to managerial negligence (Tleane, 2020). Prior to the Pandemic the inefficient and overstaffed airline had received many excessive and unsuccessful government bailouts, to the tune of R57 billion since 1994, resulting in growing pressure from the public (Tleane, 2020). The weakened position of the airline left it vulnerable to the effects of the Pandemic. SAA, denied more bailouts by the government and left unable to pay staff, did not record a single flight between March of 2020 and September 2021 (Dube, 2021). The Pandemic proved to be the final straw for SAA as in September 2020, SAA was placed under the care of business rescue practitioners and subsequently all operations were ceased (Engineeringnews, 2020).

The low-cost subsidiary of SAA, Mango Airlines, has also been unsettled by the Pandemic. The airline at one stage possessed a fleet of 10 Boeing 737's and serviced routes to 7 cities in South Africa and one to Zanzibar, Tanzania (Mango, 2021; Planespotter, 2021c). On the 28th of April, 2021, the commercial carrier was grounded and banned from landing or taking off from all ACSA airports (ENCA, 2021). The suspension of services was due to non-payment of fees to ACSA. The debt and grounding can be linked to the struggles facing SAA.

In July 2021, Thomas Kgokolo - SAA interim chief executive officer, stated that Mango would be entering business rescue after months of delayed payments of salaries for employees of the airline. Kgokolo also stated that the plan comes into effect following a R2.7 billion government bailout to SAA subsidiaries (Businesstech, 2021). SAA exited its own business rescue plan in April 2021, with only 20% of its pre-rescue plan staff remaining. The business rescue plan involved the reduction of SAA's cost base and liabilities. The business rescue practitioners said in a statement that the objective, to leave SAA in a solvent and liquid position capable of successfully operating in the future, was achieved (News24, 2021a).

SAA was however, not completely back on track following the handover from business rescue practitioners to the interim board. SAA pilots had not received salaries between March 2020 and July 2021, as SAA and the SAA Pilots Association (SAAPA) had been locked in legal battle (News24, 2021b).

June 2021 saw a major event in the national carrier's history take place. The South African government relinquished its majority control over the airline, passing a 51% stake over to a group of private investors, collectively referred to as the Takatso Consortium (Theafricanreport, 2021). The consortium consists of Harith General

Partners and Global Airways. The Department of Public Enterprises (DPE) released a statement confirming that due diligence was conducted of which the outcome was satisfactory. The DPE stated that the consortium possesses the required assets, technical knowledge, expertise, finances and infrastructure to successfully operate a new SAA (Fin24, 2021). The DPE also made it clear that no further government guarantees would be needed and that all historic liabilities would be the government's responsibility to settle.

On the 23rd of September 2021 SAA exited its grounding status and resumed flights. SAA restarted operations with a fleet of just 6 Airbuses, 3 Airbus 319's, 2 Airbus A320's and 1 Airbus A330 (Planespotter, 2022). The fleet reduction in size illustrates the dire situation which SAA found itself in and the enormous scale of restructuring which took place. In 2020, SAA returned 2 Boeing 737 Freighters, 4 Airbus A319's, 10 A320's, 6 A330-200s, 4 A330-300s, 3 A340-300s, 3 A340-600s and 4 of the new A350-900's (Planespotter, 2022). The number of returns within the space of one year therefore totalled 36.

SAA's new route network consists of daily flights between Johannesburg and Cape Town as well as flights to the capitals of Ghana (Accra), the Democratic Republic of the Congo (Kinshasa), Zimbabwe (Harare), Zambia (Lusaka) and Mozambique (Maputo) (Dron, 2021). SAA interim CEO stated: "Our first order of business is to service our start-up routes efficiently and profitably, and then look to expanding the network and growing our fleet, all depending on demand and market conditions."

In November 2021, South African Minister of Public Enterprises, Pravin Gordhan, said that the majority stake sale was expected to take place in early 2022 (Bloomberg, 2021). As of writing, the majority stake sale had not taken place with government still processing specifics of the deal in line with regulations (Kobokana, 2022).

2.4.2 Comair

In the cutthroat and fickle South African airline industry, Comair, up until 2020, had proven to be the most consistently successful airline to operate in the country (Klint, 2019). The Pandemic and its concomitant implications changed this. In May 2020, Comair entered into voluntary business rescue. The airline had started to suffer financial strain before the Pandemic, but the lockdown eroded the airlines revenue base leaving it unable to forge a recovery.

Comair operates low cost carrier Kulula and British Airways under license in South Africa (Business Maverick, 2020). Comair, the only airline traded on the Johannesburg Stock Exchange (JSE), had the trading of shares suspended (Reuters, 2020b). The carrier stated that the decision was taken to protect company interests after posting a revenue loss of R564 million for the first half of 2020 (Le Journal de l'Aviation, 2020). The rescue plan was expected to end in December 2020.

Comair recorded a profit in every single one of its 72 years of service and in 2018 alone posted record profit earnings of R340 million. Comair is known for its business diversification and profit generation linked to non-aeronautical services such as food catering and flight training (Skift, 2019). The fact that such an historically successful, profitable and diverse airline could not survive further provides proof of the detrimental impact the Pandemic has had on airlines and the air travel industry in South Africa.

In December 2020, Comair, still in business recuse, resumed operations. The Comair rescue commission injected half a billion Rand into the airline to lift it out of bankruptcy.

British Airways and Kulula flights continued until Comair suspended all flights and grounded its fleet on the 5th of July 2021, just eight months after restarting. The suspension came as higher levels of lockdown were implemented by the South African Government in an attempt to halt the rapidly growing number of Covid-19 cases in the Gauteng province. The “third wave” of infections was attributed to the highly transmissible “Delta” variant of the virus. Comair stated that it would aim to resume scheduled flights on the 1st of September 2021 (ch-aviation, 2021a).

Comair and Kulula restarted operations on the 1st of September 2021. Early in November, Kulula launched a twice-daily service between Cape Town and Durban and stated that the airline had fully restored its pre-Covid route network (Kulula, 2021). Kulula also launched three flexible fare package options, Fly Light, Pack & Go and Fully Loaded, all offering varying levels of luggage options and priority benefits at different price points. The packages are aimed at adding value to Kulula’s service offerings in order to compete with Lift, FlySafair and Airlink.

In June 2022, Comair announced the suspension of all Kulula and British Airways flights in South Africa, while its business rescue practitioners attempted to raise the necessary funds (Lechman, 2022). The announcement came after a very long series of setbacks for Kulula in 2022, including the grounding of all Kulula flights due to safety concerns (Zulu, 2022).

Comair’s turbulent times illustrate the uncertainty caused by the continuous discovery of new variants and outbreaks. These events have been shown to create an extremely volatile and unpredictable industry. Airlines need to have solid and committed financial backing as well as flexible operational capabilities in order to survive the Pandemic and its associated turbulent demand characteristics.

2.4.3 LIFT Airlines

Despite the damage caused to the South African air travel industry by the Pandemic, the turbulent market did open up some opportunities for entrepreneurs. As mentioned earlier, Global Airways forms a key part of the Takatso Consortium. Global airways is a Johannesburg based aircraft, crew, maintenance and insurance (ACMI) lease specialist, operating a fleet of 10 Airbus A320 and A340 aircraft (Global Airways, 2021). Before its historic involvement in the privatization of SAA, Global Airways was already busy expanding its operations. In December 2020, founder of Kulula, Gideon Novick, along with former Uber Africa CEO, Jonathan Ayache, launched LIFT (Airways magazine, 2020).

LIFT draws inspiration from Uber's operational style, offering unprecedented levels of passenger flexibility as ticket reservations and passenger names can be changed without penalty up to 24 hours before departure. The airline partners with South African wine farms and cafés as it aims to provide value-added in-flight services never previously offered by any South African airline (iol, 2020). The founders stated that the Pandemic offered the perfect opportunity to start a new airline, citing historically low oil, staff and aircraft prices (Reuters, 2020a). LIFT operates 3 narrow bodied Airbus A320's, which it leases from the above-mentioned Global Airways, between Johannesburg and Cape Town (LIFT, 2021).

LIFT was forced to down all flights on the 5th of July 2021, like Comair, due to decreased demand caused by travel restrictions implemented to combat the "third wave". LIFT recommenced flights from the 1st of August while Comair was only able to restart at the beginning of September (ch-aviation, 2021b). On the 30th of August 2021, LIFT launched "LIFT Premium", an upper ticket class aimed at passengers looking for a more luxurious experience. The Premium ticket offers extra legroom, reclining seats, a removed middle seat, unlimited penalty-free flight changes, priority boarding, lounge access and other services. At launch, Premium tickets cost R2 851 for a one way flight between Johannesburg and Cape Town while standard tickets cost between R805 and R1 150 (Vermeulen, 2021). It is clear that LIFT is trying to offer value added and diverse services to its customers during these unprecedented times

In December 2021, LIFT celebrated one year of operations. In its inaugural year, LIFT carried over 300 000 passengers and operated 2 000 flights. The airline impressed in terms of efficiency, recording an on-time-departure score of 97% (Smith, 2021). Lift continued to show positive growth in 2022. In October 2022, the airline started operating flights between Johannesburg and Durban while flights between Cape Town and Durban commenced in November of the same year (businesstech, 2022b).

2.4.4 Airlink

Airlink, a former Johannesburg based SAA subsidiary regional carrier, took the opportunity afforded by SAA’s Pandemic linked struggles to split from the national carrier. Airlink changed its name from SA Airlink to Airlink, subsequently ending a franchise agreement dating back to 1995. The airline started selling tickets under its own code (4Z) in place of SAA’s code. Airlink entered into interline agreements with large international carriers Emirates, Qatar Airways, British Airways, Air France, KLM and United Airlines (Businesstech, 2020). Airlink now offers flights to over 40 cities and 13 African countries including Botswana, Lesotho, Madagascar, Mozambique, Namibia and Zimbabwe (Flyairlink, 2021). Figure 3, below, illustrates the extensive route network which Airlink operates.

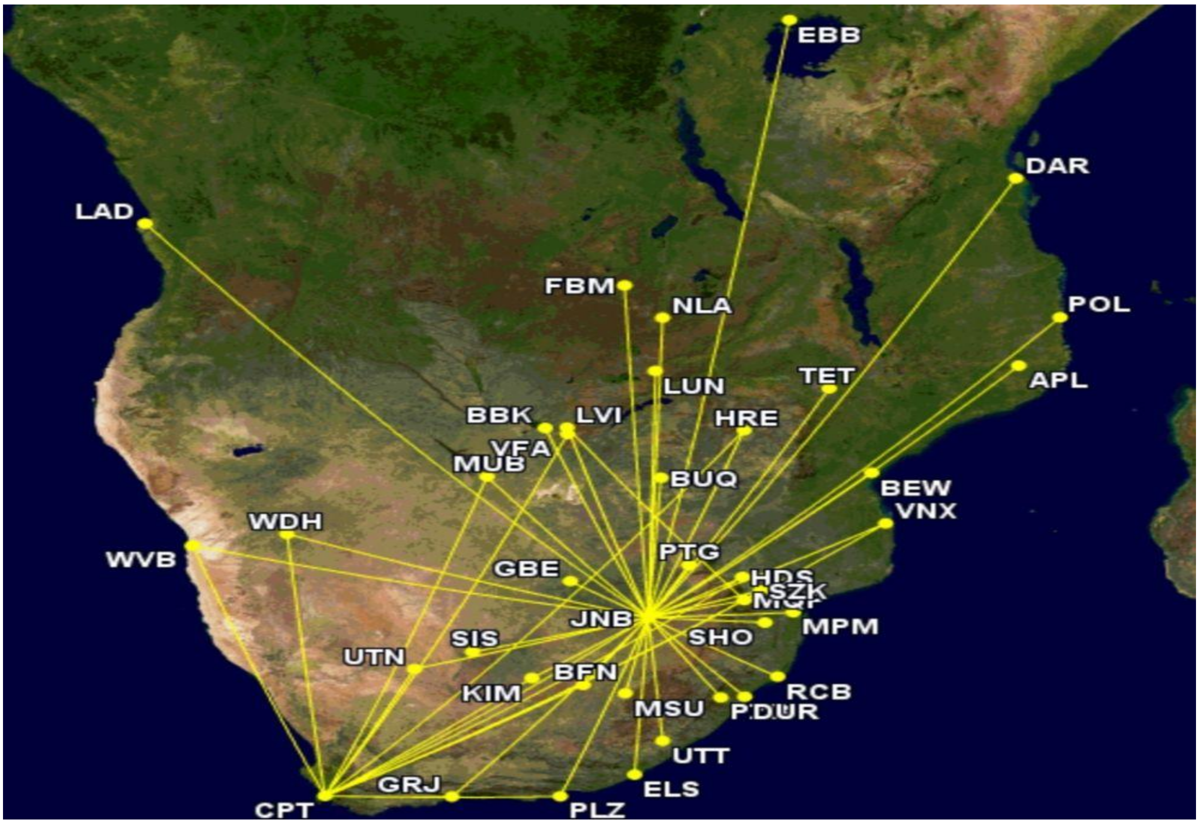

Figure 3: Airlink route network (Source: Simplyflying, 2022)

Just months after splitting from SAA, Airlink became the third largest airline within Africa by seat capacity (1.2 million) and second largest by number of flights (anna aero, 2021). The high number of flights can be attributed to the smaller size and higher capacity nature of aircraft within the Airlink fleet. The carrier operates a fleet of 28 Embraer ERJ-145's, 3 ERJ-170's and 12 ERJ-190's (Planespotter, 2021a). The smaller capacity fleet indicates that Airlink possesses a "rightsizing" philosophy, which has proven to be successful in recent years and is possibly the right call during current turbulent markets plagued by reductions in demand. Smaller aircraft have been shown to be more efficient, entail lower operating costs, higher load factors and therefore better revenue per seat kilometre (Embraercommercialaviation, 2020).

In February 2022, Airlink operated 5 068 flights, more than Kenya Airways and Royal Air Maroc, continuing its trend as the third largest carrier in Africa measured in flights.

By comparison, FlySafair operated 2 104 flights in the same month. Airlink offered the second most seats in South Africa in February 2022 at 291 938 while FlySafair offered 383 832. The airline also now operates the 7th longest non-stop ERJ-190 flight in the world, Johannesburg to Uganda's capital, Entebbe (Simplyflying, 2022). In September 2022, Airlink acquired a 40% stake in FlyNamibia (Orban, 2022). The deal further enhances Airlinks objective to establish a comprehensive and efficient air connectivity network within Africa. Deal came in the same month that Air Belgium signed a commercial deal with Airlink (flyairlink, 2022). The deal allows Air Belgium passengers convenient connections to 36 destinations within Southern Africa.

The multiple agreements with prodigious airlines, efficient and flexible fleet, high load factor along with the carrier's impressive domestic and regional network, places Airlink in an advantageous position to tap into SAA's unsatisfied demand and achieve steady growth.

2.4.5 FlySafair

The South African airline which seems to have handled the Pandemic the best is FlySafair (Chen, 2020). The airline has proven to be robust and flexible, offering and operating flights throughout the tumultuous years of 2020 and 2021. The airline only suspended flights from March to June of 2020 as government implemented harsh and universal travel restrictions. FlySafair remained determined to continue its loyalty flights and persisted with operations despite decreased demand.

A report by the Centre for Aviation stated that at one point in 2020, 74% of available seats in the South African air travel market were operated by FlySafair (FlySafair, 2020). The airline took the opportunity to expand and announced the addition of two next generation Boeing 737-800's to the fleet. CMO of FlySafair, Kirby Gordon said:

"Now's a great time to look to expand your fleet, if you're in a position to do so, because with the industry being where it is, there are plenty of aircraft up for grabs at very reasonable prices. It was important to us that we got our operations going as soon as it was feasible to do so, especially as it was clear that there was not going to be any state support for our sector. We're also in the fortunate position where we perform all our own maintenance, so there's been no reliance on possibly unstable third parties in that regard." (FlySafair, 2020). FlySafair possesses a fleet of 20 aircraft. The airline, during the Pandemic, has so far stored only 1 aircraft and scrapped another (Planespotter, 2021b).

In October 2020 FlySafair entered into an interline agreement with Qatar Airways (Businessinsider, 2020b). Soon after, in November of 2020, FlySafair increased its interline agreement portfolio by entering an additional agreement with Emirates (Businessinsider, 2020a).

In February 2021, FlySafair's application to service flights between South Africa and Mauritius was approved. The airline announced that it will operate two weekly flights to Sir Seewoosagur Ramgoolam International Airport once travel restrictions have been eased. Kirby Gordon stated that the events of 2020 had given the airline pause to implement new strategies to capitalize on the unsatisfied capacity to Mauritius caused by the ongoing grounding of large local carriers (FlySafair, 2021a).

On the 17th of May 2021, FlySafair confirmed that it had entered into a partnership deal with the local travel booking company, Tripco (operators of LekkeSlaap) to offer comprehensive travel packages (FlySafair, 2021b).

In July 2021, the commercial airline further demonstrated confidence in the South African air travel industry's recovery by announcing a new route between Bloemfontein and Cape Town. The airline began servicing the route on the 30th of July (Msn, 2021). In August 2021, FlySafair launched a Business Class service option. The option includes an empty middle seat and priority baggage claim status on arrival (Moodley, 2021). In October 2021 FlySafair launched an app designed to boost passenger accessibility and simplify the flying process. The app allows passengers to set up a personal profile, book flights, complete check-in's and gain special access to promotions (Stuff, 2021). The airline expanded its fleet to 25 in August when it took delivery of a 737-800. The airline continued a positive 2022 when in October it received approval to operate flights to 11 new destinations, a development that will see FlySafair operate 120 daily flights (businesstech, 2022a).

Summary of Findings:

1. After years of struggle and government bailouts, SAA entered business rescue. The massive reduction in air travel demand caused by the Pandemic was the final straw. SAA sold a majority stake to a private consortium. It remains to be seen if the new and restructured SAA will be successful.

2. Comair enjoyed 72 years of success up until 2019 when financial issues arose. The carrier was struck by travel restrictions and national lockdowns at the worst time. Reduced ticket demand cut away at revenue leaving the airline unable to cover losses posted in the first half of 2020. Despite a voluntary rescue plan, which saw cash injections to the value of R500 million, neither British Airways nor Kulula are operating flights yet.

3. LIFT Airlines launched at the end of 2020 despite the Pandemic. The airline aimed to capitalize on low staff, oil and aircraft prices. LIFT aims to counter current uncertainty within the passenger market by offering penalty-free flexible

booking arrangements and high-quality on-board food and beverage services. Fare prices are low and fixed, making the airline an attractive prospect to potential air travellers.

4. Airlink took the opportunity afforded by the Pandemic to split from SAA. The airline also secured many impressive interline agreements with large international carriers. Airlink boasts an impressive network with flights to over 40 cities in Africa. The carrier's flexible and efficient fleet of Embraer jets is well suited to the current levels of air travel demand being experienced within the market. The fleet is capable of achieving excellent revenue per seat kilometre with its smaller, lower capacity and less costly aircraft.

5. FlySafair has proven to be the most robust of South Africa's commercial airlines. The airline continued to operate flights throughout the Pandemic despite low levels of demand. At one stage, FlySafair accounted for 74% of all available seats in South Africa. The airline took the opportunity to expand its fleet by ordering two next generation 737s. FlySafair also opened up many routes to new destinations.

2.5 PREVIOUS AIR TRAVEL DEMAND CRISES

The air travel industry has suffered its fair share of global crises during the past century. These crises range from oil shortages to wars to infectious disease outbreaks which have all caused extensive damage to global air travel demand. None of the past crises, however, have proven to be as damaging or long lasting as the current Coronavirus Pandemic. It is important that studies conducted on the effects of these previous crises are reviewed. This will provide insight and aid in understanding the entire potential effect that the Pandemic could have on air travel demand.

2.5.1 9/11

The terrorist attacks against the United States of America (US) had an immediate and negative effect on the air travel industry. The attacks were carried out by Islamic extremist group, Al-Qaeda, by hijacking and flying commercial aircraft into the Pentagon and both Twin Towers of the World Trade Centre. The involvement of airlines and aircraft ignited multiple safety concerns which led to large scale commercial fleet groundings and security operations. The events of 9/11 led to a 31.6% reduction in U.S. air travel passenger numbers for September 2001 compared to September of the previous year (Clark, McGibany and Myers, 2009).

Legacy carriers were forced to reduce costs to compete with new low-cost carriers which had seized the opportunity to enter the market. One example of this is when Ryanair capitalized on low aircraft prices by purchasing 100 Boeing 737's at a discount of 53%. Furthermore, reductions in capacity resulted in the loss of 62 000 airline related jobs within the US industry (Sehl, 2020).

In 2006, an article published in the Journal of Applied Economics attempted to determine whether the effects of the terrorist attack had been temporary or longer lasting (Blunk, Clark and McGibany, 2006). The researchers state that air travel demand for the period of Sept – December 2001 was down by 20% compared to the same period in 2000 and that profits for the last quarter of 2001 declined by $3.2 billion. The researchers state that the events of 9/11 broke the US air travel industry's profitability streak of 24 quarters.

The paper aimed to use time-series data and econometric forecasting techniques to create a counterfactual scenario, in which the attacks do not take place, and compare it to actual air travel demand recorded following the attacks. The paper found that the attacks had a significant short run impact on air travel demand and resulted in the bankruptcy of multiple airlines. In addition, the paper found that the events of 9/11 were not temporary and that post 9/11 air travel volumes remained below volumes which would have been expected had the attacks not occurred.

A similar paper published in 2004 aimed to investigate the impact of the attacks on U.S. Airline demand. The researchers used monthly time-series data from 1986-2003 to analyse the demand shock. The researchers controlled for cyclical and seasonal trends as well as the immediate downward drop in demand resulting from the cessation of aviation operations. The paper concluded that the events of 9/11 resulted in longer lasting effects, in addition to the immediate 30% drop in air travel demand. The paper states that the events of 9/11 contributed to a persistent downward shift for air travel demand of 7.4%, still perceivable at the time the paper was written in November of 2003 (Ito and Lee, 2005). The researchers estimated that up to 90% of the ongoing negative demand shock experienced at the time could be attributed to the events of 9/11.

In 2004, researchers studied the impact of the 9/11 attacks on Spanish air travel demand (Inglada and Rey, 2004). The researchers employed an Auto Regressive Integrated Moving Average (ARIMA) model to analyse monthly air travel data for 1980 to 2003. The study found that the terrorist attacks led to long-term effects for Spanish air travel demand. The researchers attributed the ongoing impact to the implementation of numerous security measures resulting in lower levels of air travel convenience. The effects occurred in Spain at the same time as those felt by the US air travel industry but were not as strong.

While it must be noted that the air travel industry eventually recovered and recorded impressive growth between the events of 9/11 and the Coronavirus Pandemic, the abovementioned studies highlight the lasting effects which demand shocks can have on the air travel industry. It is clear that the recovery for the air travel industry following the Coronavirus Pandemic, a demand shock several times larger than that of 9/11, will not be swift or without lasting implications.

South African air travel was largely unaffected by the event of 9/11. South African air travel passenger movements rose by 104 286 from 7 948 374 in 2001 to 8 052 660 in 2002 (WorldBank, 2021).

2.5.2 Financial Crisis

The events of 9/11 sent shockwaves throughout the entire air travel industry. Longer lasting demand impacts, however, were not as severe for the African and more specifically, South African, air travel industries. Due to the South African focused nature of this study, the 2008 financial crisis and its specific effects on the African air travel industry must be reviewed and understood.

The CEO of IATA at the time, Giovanni Bisignan, stated that the global financial crisis of 2008 had plunged air travel to passenger volumes last seen in 2006, thereby costing the air travel industry two years of growth. Similarly, Airport Council International (ACI) established that European airports would lose out on 105 million passengers for 2009, falling below 2006 levels (CAPA, 2009).

African air travel demand was damaged in a similar fashion. October 2009 RPKs for the continent were 2.6% lower than October 2008 levels. This was only marginally better than European RPK growth (-3%) and on par with the negative impact felt within the North America industry (CAPA, 2009). As discussed in the previous section, South African air travel industry was hit harder by the financial crisis than the events of 9/11. Air passengers carried by South African registered airlines for 2008 equalled 13.1 million. This figured dropped by 631 808 to 12.5 million in 2009.

South African air travel demand made a sharp recovery the following year attributed to a strong influx of tourists who travelled to South Africa for the 2010 Football World Cup. In comparison, the total global air travellers rose from 2.2 billion to 2.25 billion from 2008 to 2009, mainly boosted by Middle Eastern air passenger demand growth which persisted despite the crisis (WorldBank, 2021).

2.5.3 Previous Infectious Disease Outbreaks

Since the turn of the century, a handful of infectious disease outbreaks have rocked the world. This sub-section will discuss the two outbreaks which impacted the global aviation industry the most. The Severe Acute Respiratory Syndrome (SARS) outbreak of 2002 and the Swine Flu Pandemic of 2009.

SARS is a contagious viral respiratory disease caused by a strain of Coronavirus discovered in April of 2003 and named SARS-CoV-1 (WHO, 2021). The virus originated in Guangdong, Southern China in November 2002 but the Chinese government only officially informed the World Health Organisation (WHO) in February 2003 (Huang, 2004). Due to slow action and censorship of information on the virus, the disease spread to 29 countries infecting 8096 people and killing 774 (CDC, 2013).

In an economic report written in January 2020, prior to the Covid-19 Pandemic , IATA labelled SARS as the disease which proved most disruptive to air travel numbers in recent years (IATA Economics, 2020b). The report also found that Asian airlines and airports were worst affected by the outbreak. In May 2003, at the peak of the outbreak, Asia-Pacific airlines suffered a 35% decline in RPKs. Asia-Pacific airlines reported annual RPK and revenue losses of US$ 39 billion and US$ 6 billion respectively for 2003.

While less affected than Asian airlines, losses suffered by US airlines were still severe. Airlines based in the US lost 3.7% (12.8 billion) of annual RPKs and US$ 1 billion in revenue for 2003 (IATA Economics, 2006). The outbreak led to a decline of 20% and 14% in passenger traffic for Hong Kong International Airport and Singapore Changi International Airport respectively. The most likely reason for the severe decline is the fact that both countries were placed on both the World Health Organisation (WHO) and Centre for Disease control and prevention (CDC) travel advisory lists (Chung, 2015).

The most recent flu Pandemic occurred in 2009, caused by a novel H1N1 Influenza virus. The virus was also referred to as “Swine Flu”. The Pandemic ran from June 2009 to August 2010. One study suggests that in total the virus infected between 11 and 21% of the global population (700 million – 1.4 billion) (CIDRAP, 2011). A study published in The Lancet headed Infectious Disease Online Firsts, co-authored by 9 CDC Influenza specialists, believes that the virus killed between 150 000 – 500 000 people, making it about as deadly as seasonal flu (Dawood *et al.*, 2012).

The WHO issued a level 6 Pandemic alert (the highest level) but did not issue travel restrictions (Chan, 2009). The avoidance of travel restrictions meant that air travel demand was not as severely impacted as it was during the SARS outbreak. One study aimed to analyse the impact of the Swine Flu Pandemic on 12 Asian airports. The researchers found that eleven out of the twelve airports surveyed reported decreases in passenger volumes for 2009 (Chung, 2015). Tokyo International Airport reported the largest decline in passenger numbers at –7.2%.

The overall impact on the twelve airports was far less severe than predicted or expected. The researchers attribute this to the previous SARS outbreak and how it had prepared Asian airports to manage such crises. In the end, the H1N1 virus turned out to be far less severe than expected and global air travel was subsequently impacted only on a minimal scale.

Summary of findings:

1. The attacks of September 2001 had significant short-term effects on U.S. air travel demand and the air travel industry in general.

2. Two studies proved that the effect was not only temporary but also longer lasting with effects being felt up until the time of writing in November 2003.

3. The main takeaway is that smaller and more isolated demand shocks, relative to the current Pandemic, still have the power to have a long-term impact on air travel demand.

4. The 2008 financial crisis cut international travel growth by two years. The effects of the crisis hit Africa harder than the events of September 2001. South African air travel demand dropped by 4.8%, or 631 808 passengers for the year of 2009 but made a strong recovery in 2010.

5. The epidemiological nature of the virus meant that tracing and isolation measures were effective in limiting the spread of SARS. Infections were mostly

limited to Asia. Subsequently, Asian-Pacific airlines were the hardest hit. Air travel in the region recovered strongly after 9 months.

6. The H1N1 outbreak of 2009 turned out to be a false alarm with the disease proving to be far less fatal than first thought. The impact on the air travel industry was less severe than expected thanks to the WHO deciding not to put restrictions on travel early on in the Pandemic.

2.6 INTERVENTION ANALYSIS

In time series analysis, intervention analysis can be defined as a modelling technique used to incorporate the effects of exogenous factors or interventions (Matarise, 2011). The external shocks, to which the time series is subjected, may be permanent, temporary or abrupt interventions. Examples of exogenous factors can be weather disasters, policy changes, wars, resource shortages or communicable diseases. Interventions result in unexpected or unusual changes in the time series data. For example, the Coronavirus Pandemic and its associated travel restrictions have led to a drastic decline in global air travel demand.

One of the earliest breakthrough applications of the intervention analysis was performed in 1975 when researchers attempted to investigate the impact of two interventions which occurred in Los Angeles in the 1960's (Box and Tiao, 1975). The paper aimed to analyse the effect of traffic diversion caused by the opening of the Golden State Freeway as well as policy changes relating to the regulation of hydrocarbons within petrol sold locally at the time. The authors of the paper state that intervention analysis is a useful modelling tool granted that the exogenous factors or interventions occurred at a known point in time.

In 1996 another successful application of time series intervention analysis was undertaken by Bonham and Gangnes (2010) who examined the effect of newly implemented room taxes on Hawaiian hotel revenues. Intervention analysis was found to be very effective in measuring the impact of shock events on forecast variables for various other studies (Montgomery and Weatherby, 1980; Izenman, Alan and Zabell, Sandy, 1981).

Goh and Law (2002) further proved the usefulness and accuracy of intervention analysis. The researchers attempted to examine the effectiveness of the use of SARIMA intervention analysis to forecast tourist demand for Hong Kong following various large interventions, namely visa policy changes, a Bird Flu outbreak and the Asian financial crisis. The SARIMA with intervention analysis model was comparatively analysed alongside eight other time series models and found to produce the most accurate of tourist demand forecasts.

In 2005, an important intervention analysis study was undertaken, aiming to analyse the effect of the 9/11 attacks on US air travel passenger demand (Lee, Oh and O'Leary, 2005). The researchers established that recent ARIMA modelling methods outperformed other time series forecasting techniques. The article found the attacks led to a demand decline of 64 million seats in the first nine months with the impact decreasing each month.

By the end of month 9, the model indicated that 95,2% of the impact had passed. The results therefore indicated a strong short-term impact, unlike studies discussed in above sub-sections, and no major long-term effect. The researchers did however state that demand had not fully recovered at the time of writing but that the trend indicated a continuously decreasing impact. The researchers said that the study was hindered by insufficient post-intervention observations. The study offers valuable insight that can be used by policy makers involved in planning procedures and crisis management of future interventions.

A further important example of intervention analysis to forecast air travel demand was conducted in 2010. The purpose of the study was to examine the impact of the SARS outbreak on the arrival of Japanese tourists to Taiwan (Min *et al.*, 2011). Prior to the outbreak, Japanese tourists accounted for 30% of all tourist visits to Taiwan. The researchers created a pre-intervention, or counterfactual, model based on 291 observations between January 1979 - March 2003. After this, the researchers used SARIMA with intervention to assess the impact of the epidemic.

Residual autocorrelation was found to be small when compared to the standard errors, therefore suggesting that the model was a suitable fit. The counterfactual and intervention scenarios were comparatively analysed. The model results indicated that there had been a 50% decline in Japanese tourist arrivals in the 5 months following the outbreak. May 2003 showed the highest decline of 92%, when the WHO issued travel warnings relating to Taiwan.

The number of inbound Japanese tourists started to increase gradually from July 2003 following the removal of Taiwan from the WHO's travel advisory red list. The decrease in impact following the announcement shows the influence that the WHO's advisories have on consumer travel decisions as well as passengers' willingness to travel by air soon after infectious outbreaks. The researchers stated that it is important that government and policy makers analyse the impacts of such interventions to aid in the handling of future crises and that the study provides insight on how tourist industries may respond to similar shocks.

SUMMARY OF FINDINGS

1. The literature review revealed that intervention analysis has been successfully employed in multiple studies aiming to analyse the impact of exogenous factors on timeseries data.

2. Studies have used intervention analysis to measure the impact of various interventions, such as 9/11 and infectious disease outbreaks, on air travel demand.

3. One study compared SARIMA with intervention analysis to eight other modelling techniques and found it to be the most accurate.

4. All intervention studies reviewed concluded that the results of the studies can be used to aid policy planners and crisis management officials in the future.

5. Conducting comparative analysis between the counterfactual forecast and intervention forecast is a reliable way of measuring the impact of crises on air travel demand.

6. The main takeaway is that intervention analysis has proven to be an effective tool in measuring the effects of crises and can therefore be expected to be successful in analysing the impact of the current Pandemic on South African air travel demand.

2.7 RECOVERY PREDICTIONS

Various organisations within the aviation industry have constructed their own recovery predictions and scenarios. Such predictions are difficult to create but are essential to industry stakeholders who use them in strategic decision making and planning. Due to the unprecedented uncertainty and unpredictability of the situation relating to Covid-19 Pandemic and its effects on air travel, findings from these reports may change after the publication of this paper.

In May 2021, Chief Economist of IATA, Brian Pierce, released a long-term post Pandemic passenger recovery report. The report produced interesting findings and showcased IATA's confidence in the recovery of the industry (Pearce, 2021). Figure 4, below, has been sourced from the report and shows that previous demand shocks (measured in RPKs), such as the 1991 global recession, 9/11 and the SARS Pandemic, did not last long and all ended within 6-18 months. Findings in the literature review section support this argument.

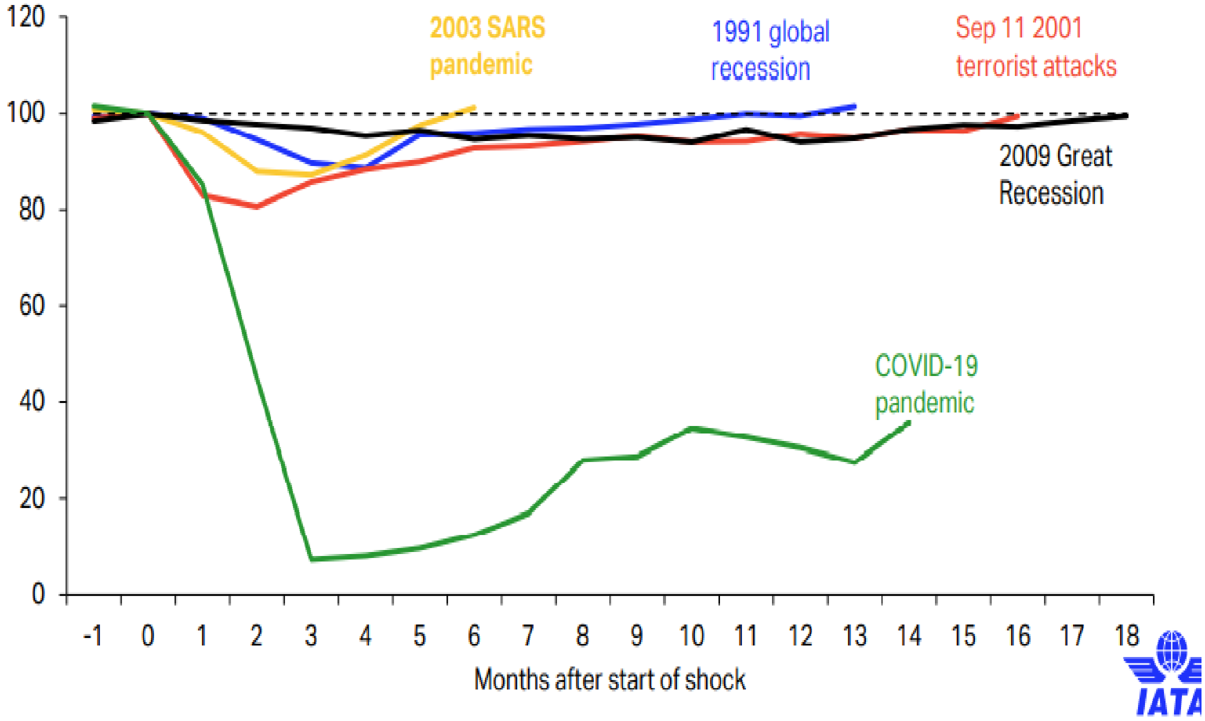

Figure 4: Previous demand shocks recoveries measured in RPKs, 14 months after start of Pandemic, indexed at start of shock (Source: Pearce, 2021)

It is, however, crucial to remember that the effect of the Covid-19 Pandemic is of an unprecedented scale which will entail extended and interrupted periods of recovery. It remains to be seen if it can be compared to previous demand shocks. The figure illustrates that, 14 months after the Covid demand shock, global RPKs remained below 40% of 2019 levels.

On a supplementary note, in October 2021, another senior economist at IATA, Ezgi Gulbas, provided an updated figure, Figure 5 below, illustrating the difference between the Covid Pandemic shock and previous demand shocks after 19 months. The figure shows that 5 months after Pearce's report and 19 months after the shock, global RPKs still remained below 40% of 2019 levels.

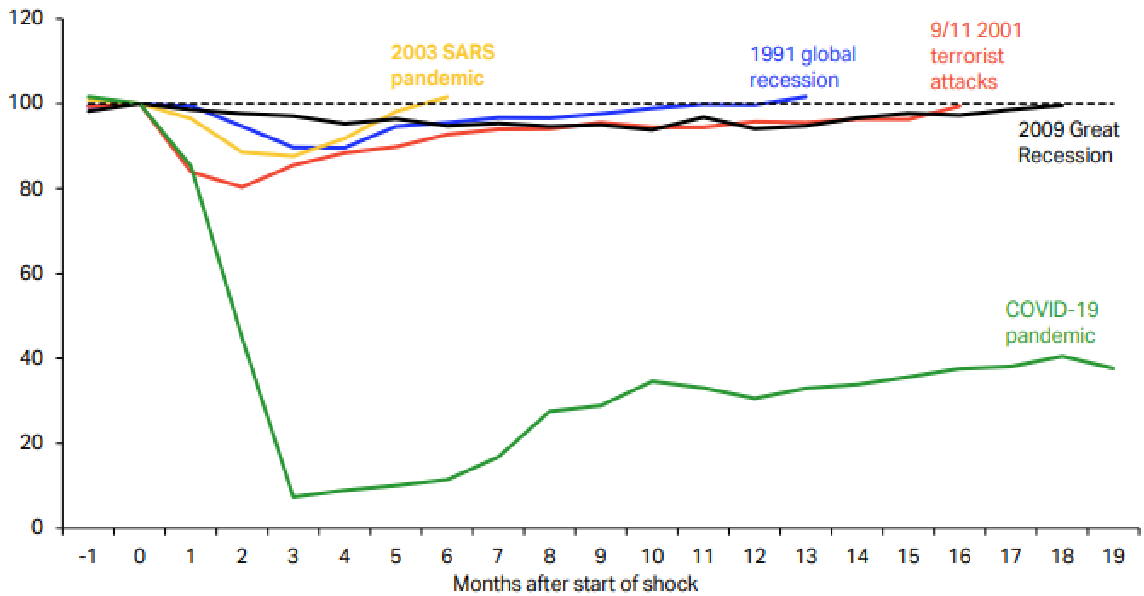

Figure 5: Previous demand shock recoveries measured in RPKs, 19 months after start of Pandemic, indexed at start of shock (Source: Gulbas, 2021)

The report created by Brian Pearce highlighted a positive and important aspect for the recovery of air travel - the fact that the global economy has recovered very well.

Figure 6, shown below, illustrates that by the end of 2020, global industrial production as well as cross-border trade had recovered and went on to settle 2% higher than pre-Pandemic levels by February 2021. The recovery of these two indicators is extremely promising as economic health is strongly linked to air travel demand (Florida, Mellander and Holgersson, 2015; InterVISTAS, 2015; Zhang and Graham, 2020).

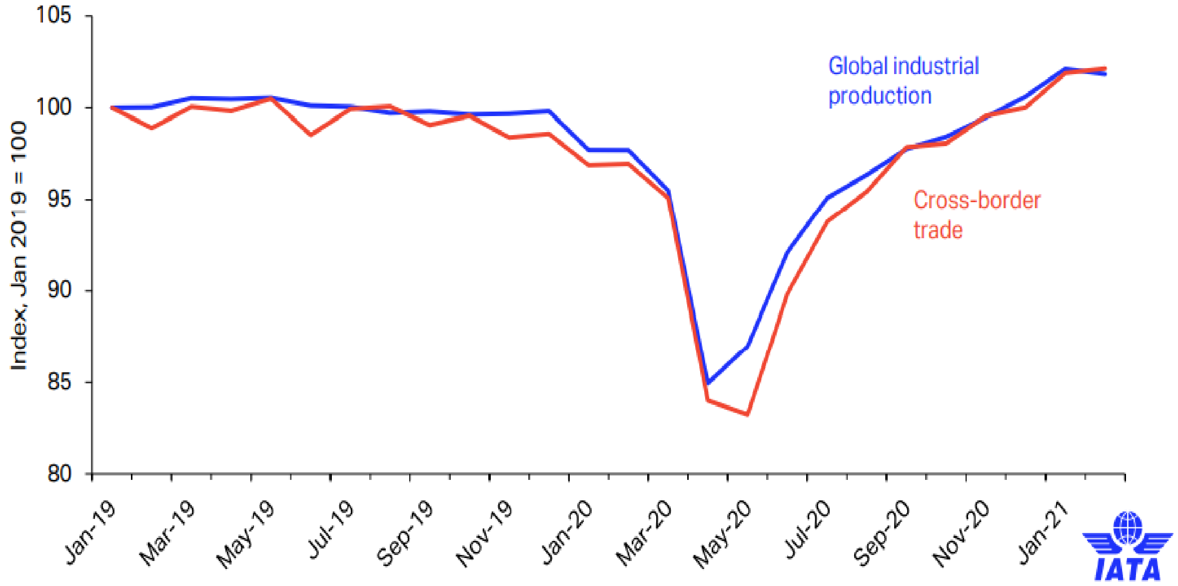

Figure 6: Global economic recovery (Source: Pearce, 2021)

The Pearce report also discovered compelling evidence of pent-up demand amongst air travellers. In May 2021, the United Kingdom (UK) added Greenland, Gibraltar, Portugal and Iceland to its "Green list" of nations to travel to. Flight bookings to these nations immediately increased from 80% below to 40% above 2019 levels. The recovery of the global economy paired with this evidence of air passengers' desire to travel, when allowed, provides hope for a strong recovery when restrictions are eased.

The same report states that different markets will recover at vastly different rates. These differences can be based on vaccination campaigns, virus outbreaks, risk aversion and travel restrictions. Regions with strong domestic air travel markets will recover quicker than those more dependent on international travel. This point is supported by the fact that Middle Eastern airlines, heavily dependent on international travel, have proven to be some of the worst affected airlines during the Pandemic

(Harper, 2021). The report stated that Asian, North and South American markets are expected to reach 2019 levels by the end of 2022. Middle eastern, African and European markets are predicted to lag behind and recover by the end of 2023.

Figure 7, below, shows the full impact of the Pandemic as predicted by IATA. The April 2021 forecast predicted that air traveller volumes compared to 2019 will be 52% for 2021, 88% for 2022 and 105% in 2023. By 2023 global passenger numbers are predicted to reach 5.6 billion, 7% lower than pre-intervention forecasts. Figure 7 also illustrates that IATA predicts that the Pandemic will cost the industry 2 years of growth.

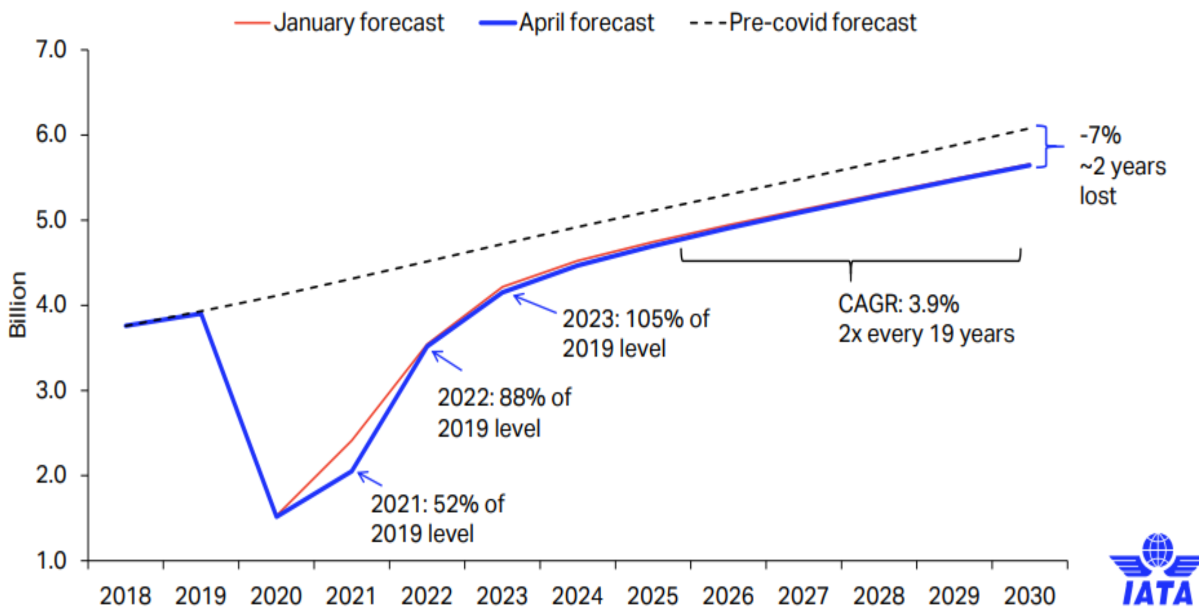

Figure 7: Global passenger movement estimates (O-D) until 2030 (Source: Pearce, 2021)Table 3, below, shows ICAO's predicted recovery forecast of international and domestic air travel in the first and last months of 2022, as stated in ICAO's Impact Analysis report, called: Effects of Novel Coronavirus (COVID-19) on Civil Aviation: Economics Impact Analysis.

Table 3: ICAO international and domestic recovery forecast 2022 vs 2019 levels (Source: ICAO Air Transport Bureau, 2022)

	DOMESTIC	INTERNATIONAL
JAN 2022 VS. 2019 LEVELS	75.3%	42.6%
DECEMBER 2022 VS. 2019 LEVELS	84.8% to 94.4%	60.7% to 76.5%

The ICAO report predicts that global domestic air travel will rise from 75.3% of 2019 levels in January 2022 to between 84.8% and 94.4% by the end of 2022. International air travel is expected to improve on recovery levels of 42.6% in January 2022 to between 60.7% and 76.5% by December 2022. These predictions will be compared to this papers intervention forecast results in Chapter 4:

Global consultancy agency, Bain and Company, started constructing regularly updated forecasts of global RPK recovery based on 4 different scenarios (Bain and Company, 2021). The forecasts are built by the Bain analysis team based on projected market and financial information provided by external financial organizations as well as data from IATA, International Monetary Fund, Johns Hopkins University, University of Oxford, World Bank and Numbeo.

The four scenarios constructed are as follows:

1. Baseline - The most likely outcome based on current situation.

2. Coordinated recovery - Systematic collaboration and execution of effective global Pandemic responses across all regions.

3. Accelerated vaccine - The widespread availability of an effective vaccine (or other treatment) which occurs in phases across all regions.

4. Drifting - A persistent Pandemic consisting of widespread rolling waves of outbreaks due to inefficient and ineffective government and social response to outbreaks.

The four abovementioned scenarios are also compared to a 2019 pre-crisis forecast. The spread of the Delta variant led to massive air travel projection declines in the forecast update of September 2021. The variant led to large reductions in consumer travel confidence and long-haul flight projections. The Delta variant was a stark reminder that overly optimistic predictions need to be kept in check (Schaper, 2021).

Figure 8, below, illustrates the recovery of global air travel RPKs based on the different scenarios created by Bain and Company, as of September 2021.

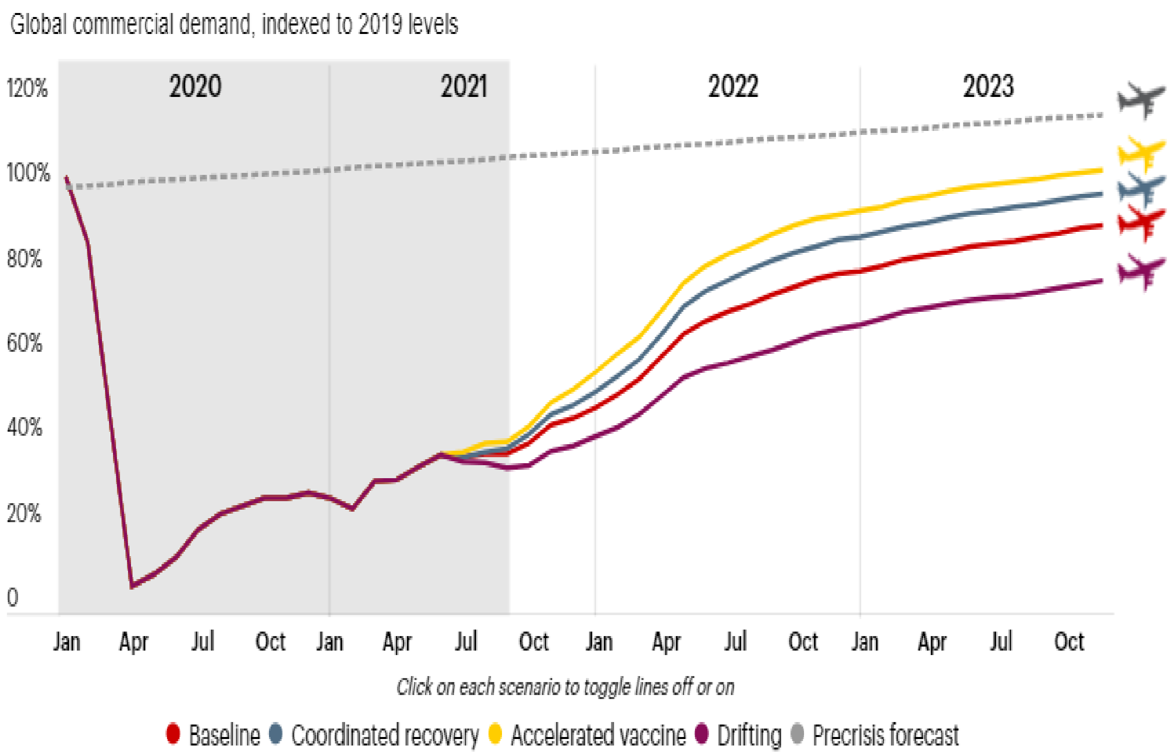

Figure 8: Global air travel demand estimates Jan 2020-Oct 2023, as of September 2021 (Source: Bain and Company, 2021)

The Bain and Company September 2021 forecast aligns with the data cut-off date for the model constructed for this paper. The models will thus be referenced against each other in the results section of this paper. The forecast clearly suggested that an accelerated vaccination program would offer the quickest recovery of global air travel demand. By the beginning of 2022 air travel was expected to reach 56.79% of 2019 levels under optimistic scenario conditions. Nearly full recovery was predicted by the end of 2022 at 94.66% under such conditions. A scenario in which coordinated recovery took place would mean that recovery levels would have reached 52.18% by January 2022 and 88.64% by the end of 2022.

For the September 2021 model, the baseline, or current predictions, forecasted that air travel would reach only 48.46% of 2019 levels by the beginning of 2022 and 80.50% by the end of 2022. The most pessimistic “drifting” scenario illustrates the expected effects of the emergence of new variants and continuous waves of outbreaks. This scenario suggested that by the beginning of 2022 only 41% of air travel demand would have been recovered. Recovery throughout 2022 will remain low at around 67.78% by the end of the year.

The accelerated vaccine scenario would see full recovery of air travel demand in May 2023. The drifting scenario, by comparison predicts that air travel levels will be 22% lower at 78.24% of 2019 levels in May 2023 with baseline estimates lagging behind the accelerated vaccine scenario by 15% at 85.29%. These results will be compared to the results of this paper’s recovery model in Chapter 4.

As shown below in Figure 9, Bain and Company also predicted the air travel demand levels of various regions for June 2022. China is expected to show full demand recovery by mid-2022 followed strongly by the United States and Russia, both at 83%. This supports IATA's statement that large domestic markets will recover the quickest. South Africa is expected to regain 69% of its 2019 air travel demand by June 2022. This puts South Africa on par with predictions for Germany and ahead of nations such as Japan and India which are expected to reach recovery levels of 55% and 56% respectively. These predictions will be compared to the forecasting predictions generated by this papers model.

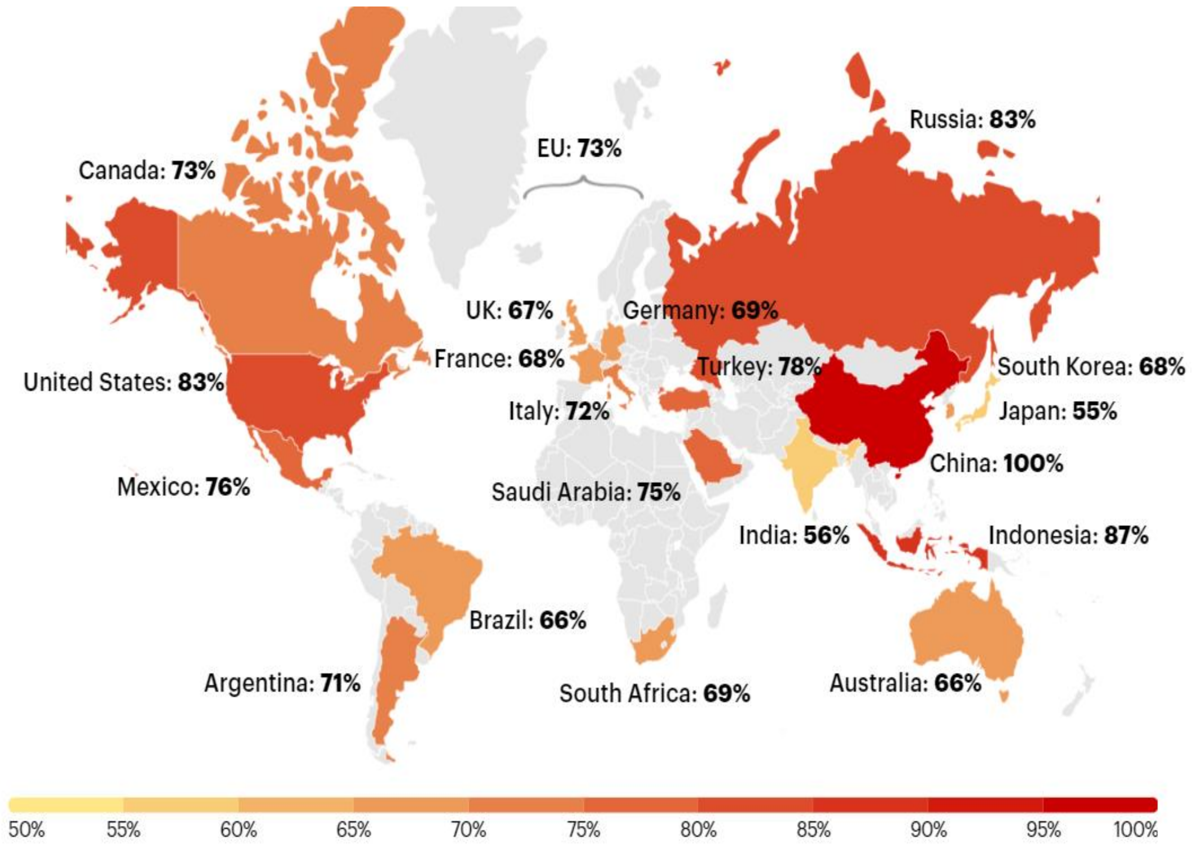

Figure 9:June 2022 predictions for air travel demand versus 2019 levels (Source: Bain and Company, 2021)

Gudmundsson, Cattaneo and Redondi (2021) studied the relationship between air travel demand recovery and large economic shocks. The study predicts the recovery of air travel demand in the presence of the Covid-19 Pandemic. The paper used an

Autoregressive Integrated Moving Average with Exogenous Variables (ARIMAX) model to predict the recovery of passenger demand, split into four regions: Asia, North America, Europe and World. The model predicted that on average air travel demand would bounce back to 2019 levels in 2.4 years starting in 2020. The analysis suggests that 66.5% of cases would recover by the end of 2022, 27.5% by the end of 2023 and 6.3% after 2023. The model included optimistic, average and pessimistic scenarios. The most optimistic scenario predicted world recovery by mid-2022 while the pessimistic forecast predicted recovery in only 2026.

The researchers note that the findings suggestion that air travel demand will recover to 2019 levels is in contrast with most macro-economic studies, which tend to state that exogenous shocks are permanently scarring to the economy. The study finds that even after severe Pandemic lockdowns and restrictions, air travel shocks will not be permanent. The authors highlight the fact that the findings of this paper are well supported by a multitude of studies within the air transport industry which all advocate that air travel is notoriously capable of bouncing back following exogenous shocks (Balke and Fomby, 1994; Pearce, 2012; Perron, 1989; Rappoport and Reichlin, 1989).

The researchers state that while new scenarios may arise, current findings suggest that the effect of the Pandemic on air travel demand will be temporary and not permanent. These findings will be considered during the model selection phase of this paper.

SUMMARY OF FINDINGS

1.) Review of IATA's long-term recovery presentation shows that previous demand shocks lasted 6-18 months. IATA has strong confidence that air travel demand will recover well.

2.) The global economy, which is strongly linked to air travel demand, measured in cross-border trade and global industrial production, has recovered well, surpassing 2019 levels.

3.) IATA highlighted that there is definite pent-up demand amongst passengers. Nations moved to a "green list" saw large increases in air traveller arrivals, in one case an increase from 80% below to 40% above 2019 levels in the space of a week.

4.) Strong domestic markets, such as China and the US, will recover first with Middle Eastern airlines set to take longer.

5.) IATA predicts that 2022 will see global air travel demand at 88% of 2019 levels with full recovery to take place in 2023.

6.) IATA predicts that 2-3 years of air travel demand growth will be lost.

7.) Bain and Company predict that in the best-case scenario, air travel demand will reach 94% of 2019 levels by the end of 2022. Conversely, the worst-case scenario will see air travel demand rise to only 67% of 2019 levels by the end of 2022.

8.) Bain and Company predict that South African air travel demand will recover to 69% of 2019 demand by June 2022.

2.8 OVERALL SUMMARY OF LITERATURE REVIEW

The first section of the literature review aimed to investigate the effect of the Covid-19 Pandemic on global air travel. It was found that the shock resulted in an immediate 94% decline in air travel demand, resulting in a revenue loss of $466 billion for the year of 2020. This instantly cemented the event as the largest ever air travel demand crises.

The effects of the Pandemic on South African airports and airlines were just as severe and damaging. ACSA reported a revenue loss, R2.6 billion, in 2020 – for only the second time in 28 years. ACSA reported that domestic air travel demand fell by 62% in 2020 and 30.8% in 2021 compared to 2019 while international air travel demand declined by 74% for both years respectively. The Pandemic led to 4 of South Africa's airlines being put into business rescue leaving Airlink, FlySafair and Lift to capitalise.

Investigation into previous air travel demand crises further showcased the immense impact of the Covid-19 Pandemic on air travel. None of the previous air travel demand crises such as 9/11, SARS or the 2008 Financial Crisis, come near to the Pandemic in terms of duration and magnitude of the shock to air travel demand. Examining these past events does however give insight into how recovery may take place.

The next section of literature review examined the use of intervention analyses. Literature shows that intervention analysis has been successfully employed to analyse the impact of exogenous shocks on time series data many times. Intervention analysis has been used in many studies that investigate the impact of shocks mentioned in the previous section.

The final section of the literature review investigated recovery predictions and forecasts from established organisations such as IATA, ICAO and Bain and Company. Findings suggest that the recovery will take time but that there is a large amount of pent-up demand that will accelerate recovery when restrictions are eased. The findings from IATA suggest that 2-3 years of air travel demand growth will ultimately be lost as a result of the Covid-19 Pandemic.

CHAPTER 3: DATA AND METHODOLOGY

3.1 INTRODUCTION

For the purposes of the intervention analysis forecast model constructed in this study, quantitative data on domestic, international, regional and unscheduled air traveller passenger numbers, between April 2012 and September 2021, was obtained from ACSA. The data captures total monthly passenger departures and arrivals as well as aircraft movements, for all carriers operating at ACSA airports. This study will analyse only the international and domestic air travel data as the regional and unscheduled figures are negligible.

This is widely regarded as the best source of comprehensive South African air traveller passenger movement data. ACSA handles over 97% of all air transport services and passenger movements in South Africa and operates the nine largest airports in the country (Baikgaki and Daw, 2013). It can therefore be assumed that ACSA passenger movement data provides an excellent representation of South African air travel demand. For reference, Figure 10 ,below, illustrates the nine ACSA airport locations with the size of the bubbles linked to the total annual passengers carried in 2019.

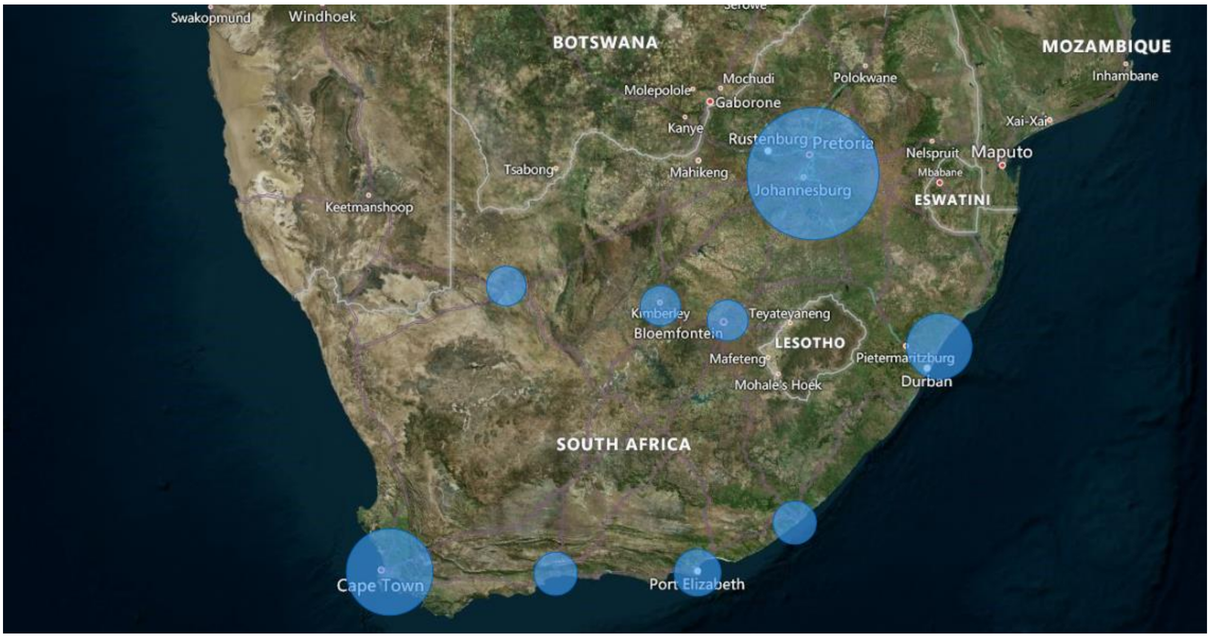

Figure 10: ACSA airport locations by total annual passenger count in 2019 (Source: ACSA, 2019) (Own analysis on Power BI)

The data is not of a sensitive nature as it does not contain any individual airline, passenger or ticket information and presents the data at a consolidated level. The passenger movement data can be freely and openly found on ACSA's website (ACSA, 2022b). The data on the website, however, only dates back to 2016. In order to obtain a larger range of data, ACSA was contacted via email. ACSA provided passenger movement data dating back to April 2012.

After further communication with ACSA, it became clear that it was not possible to secure time series data older than this. The data set contained a satisfactory number of observations (114) to construct the SARIMA intervention model. It was decided that data up until September 2021 would be used. This was the latest available data when construction of the model commenced just after ethical clearance was granted (see following section). Waiting for new data would have further delayed construction of the model, thereby reducing the timeliness of the results of this study. Furthermore, only the forecasting component of the research is hampered by the limited post intervention observations as the impact analysis was conducted on actual observations. Future research can build on the model and use newer data.

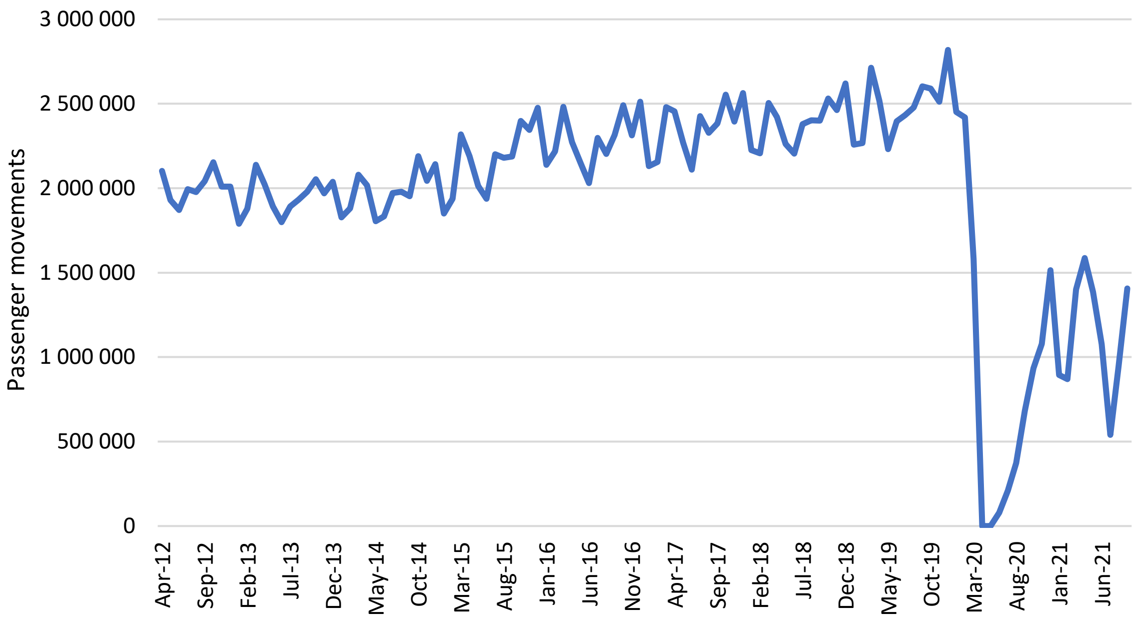

Figure 11: Domestic passenger movements April 2012 - September 2021 (Source: ACSA, 2022b)

Figure 11, above, shows ACSA domestic passenger arrivals and departures between April 2012 and September 2021. Between 2012 and the Pandemic, South African domestic air travel had shown strong annual growth reaching its highest peak ever at 2 818 636 passengers in December 2019. 2019 in general was a positive year for domestic air travel as ACSA enjoyed its busiest festive period on record in terms of domestic passenger numbers.

The first effects of the Pandemic and its associated travel restrictions were felt in March 2020 when domestic air travel movements fell to 1 580 370, 58% below March 2019 figures. The South African lockdown meant that not a single domestic air passenger movement was recorded in the months of April and May of 2020. From

June to December 2020, South African domestic air travel demand grew each month. In December 2020 1 514 920 domestic passenger movements were recorded, a recovery of 53,7% compared to December 2019 figures. A solid recovery looked to be underway.

The more contagious Beta variant, discovered in August 2020, had started to spark South Africa's second wave of cases by November 2020. The second wave ravaged the country and peaked in January 2021 (Al Hasan *et al.*, 2022). Subsequently, December's growth was cut short as domestic air traveller movements fell to 894 409 and 869 585 for January and February 2021. The subsidence of the second wave led to large domestic demand recovery in March 2021 as passenger movements grew by 530 493 or 61%, the largest monthly recovery increase during the Pandemic. By April 2021, domestic passenger movements totalled 1 587 340. This is the highest recorded recovery so far at 63% of April 2019 figures.

Hopes of a recovery were again spoiled by the emergence of a new variant in India, the Delta variant. The Delta variant contributed to India's devastating second wave which emerged in late 2020 and cases peaked in May 2021 (Masih, 2021). During the same month, cases in South Africa began to climb dramatically and passenger movements immediately declined. When the Delta wave peaked in July 2021 at 20 000 cases per day, domestic passenger movements fell to 539 692 for July 2021, lower than figures recorded in September 2020 and 78% below July 2019 figures (Al Hasan *et al.*, 2022).

The third wave subsided, and passenger movements began to pick up. In September 2021 ACSA recorded 1 406 616 domestic passenger movements, 54% versus September 2019 numbers.

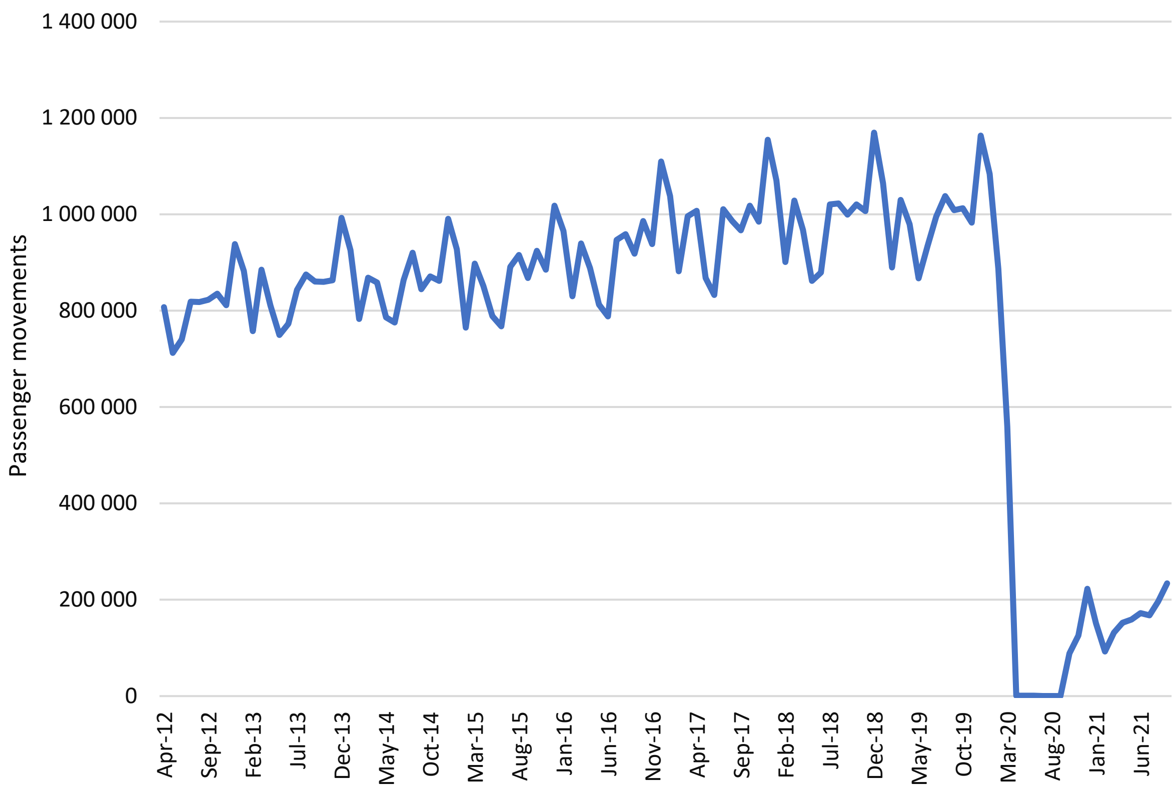

Figure 12: International passenger movements April 2012 – September 2021 (Source: ACSA, 2022b)

Figure 12, above, illustrates ACSA international passenger movements recorded between April 2012 and September 2021. ACSA international air travel figures for the 2019/2020 festive period were on par with those of the 2018/2019 period. In March 2020, international air passenger movements fell to 559 172, 54% of 2019 figures. The decline was slightly worse for international passenger numbers than it was for domestic. This can be attributed to the early implementation, relative to South Africa, of travel restrictions by various countries.

Between April and September 2020, only 3101 international passenger movements were recorded at ACSA airports. In October 2020, partial restrictions on international travel to and from South Africa began to be lifted and in December 2020, 222 639 international passengers arrived at and departed from South African airports, a recovery of 19% compared to 2019 figures. The second wave, caused by the Beta variant, led to a decline in the already beleaguered international air travel recovery rate, falling to 92 186 or 10% of 2019 numbers.

Interestingly, from February onwards, international air travel passenger numbers for South Africa continued to rise every month to 23% of 2019 figures by September 2021, despite the Delta fuelled third wave. This can be attributed to the increasing number of vaccinated travellers at the time.

3.2 ETHICAL CLEARANCE

An application for ethical clearance was submitted and reviewed by the Research Ethics Committee: Social, Behavioural and Educational Research (REC: SBE) on the 24th of June 2021. The REC:SEC communicated that the study is exempt from the ethical review and clearance process for the following reasons:

1.) The study includes data which is freely accessible to the public.
2.) The study does not include the participation of human subjects.
3.) The study does not involve personal identifiable information.

Data collection only commenced after receiving the exemption of ethical clearance and review letter from the REC: SEC.

3.3 MODEL BACKGROUND AND JUSTIFICATION

During the literature review stage of this paper, it became clear that intervention analysis could be successfully used to analyse the effect of the Pandemic on South African domestic and international travel. As discussed in the literature review section, intervention analysis has been used in multiple studies to successfully analyse the effects of exogenous shocks on time series data. Intervention analysis is universally regarded as the standard technique used to analyse effects of interventions on time series (Gilmour *et al.*, 2006; Pennsylvania State University, 2021).

More specifically, many studies have used intervention analysis to examine the effects of such shocks on air travel demand. These studies include shocks such as the 9/11 terrorist attacks, 2002 SARS outbreak, 2008 financial crisis, and 2009 Swine Flu Pandemic (Goh and Law, 2002; Lee, Oh and O'leary, 2005; Min *et al.*, 2011).

In time series, intervention analysis is the analysis of how the mean level of the series has changed following a shock (intervention). In the case of this study, the goal is to analyse the effect of the Covid-19 Pandemic on ACSA domestic and international passenger movements. Due to the unpredictable nature of the Pandemic, it was decided that a simple, efficient and parsimonious model would be required. The usual variables historically linked to air travel and used to predict air travel demand, such as GDP, oil and aviation fuel prices, are more difficult to employ during the Pandemic as air travel has remained affected while the global economy and associated social economic variables have rebounded relatively well (Valput, 2020).

The historic relationship between these variables and air travel will not hold for the next few years and until the Pandemic is over. This is well supported by various research endeavours, which for example, found that world GDP fell between 10-15% in 2020 while air transport demand fell to as low as 70% in some regions (Gudmundsson, Cattaneo and Redondi, 2021; McKibbin and Fernando, 2021).

It is clear that the relationship between these traditional variables and air travel has become very strained and unreliable. Traditional multiple regression analysis techniques, which employ the usual variables named above, are therefore difficult to use during the Pandemic. It was thus decided to focus on a univariate approach using only the ACSA passenger movement data instead of an analysis compromised by complexity. The advantages of a univariate approach are that the model is robust and easy to build, adjust and interpret (Sahoo, Soumya, 2014).

In a 2013 paper, written by the UK Airports commission, varying forecast methods used within the aviation industry were addressed and discussed. The paper suggested that while forecasts which rely solely on historic values can sometimes be seen as simplistic, these models are able to respond more quickly to changes in demand and can be used as a benchmark for future models (Airports Commision UK, 2013). The decision to use a simple, robust and flexible model, for the purpose of this paper, is therefore justified due to the uniquely dynamic Pandemic environment. This papers model can be used by researchers in the future as a benchmark or baseline element.

Consultations were held with Stellenbosch University's Centre for Statistical Consultation (CSC) to evaluate the research objectives of the paper's proposed model and to ensure the overall construction of a suitable and satisfactory model.

During the meeting it was established that:

1. There are enough data observations (114) to construct a base model and intervention model
2. The simple univariate approach to the model would be best given the current Pandemic and unreliable nature of current variables and the relationships between them
3. A SARIMA with intervention model, using the ACSA data could be used to achieve the research objectives of this paper

3.4 MODEL DESIGN AND CONSTRUCTION

The design and construction of the model is illustrated below.

Both the domestic and international time series up to and including case 95 (February 2020) behave very similarly and therefore analogous models can be fitted to both. For the purpose of this paper, the international model design and construction process will be explained. See Annexure A: Domestic model, for the domestic model design specifications.

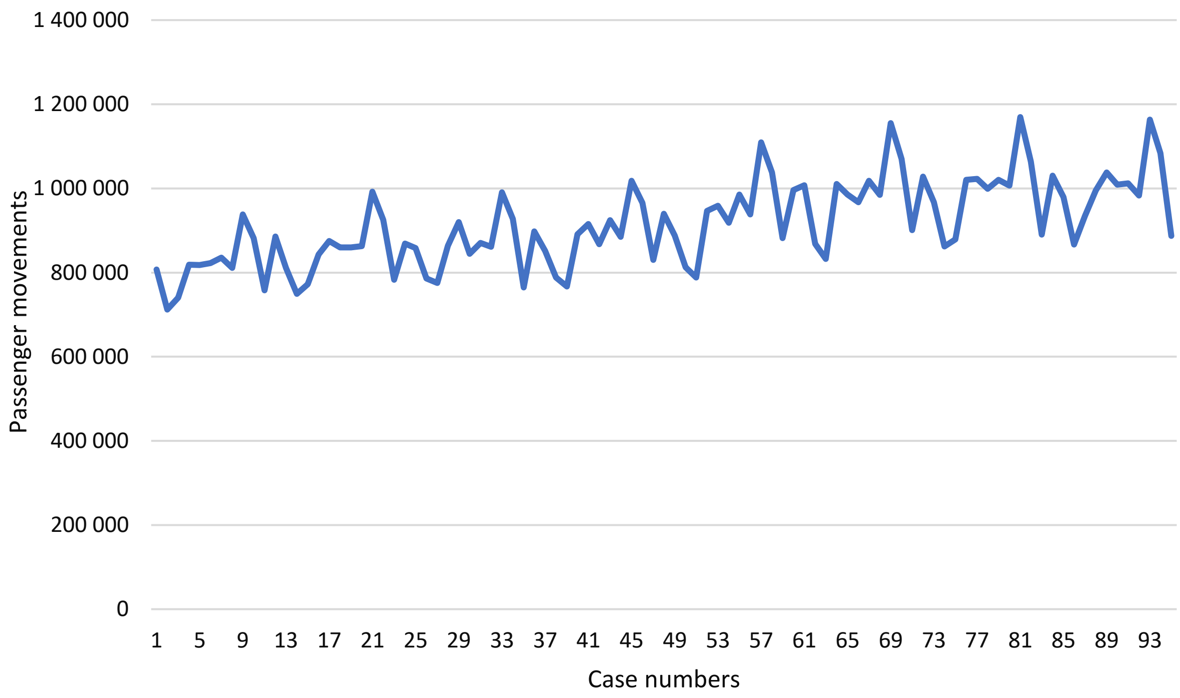

Figure 13: Plot of pre-intervention international variables (Source: ACSA, 2022b)

Figure 13 above shows the international cases (monthly passenger data) ranging from April 2012 up until February 2020, one month prior to the implementation of travel restrictions and lockdowns. The series has an upward linear trend and is therefore not a stationary series. A stationary series can be described as a series which has statistical properties, such as mean and variance, that do not change over time (Kwiatkowski *et al.*, 1992). The international series clearly changes over time and is therefore nonstationary. When constructing a forecast model, it is important to use stationary data as nonstationary data leads to unreliable and spurious results.

Nonstationary series can indicate a relationship between two variables that does not actually exist (Iordanova, 2021). The data needs to be “flattened” to remove increasing variances in order to be used in the model. The transformation of the data will stabilize the mean and remove seasonality and trend from the series. The nonstationary data will be differenced in order to transform it. Differencing entails taking a data observation at a certain time and subtracting it from the observation before it (Rasheed, 2020).

We differentiate the series to arrive at d(INT) = INT(t) – INT(t-1) for t = 2…, T where T = 95. The series d(INT) is then stationary.

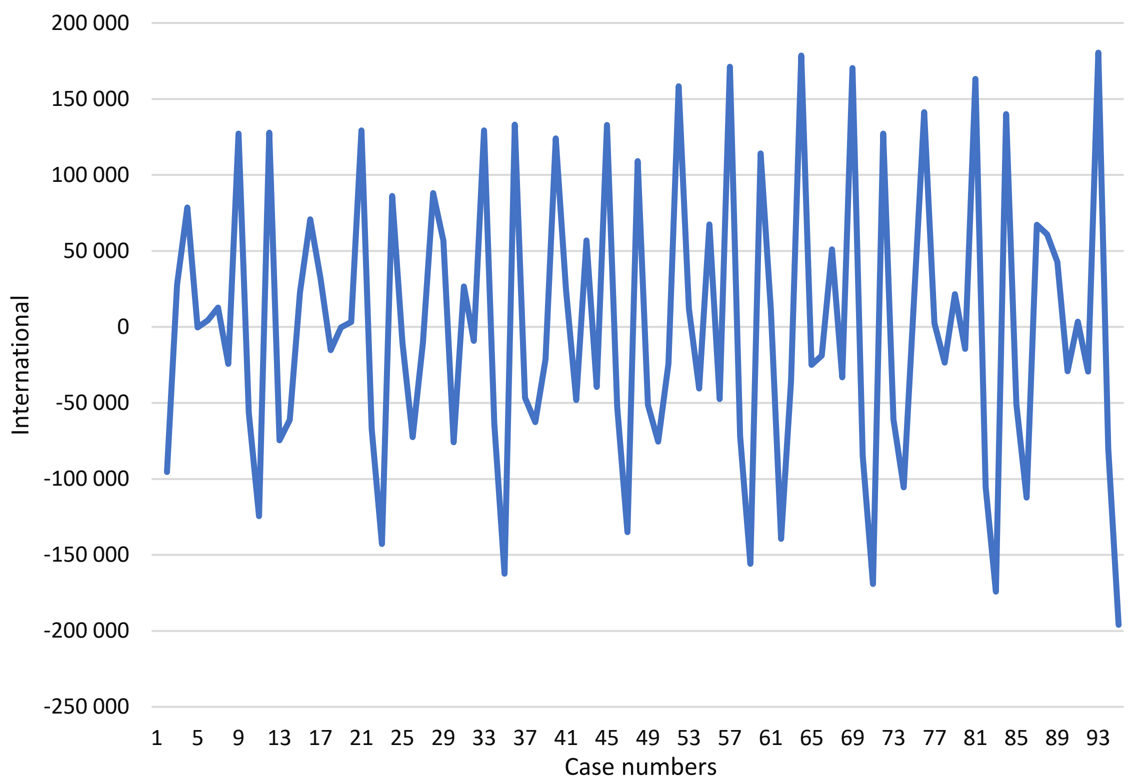

Figure 14: Plot of differenced international series (Own analysis)

D (-1) in Figure 14 above, shows that the series has been differentiated once. Now that the series is stationary, a SARIMA model can be fitted to it in the form SARIMA (p, d,q) x (P,D,Q)S where:

p = The number of autoregressive (AR) parameters in the model

q = The number of moving average (MA) parameters in the model

d = The number of differences necessary to make the series stationary

P = The number of seasonal autoregressive parameters in the model

Q = The number of seasonal moving average parameters in the model

D = The number of seasonal differences necessary to make the series stationary

The series is monthly and therefore the seasonal length of the series is S = 12. No further linear increases are recorded at lags 12, 24, 36, 48 etc. meaning no seasonal differencing is necessary and thus D = 0 (otexts, 2022; Towardsdatascience, 2022).

A correlogram is a visual technique used to identify serial correlation, or autocorrelation, in data which occurs over time. The correlograms of autocorrelation functions (ACF's) and partial autocorrelation functions (PACF's), in Figure 15 and Figure 16 respectively, assist in identifying p, q, P & Q.

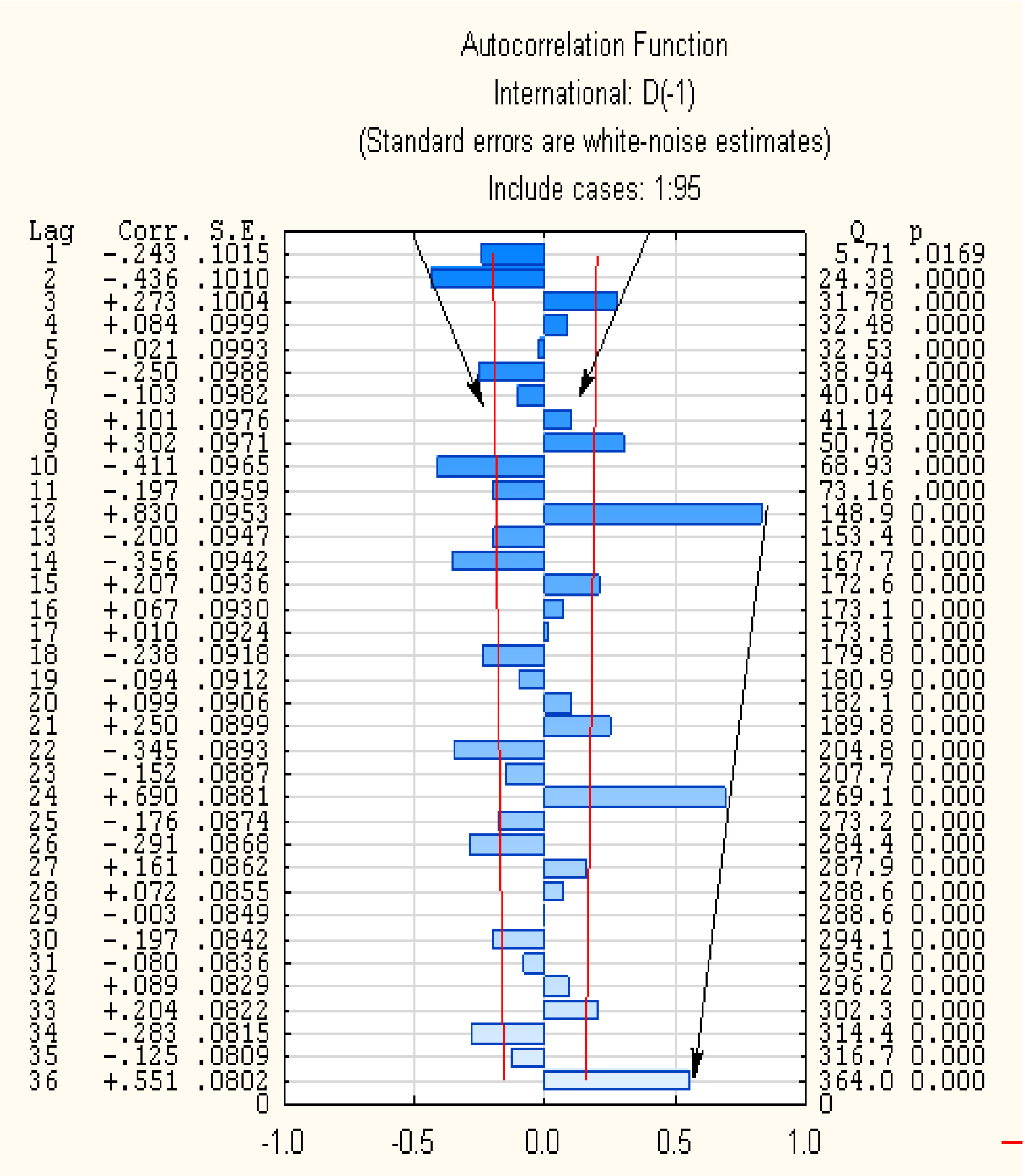

Figure 15: Autocorrelation Function for international D (-1) (Analysis done on Statistica)

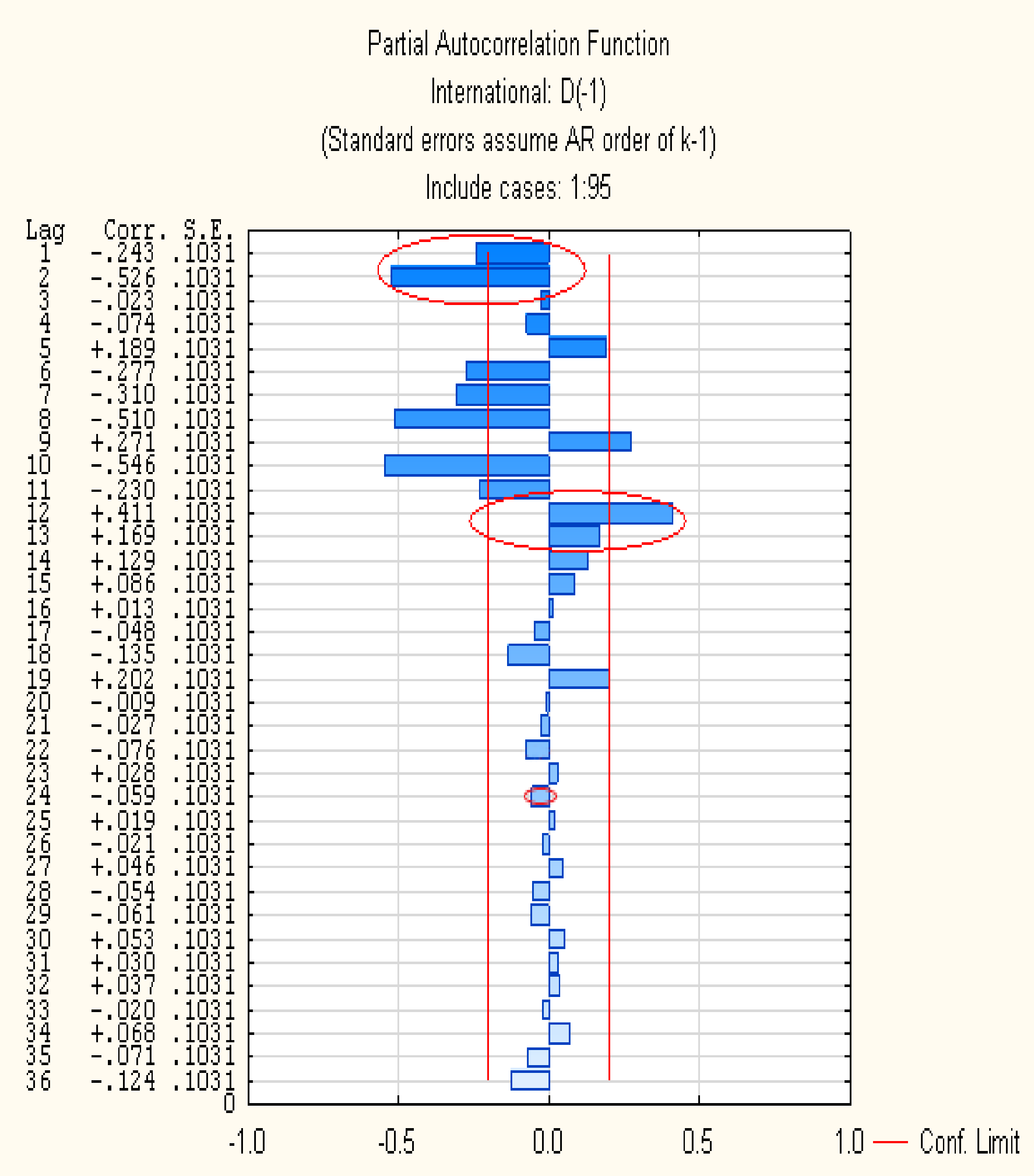

Figure 16: Partial Autocorrelation Function for international D (-1) (Analysis done on Statistica)

It can be noted that the ACF's become smaller as lag increases from 1 – 7, indicated by the small downward arrows in the first correlogram. Additionally, two significant PACF's are found at lags 1 and 2, indicated by the first ellipse in the second correlogram. The pattern of downward trending ACF's and two significant PACF's indicate that the model for the simple nonseasonal lags is an AR (2) or ARIMA (2,1,0) on the first difference. Therefore p = 2, d = 1 and q = 0.

For the seasonal lags at 12, 24, 36 and so forth, it can be noted that seasonal ACFS's show a downward trend, indicated by the large downward arrow in the first correlogram. Note the decrease for each 12-month lag. There is also only one significant PACF at the first seasonal lag t = 12. PACF at lag 25, indicated by the small ellipse in the second correlogram, is not significant. These observations indicate that the suitable model is a seasonal AR (1)/seasonal ARMA (1,0) or ARIMA (1,0,0) model. Combining the model for the nonseasonal lags and the seasonal model illustrates that the appropriate model to be fitted is SARIMA (2,1,0) x(1,0,0)12. Therefore P = 1, Q = 0 and D = 0 for the seasonal parameters of the combined model.

Table 4: Parameter estimates for international D (-1) (Analysis done on Statistica)

	Input: International (ACSA DATA 20210721-Zack Sterley) Transformations: D(1) Model:(2,1,0)(1,0,0) Seasonal lag: 12 MS Residual= 9988E5 Include cases: 1:95					
Paramet.	Param.	Asympt. Std.Err.	Asympt. t(91)	p	Lower 95% Conf	Upper 95% Conf
p(1)	-0.651425	0.094840	-6.86864	0.000000	-0.839814	-0.463036
p(2)	-0.445510	0.094895	-4.69479	0.000009	-0.634006	-0.257013
Ps(1)	0.991617	0.045753	21.67325	0.000000	0.900734	1.082500

Table 4, above, shows the estimated parameters. The two estimated autoregressive (AR) parameters are then $\varphi1$ = -0.651425 and $\varphi2$ = -0.44551 and the seasonal autoregressive parameter is $\Phi1$=0.991617. All parameters are significantly different from zero. The asymptotic standard errors for the two autoregressive parameters are 0.094840 and 0.094895 respectively and 0.045753 for the seasonal autoregressive parameter. This is an approximation of the parameter standard error. Asymptotic t values are -6.86864 and -4.69479 for the two autoregressive parameters and

21.67325 for the seasonal autoregressive parameter. The p-value also shows that all three parameters are significantly different from zero.

The model discussed above can now be used as a base model on which different intervention analyses can be fitted. It must again be stated that the domestic base series up to case 95 is very similar and can therefore be identified similarly. After the SARIMA model was identified and the parameters were estimated, the residuals (difference between the observations and the fitted values) were computed and the ACF's and PACF's of these residuals were investigated to see if there is any pattern and possible model left over. According to the Q-test of Ljung-Box, which tests for autocorrelation, the residuals were white noise. All the ACFs and all the PACFs are within the red confidence limits and all p-values of the successive Q tests in the ACF plots are larger than 0.05, indicating white noise at all lags of the autocorrelations (ACFs). This is a good result for the model as it suggests that there is no significant "lack of fit."

See Annexure A: Domestic model for the domestic model design specifications.

The model explained will be able to achieve the research objectives discussed in Chapter 1, namely:

1. To investigate South African air travel demand within a counterfactual "Covid-Free" scenario (Baseline)

2. Analyse the effects of the intervention and create and examine likely recovery forecasts (Intervention analysis)

3. Compare the baseline results with the actual recovery and forecasted observations (Comparative analysis)

4. Use the results of the comparative analysis to discuss the full impact so far, as well as the potential impact of the Pandemic on South African air travel demand

3.5 INTERVENTION MODEL IMPACT PATTERN SELECTION

There are three traditional types of impact patterns which an intervention can have on the values of a time series (TIBCO, 2021). These are listed below:

1. Abrupt/Permanent – An abrupt permanent impact pattern simply implies that the overall mean of the times series shifted after the intervention; the overall shift is denoted by ω (omega).

2. Abrupt/Temporary – The abrupt temporary impact pattern implies an initial abrupt increase or decrease due to the intervention which then slowly decays, without permanently changing the mean of the series. The delta parameter indicates the trend and rate of return to the original mean of the series.

3. Gradual/Permanent - The gradual permanent impact pattern implies that the increase or decrease due to the intervention is gradual, and that the final permanent impact becomes evident only after some time.

Three domestic and international intervention models were constructed, each with a different impact pattern. The gradual/permanent models were immediately removed from consideration given the fact that the Pandemic had resulted in an immediate and abrupt decline in South African air travel demand, both domestic and international. Based on findings relating to air travel's ability to recover to pre-intervention levels, discussed in the Recovery Predictions section of the literature review (see Gudmundsson, Cattaneo and Redondi, 2021), it was decided that the abrupt/temporary impact pattern would be selected for the domestic model. It must, however, be noted that the difference in results of the two models was minimal.

An issue was encountered with the international abrupt/temporary model. The delta parameter, used to indicate and model the trend and rate of recovery, was larger than one. The delta parameter cannot be larger than one and that the model should not be used. This is due to the severe nature of the decline that South African international air travel demand continues to suffer. Due to a combination of poor current recovery figures and limited post-intervention observations, it is impossible for the model to determine that the nature of the intervention is temporary. In the short to medium term, the mean of international air travel demand has shifted. The abrupt/permanent model has comparable results and will therefore be used to complete the short-term international forecast objectives of the study.

3.6 ASSUMPTIONS AND LIMITATIONS

The model can provide forecasts of what can be expected with regards to South African air travel demand. While these are forecasts and not guarantees, the model has the potential to aid aviation industry members in planning and strategic decision making. While its nature makes it simple and robust, the model is limited by the following two factors:

1.) The secretive nature of the aviation industry.

2.) The unpredictable and ever-changing Pandemic.

The nature of the aviation industry makes the collection of airline specific and detailed data, difficult. The competitive nature of the industry means airlines are notoriously reluctant to share data with researchers. This challenge was overcome when consultation with the CSC determined that the consolidated ACSA passenger movement was determined to be sufficient to construct a SARIMA with intervention model.

The model is however hindered by a limited amount of post intervention data as the cut-off point for data collection was September 2021 in order to complete the model and offer urgently required results and forecasts. The limited amount of post intervention observations allows for timely results but does shorten the length of the forecast which can be prepared. While the mean forecast values trend upwards, the spread of prediction intervals is quite large.

Due to the variability and unpredictability in the limited post-intervention observations, the prediction interval of the model is wide. Three likely future scenarios (linked to the upper and lower prediction intervals and the forecast average) will be used to aid in the discussion of the forecasted predictions. The scenarios will be labelled as follows:

1. Optimistic – The most positive forecast scenario which assumes excellent and accelerated vaccine rollout programmes, outstanding vaccine efficacy, rapid reductions in travel restrictions, no emergence of new variants of concern, other effective treatments and the realisation of predicted pent up travel demand.

2. Neutral "Current baseline" – The average forecast represents the most likely scenario. This scenario assumes continuous and positive recovery trends widely accepted in forecasts created by various organisations around the world. This scenario also includes the assumptions that vaccine rollout programmes continue to progress steadily at current rates, good vaccine efficacy against new variants, continued moderate reactive measures against emerging variants and moderate medium-term travel bans.

3. Pessimistic – This scenario assumes the occurrence of many negative developments such as the emergence of new, highly virulent and contagious variants, rolling waves of infections, hospitalisations and deaths, poor vaccine rollout programmes, poor vaccine efficacy against new variants and aggressive and longer lasting travel restrictions. This scenario, while unlikely, assumes that air travel is again halted completely as in early 2020. Such a scenario is unlikely due to the increase in understanding of the virus as well as vast improvements in testing and hygiene procedures within the air travel industry.

CHAPTER 4: ANALYSIS AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

The way forward regarding analysis has been paved by chapter 3. Firstly, chapter 3 discussed in detail the data to be used for this model. The data includes observation of South African domestic and international passenger movements between April 2012 and September 2021. Data up until the lockdowns of March 2020 used to create a baseline model (counterfactual) and actual recovery observations thus far are used in combination with the baseline model to create recovery forecasts.

The SARIMA with intervention model used to achieve this, is clearly explained and its selection justified in terms of its ability to achieve the research objectives set out in this paper. The construction, design and selection of parameters of the model have been explained in detail.

Now that the data and methodology have been explained, the results of the analysis will be presented. First, the results relating to the South African Domestic air travel analysis and forecasts will be presented, followed by the results of the South African international air travel analysis and forecasts. To start off, the results of the Covid-free counterfactual scenario will be discussed for domestic air travel. This extension of the baseline model, created in Chapter 3, illustrates South African domestic air travel demand that would have been recorded had the Pandemic not taken place. This is achieved by utilising the SARIMA(2,1,0) x(1,0,0)12 model discussed in chapter 3.

Following this, the baseline is comparatively analysed against actual passenger observations recorded up until September 2021. This will aid in identifying the actual decrease in South African air passenger movements. The intervention models are introduced and then fitted to the SARIMA model and discussed. The intervention's impact on domestic air travel is analysed and the models are then used to forecast recovery. The actual recovery observations thus far are extended using the intervention model's forecasts. The forecasts are then comparatively analysed against the counterfactual scenario to determine the full potential impact which the intervention could have on South African air travel passenger movements.

Exactly the same process is followed in order to analyse the international air traveller passenger model results. The results of the analysis of the models are used to identify and discuss implications for South African air travel demand and the air travel industry in general. The discussion relates to implications facing international and domestic passenger movements, airlines, airport structure and management, future air travel demand and aircraft sizing.

4.2 DOMESTIC COUNTERFACTUAL SCENARIO

Figure 17, below, depicts the extended baseline for domestic air traveller movements at ACSA airports. The blue data line in the figure illustrates pre-intervention (actual) observations from April 2012 up until March 2020, just prior to the implementation of lock down restrictions. The SARIMA (2,1,0) x (1,0,0)12 model is then used to forecast a counterfactual scenario in which the Pandemic does not occur. The forecasted domestic air travel demand is illustrated by the orange line while the green and red lines show the 95% upper and lower bounds, or prediction intervals, of the forecast, respectively. The final observation forecasted is December 2024.

The prediction intervals in this case demonstrate that the probability that the forecasted values for a given future time period will fall within the range, between the lower and upper bounds, is 95%. It can clearly be seen that as the forecast extends into the future, the standard error increases, thereby weakening the accuracy of the forecast.

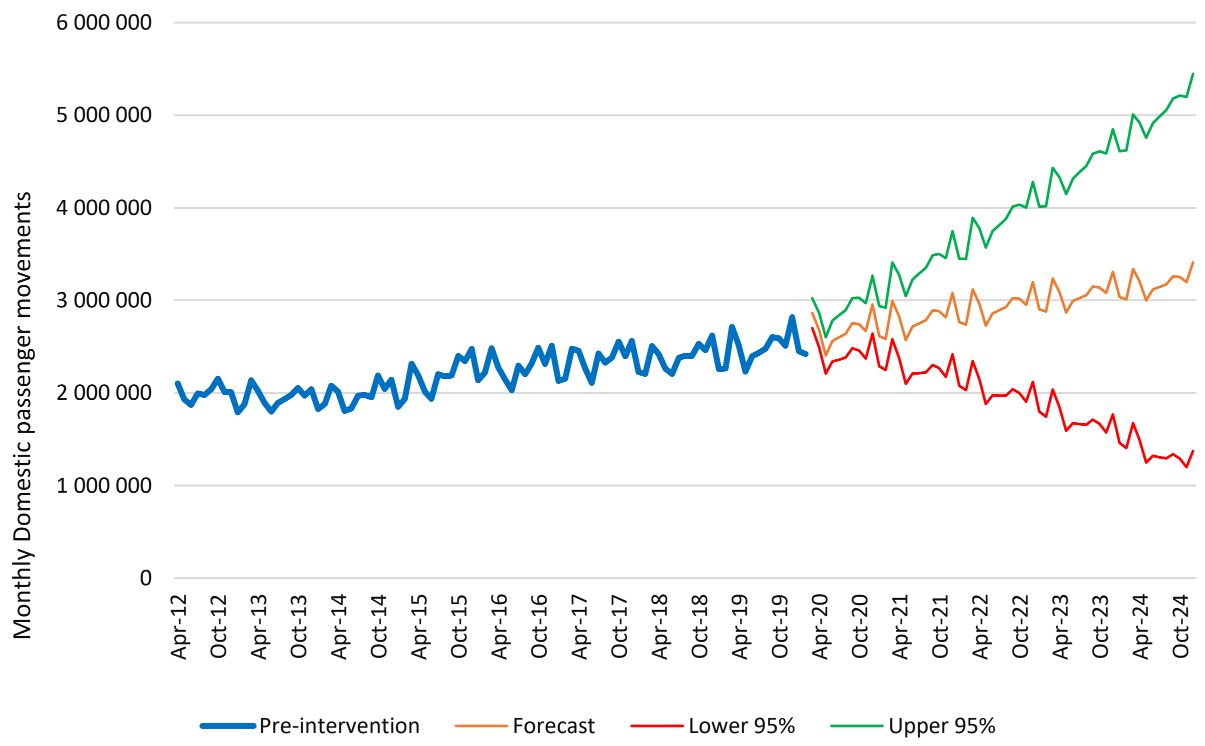

Figure 17: Extended domestic passenger numbers baseline (counterfactual scenario) (Source: ACSA data analysed on Statistica and exported to Excel)

Monthly South African domestic air travel demand grew healthily over the pre-intervention period between 2012 and 2020, rising from 2 009 316 passengers in December 2012 to a record high of 2 818 636 in December 2019. Total annual domestic passengers grew slowly between 2013 and 2014, from 23 389 813 to 23 718 509 (1.4%). The period from 2014 to 2020 saw a significant growth in South African domestic passenger demand take place. ACSA recorded total domestic annual passenger movements and year-on-year (YOY) growth between 2013 and 2019, illustrated below in Table 5.

Table 5: ACSA total domestic passenger movement growth between 2013-2019 (Source: ACSA, 2022b, own analysis)

YEAR	DOMESTIC PASSENGER MOVEMENTS	GROWTH YOY
2013	23 389 813	
2014	23 718 509	1.4%
2015	26 034 338	9.8%
2016	27 423 068	5.3%
2017	28 251 962	3%
2018	28 623 139	1.3%
2019	29 815 975	4.2%

Between the years of 2014 and 2020, South African domestic passenger movements increased by 27.09% from 23 389 813 to 29 815 975, representing growth of 4.52% per year. It is clear that the Pandemic interrupted a positive period of growth for domestic air travel in South Africa. It is therefore not surprising to see the positive trajectory of average domestic air travel demand predicted in Figure 17.

As shown in Table 6, the counterfactual model forecasted the following annual domestic passenger movements and growth Year-on-year for 2020 – 2024.

Table 6: Forecasted counterfactual domestic passenger movements at ACSA airports for 2020-2024 (Source: ACSA, 2022b, own analysis)

YEAR	DOMESTIC PASSENGER MOVEMENTS	GROWTH YOY
2020	31 740 274	6.5%
2021	33 527 673	5.6%
2022	35 186 695	4.9%
2023	36 726 623	4.3%
2024	38 155 998	3.8%

The forecast, therefore, suggests that domestic air travel demand would have continued its strong pre-Pandemic growth, increasing by 8 340 023 passengers from 29 815 975 in 2019 to 38 155 998 by the end of 2024. This would constitute growth of 28% between 2019 and 2024 at an annual growth rate of 5.6%.

4.3 COMPARISON: DOMESTIC COUNTERFACTUAL VS ACTUAL OBSERVATIONS

Figure 18, below, presents the domestic counterfactual observations compared to the actual observations from the beginning of the intervention, March 2020, up until the latest data observation included in this paper, in September 2021.[1]

[1] To prioritise timely completion of this model, data cut-off was September 2021. Future research can update the models with current data.

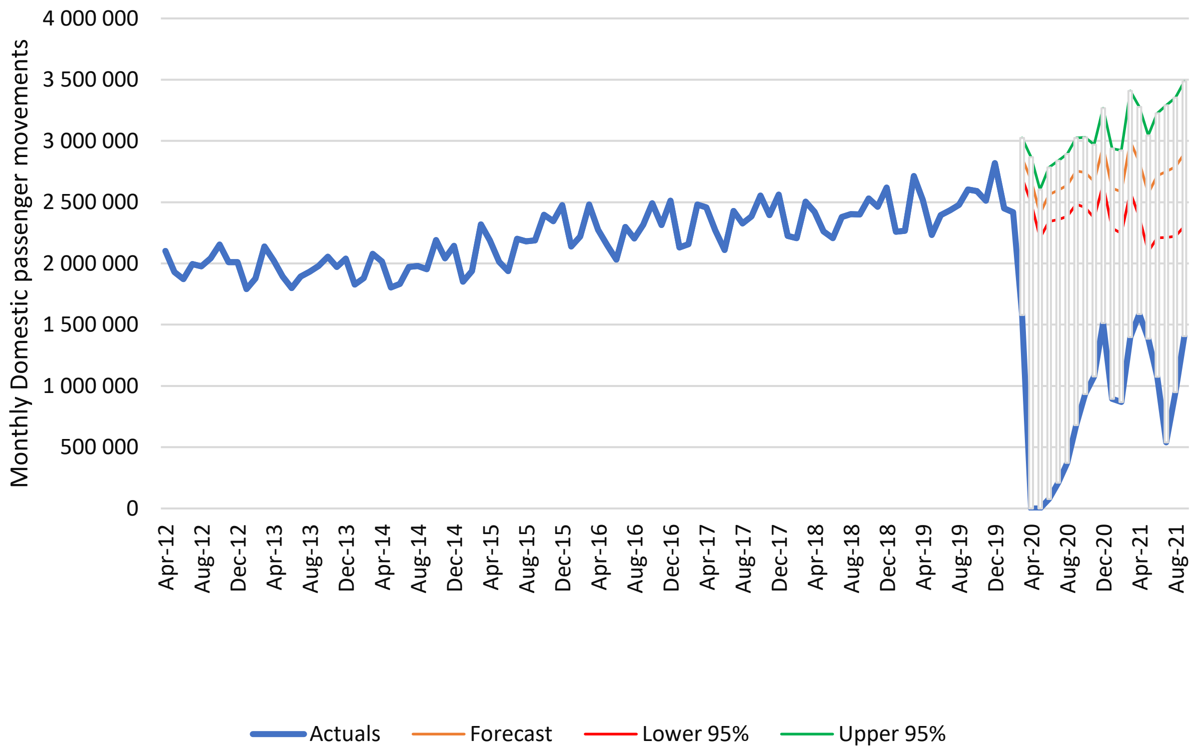

Figure 18: Domestic counterfactual scenario versus actual observations (Source: ACSA, 2021) (Own analysis)

The intervention began in March 2020, when only 1 580 370 domestic passenger movements were recorded. In comparison the baseline forecast predicts that between 2 700 606 and 3 023 073 domestic passenger movements would have occurred in the same month. This represents a loss of between 1 120 236 and 1 442 703 domestic passenger movements for the first month of the intervention. As discussed in the data section of Chapter 3, the months of April and May saw 0 domestic passenger movements take place, resulting in a combined loss of between 4 705 469 and 5 469 354 for those two months.

The rest of 2020 saw only 4 872 865 domestic passenger movements take place within South Africa. Combined with the unaffected months of January and February, the total annual domestic passenger movements for 2020 was 11 322 791, a 62% decline compared to 2019 figures. The counterfactual forecast predicted that the total South African domestic passenger movements would be between 29 313 127 and 34 167 421 for 2020. These results indicate that the Pandemic and its associated effects led to a decline in South Africa's 2020 domestic passenger numbers of between 17 990 336 and 22 844 630.

Despite a relatively positive December 2020, 2021 did not get off to a good start. Under the second wave, caused by the emergence of the Beta variant, hopes of a recovery in early 2021 were damaged. January and February recorded 894 409 and 869 585 passenger movements respectively, only 36% of 2020 figures for the same months. Positive figures in March, April and May signalled the start of another potential recovery. The first half of 2021 saw 7 213 208 domestic passenger movements while the counterfactual forecast predicted that between 13 799 675 and 18 819 970 passengers would fly domestically.

Spurred on by the Delta variant, the third wave of Covid cases in South Africa led to extremely poor recovery figures for the months of July and September. July domestic passenger movements fell to 539 692 while the lifting of travel restrictions led to some recovery in August when 949 873 passengers flew domestically in South Africa. The month of September 2021, the last actual observation used in this paper, was a positive one with 1 406 616 recorded South African domestic passenger movements, 54% compared to 2019 figures. The counterfactual forecast for September 2021 was predicted to be between 2 304 171 and 3 486 541.

The counterfactual forecast predicted that January 2021 – September 2021 would have seen between 20 539 136 and 28 949 281 domestic passenger movements. Up until September, 2021 saw 10 109 389 actual domestic passenger movements. The results suggest that the Pandemic resulted in a domestic passenger movement loss of between 10 429 747 and 18 839 892 for the first three quarters of 2021.

According to the model results, total South African domestic passenger movement losses between March 2020 and September 2021 are estimated to be between 28 420 083 and 41 684 522.

4.4 DOMESTIC RECOVERY FORECAST

Based on findings discussed in the Recovery Predictions section of the literature review, it was decided to select the abrupt/temporary domestic intervention model. The abrupt/temporary intervention input parameters are presented below in Table 7.

Table 7: Domestic Abrupt/temporary intervention input parameters (Own analysis completed on Statistica)

Paramet.	Input: DOMESTIC (ACSA DATA 20211025-Zack Sterley) Transformations: D(1) (Interrupted ARIMA) Model:(2,1,0)(1,0,0) Seasonal lag: 12 MS Residual= 5059E7							
	Param.	Asympt. Std.Err.	Asympt. t(108)	p	Lower 95% Conf	Upper 95% Conf	Interv. Case No.	Interv. Type
p(1)	-0.283	0.151	-1.87171	0.063953	-0.584	0.017		
p(2)	-0.21	0.105	-2.00966	0.046961	-0.417	-0.003		
Ps(1)	0.527	0.105	5.01317	0.000002	0.319	0.736		
Omega(1)	-1682498.632	299229.687	-5.62277	0	-2275623.785	-1089373.478	96	Abr/Temp
Delta(1)	0.99	0.023	44.00281	0	0.946	1.035	96	Abr/Temp

The two estimated autoregressive parameters are then φ1 = -0.283 and φ2 = -0.21 while the seasonal autoregressive parameter is Φ1 = 0.527. The asymptotic standard error, an approximation of the parameters standard error, is 0.151 for φ1 and 0.105

for φ2 as well as Φ1 while the asymptotic t-values are -1.87171, -2.00966 and 5.01317 for φ1, φ2 and Φ1, respectively.

The Omega (1) parameter can be defined as the estimated immediate effect of the intervention. The Omega parameter = -1682498.632. Therefore, the immediate drop in South African domestic air travel passenger demand is estimated to be 1 682498.632. The asymptotic standard error and asymptotic t-value are 299229.687 and -5.62277 respectively while the p-value of Omega (1) is 0. The delta (1) parameter is similar to a unit root in ARIMA estimation which indicates that the series has a trend and has to be differenced at least once before fitting a model to the differences.

Delta parameter models the rate of return to the pre-intervention situation. The Delta parameter must fall between 0 and 1 (the bounds of system stability). Delta parameter close to 0 indicates that the decay of the effect of the intervention will decrease speedily and recovery will be quick, while a Delta parameter close to 1 indicates a slower decay of effects on the observations and, therefore, longer recovery. In this case Delta (1) at 0.99 is close to 1 and is significant. This indicates a slow recovery trend and return to the pre-intervention situation.

The asymptotic standard error and t-value are 0.023 and 44.00281, respectively. It can be noted that both gradual/permanent and abrupt/temporary models have Delta parameters. Abrupt/permanent models do not include Delta parameters as such models only indicate an intervention without recovery.

The model parameters are then used to create the following intervention model results. Table 8, below, presents the 15-month domestic forecast model results for the period between October 2021 – December 2022.

Table 8: Domestic Abrupt/Temporary intervention model results October 2021 – December 2022 (Analysis completed on Statistica)

	Forecasts; Model:(2,1,0)(1,0,0) 1 Interventions (ACSA DATA 20211025-Zack Sterley) Input: DOMESTIC Start of origin: 1 End of origin: 114			
CaseNo.	Forecast	Lower 95,00%	Upper 95,00%	Std.Err.
115	1396978	964606	1856192	224901,3
116	1459978	924838	2021703	276682,4
117	1731652	1137207	2352429	306537,8
118	1403425	736814	2096114	342881,2
119	1389823	657988	2147487	375723,6
120	1677784	889349	2491801	404215,8
121	1782103	939906	2649636	431276,4
122	1680363	787192	2598627	456931,5
123	1522132	580968	2488149	481083,2
124	1244664	257800	2256145	504079,2
125	1465874	435248	2520880	526097,3
126	1711637	639019	2808401	547223
127	1711499	514677	2932237	609825,6
128	1749592	465623	3057247	653733
129	1897651	542068	3276693	689804,6

The average or “baseline” forecast suggests that domestic air travel passenger demand will grow from 1 396 978 in October 2021 to 1 897 651 in December 2022. The lower and upper 95% predictions suggest that December 2022 domestic passenger demand figures will be between 542 068 and 3 2766 693.

Due to the variability and unpredictability in the limited post-intervention observations, the prediction interval is wide. As discussed in the Assumptions and Limitations section of chapter 3, three possible future scenarios, optimistic, neutral and pessimistic, will be used to aid in the discussion of the forecasted average, upper bound and lower bound predictions. Figure 19 below, illustrates the abrupt/temporary domestic intervention forecast starting in April 2012 and ending in December 2022.

The actual domestic passenger movements between April 2012 and September 2021 are illustrated by the blue line while the 95% upper, forecast and 95% lower predicted observations between October 2021 and December 2022 are illustrated by the green, yellow and red lines, respectively.

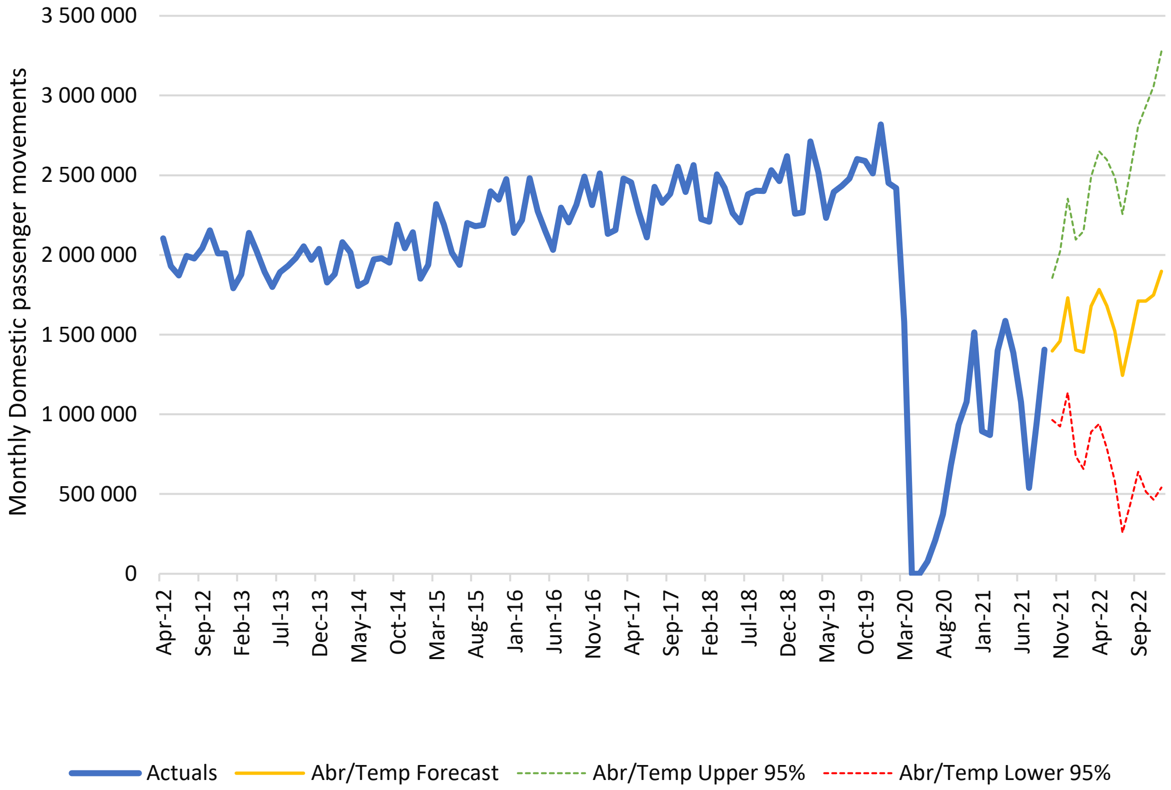

Figure 19: Domestic Abrupt/Temporary intervention forecast (Own analysis)

Optimistic scenario – This positive forecast, illustrated by the upper 95% prediction interval, is characterized by a strong domestic passenger demand rebound. The optimistic scenario predicted that South African domestic passenger movements would reach 2 352 429 in December 2021, 83% of December 2019 figures. The scenario further predicts that April 2022 figures will surpass April 2019 figures, suggesting full recovery to 2019 levels. The forecast predicts 3 276 693 domestic passenger movements in December 2022, 116% of 2019 figures for the same month. The optimistic scenario would see a total of 31 323 417 domestic passenger movements for 2022, 105% of 2019's annual figure.

Interestingly, the best-case scenario would see domestic demand levels surpass the counterfactual scenario's domestic demand levels in November 2022 thereby erasing all growth losses.

Neutral "current" scenario – The neutral forecast or the average forecast represents the scenario most likely to occur based on the current trajectory and recovery. This scenario predicted domestic passenger figures to reach 1 731 652 in December 2021, 61,4% of December 2019 figures. December 2022 would see 1 897 651 domestic passenger movements, 67.3% of December 2019 figures. Overall, the neutral scenario forecasts that 19 236 547 domestic passenger movements will take place in South Africa in 2022. This would mean that the neutral scenario would see 2022 domestic air travel numbers return to 64.5% of 2019 demand, up from the recovery of 37.9% in 2020.

Pessimistic "drifting" – The pessimistic scenario would be characterized by continued developments which negatively impact air travel demand and led to weak recovery rates. The pessimistic forecast suggests that only 1 137 207 domestic passenger movements would be recorded in December 2021, 40.3% of December 2019 figures. The negative scenario suggests that domestic passenger movements will fall to 542 068 in December 2022, just 19.2% of 2019 figures for the same month. The domestic passenger movements for the pessimistic scenario would total 7 446 652 for 2022, only 25% of 2019 total domestic passenger movements and below the 11 322 791 passenger movements recorded in 2020, down from 37.9% recovery in 2020.

Table 9, below, illustrates the comparison between this paper's own intervention model's forecast and the forecasts of both ICAO and Bain and Company, discussed in the *Recovery Predictions* section of the literature review. The forecasts are compared for the months of January and December 2022. It must be noted that the ICAO forecast as well as this paper's intervention model are both measured in passenger numbers while the Bain and Company model is measured in RPKs. The comparison still provides some insight into the difference between this paper's own model and the recovery predictions of international companies.

Table 9: Domestic intervention forecast compared to ICAO and Bain and Company Forecasts 2022 vs 2019 (Own Graph)

	BAIN AND COMPANY SEPTEMBER 2021 GLOBAL FORECAST (2022 VS 2019) – MEASURED IN RPK				ICAO FORECAST (2022 VS 2019)	INTERVENTION FORECAST, NEUTRAL SCENARIO (2022 VS 2019)		
	Accelerated Vaccine	**Coordinated recovery**	**Baseline**	**Drifting**	**Domestic**	**Domestic Optimistic**	**Domestic Neutral**	**Domestic Pessimistic**
JAN 2022	57%	52%	48%	41%	75%	93%	62%	33%
DEC 2022	95%	89%	81%	68%	85% to 94%	116%	67%	19%

For January 2022, the neutral scenario intervention analysis model prediction of 62% is the closest to that of Bain and Company under the scenario of accelerated vaccinations (57%). The intervention analysis prediction is 14% lower than that of the ICAO domestic model (75%). The December 2022 intervention analysis prediction of 67% is far off of the Bain and Company accelerated vaccine scenario prediction of 95% but is very close to the 68% prediction under the drifting scenario. The intervention prediction for the last month of 2022 is far below the ICAO forecast of between 85% and 94%

Overall, the domestic neutral scenario is relatively similar to the Bain and Company predictions. It must be noted that the forecasts from Bain and Company are for total air travel demand (international and domestic) whilst the intervention model results above are domestic only. Therefore, different air travel markets with varying factors which influence recovery are being compared. The comparison does nevertheless provide a picture of general recovery of air travel. Both the optimistic and pessimistic scenario predictions for January and December 2022 are far off predictions created by Bain and Company and ICAO.

While this does not prove the accuracy of the intervention model whatsoever, it provides insight into how this paper's model shapes up against recovery forecast models created by established companies within the aviation industry.

4.5 COMPARISON: DOMESTIC COUNTERFACTUAL VERSUS DOMESTIC ABRUPT/TEMPORARY INTERVENTION RECOVERY FORECAST

This section discusses the results drawn from the comparison between the average counterfactual forecast and the neutral scenario for the domestic abrupt/temporary intervention forecast up until June 2023. With the view to brevity, clarity and practicality of results and for the purposes of this paper, the average predictions for both the counterfactual and intervention forecast will be compared and not the 95% prediction intervals. This comparative analysis, therefore, assumes that the counterfactual growth trend would have continued in a predictable way and that the neutral or "current" recovery scenario will take place.

Comparative analysis between the counterfactual forecast and the intervention forecast will aid in determining the full possible extent of domestic passenger demand losses caused by the Pandemic should recovery take place as the forecast suggests. The comparison is illustrated below in Figure 20.

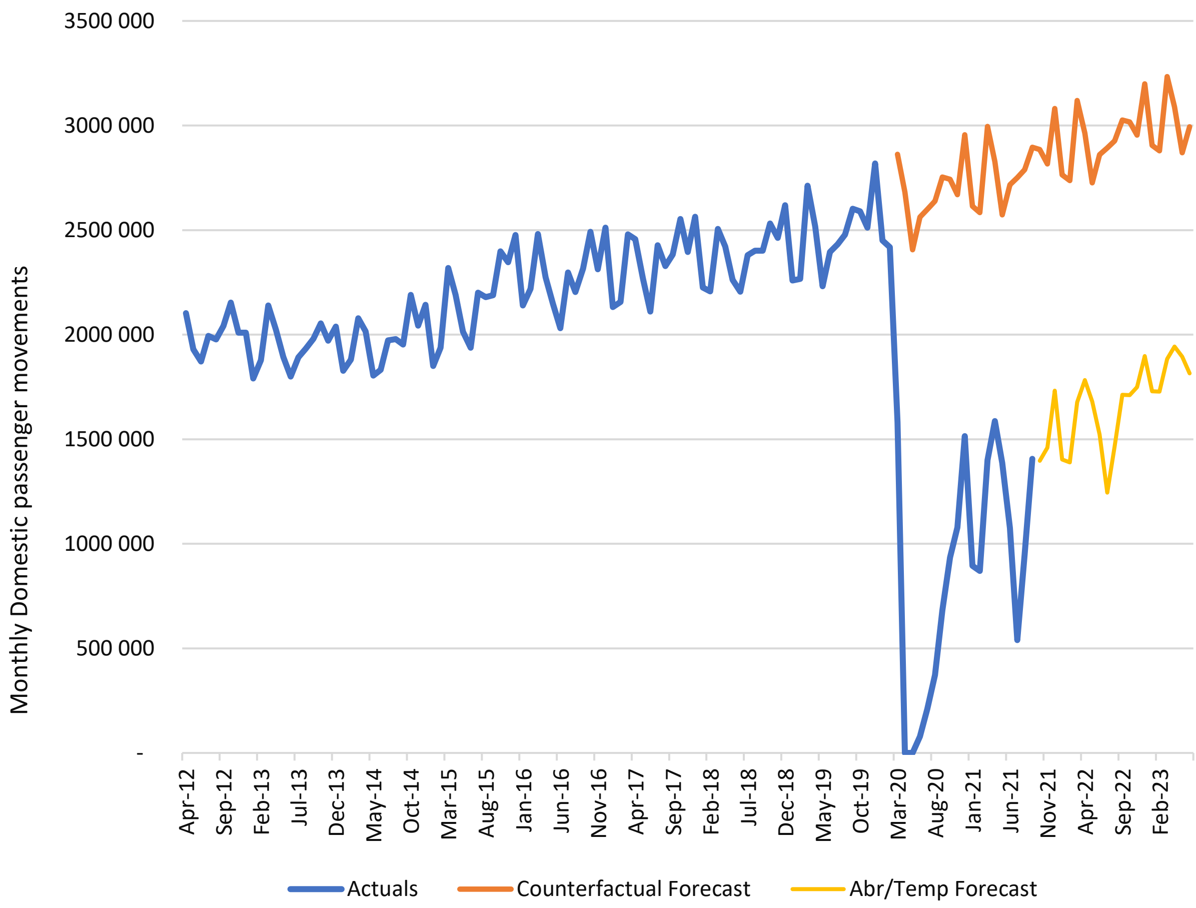

Figure 20: Average domestic counterfactual and intervention forecast comparison (Own analysis)

Earlier in this chapter, comparative analysis was conducted on counterfactual forecast versus the actual observations up until and including September 2021 (See Figure 18). It was established that from March 2020 to September 2021, between 28 420 083 and 41 684 522 South African domestic passenger movements were lost due to the Covid-19 Pandemic and its associated travel restrictions. The intervention forecast predicts 19 236 547 domestic passenger movements in 2022, 64.5% of 2019 figures. The model's predicted recovery level for 2022 is therefore up 26.6% from the recorded recovery rate of 37.9% in 2020. Furthermore, the forecast suggests, that 2022 will have 15 950 148 fewer domestic passenger movements than the counterfactual scenario's estimate of 35 186 695.

The model predicts that the first half of 2023 will see further continued slow recovery. June 2023, the last observation date for the model, is predicted to see 1 815 247 domestic passenger movements, putting its recovery figure at 60.6% of the counterfactual scenario's June 2023 prediction. When actual observations from March 2020 to September 2021 are combined with the recovery forecast predictions, it is estimated that domestic passenger movements will total 51 380 113 for the period of March 2020 – June 2023. The counterfactual forecast for the same period of March 2020 – June 2023 is 113 557 230. The comparative analysis, therefore, suggests that 62 177 117 South African domestic passenger movements will ultimately be lost between March 2020 and June 2023 as a result of the Pandemic.

4.6 INTERNATIONAL COUNTERFACTUAL SCENARIO

Figure 21, below, illustrates the counterfactual scenario (had the Pandemic not occurred) predictions for international air travel passenger movements.

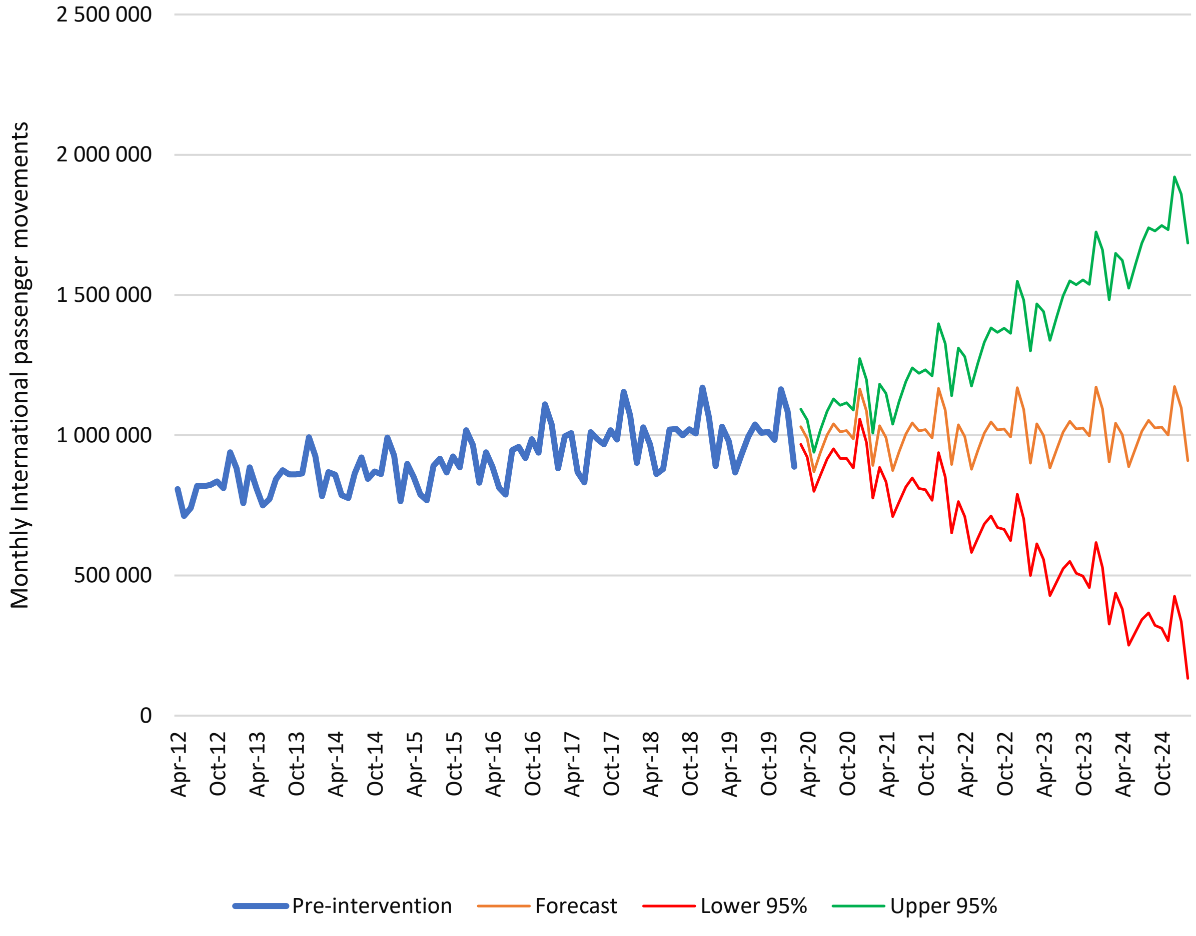

Figure 21: Extended International passenger numbers baseline (counterfactual scenario) (Source: ACSA data analysed on Statistica and exported to Excel)

In similar fashion to domestic passenger movements, South African international air travel demand grew steadily over the pre-intervention period between 2012 and 2017 followed by stagnated growth between 2017 and 2019. International passenger movements rose from 938 433 passengers in December 2012 to a record high of 1 169 540 in December 2019. ACSA total international passenger movements and Year-on-year growth, recorded between 2013 and 2019, are illustrated below in Table 10.

Table 10: ACSA total international passenger movement growth between 2013-2019 (Source: ACSA, 2022b, own analysis)

YEAR	INTERNATIONAL PASSENGER MOVEMENTS	GROWTH YOY
2013	10 152 143	
2014	10 348 187	1.93%
2015	10 499 124	1.46%
2016	11 080 996	5.54%
2017	11 743 421	5.98%
2018	11 946 122	1.73%
2019	11 964 514	0.15%

South African international passenger demand grew by 17.85% from 10 152 143 in 2013 to 11 964 514 in 2019. International passenger movements increased by 1 812 371 at a healthy growth rate of 2.98 % per year. The data suggests that South African international air travel demand was not growing as quickly as domestic air travel demand for the same period. It is, however, evident that the Pandemic interrupted a slight upward trend in international air travel demand in South Africa. This slow growth trend is illustrated in the counterfactual forecast for international passenger movements

The model forecasted annual international passenger movements and YOY growth rates for 2020-2024, illustrated below in Table 11.

Table 11: Forecasted counterfactual international passenger movements and growth at ACSA airports for 2020-2024 (Source: ACSA, 2022b, own analysis)

YEAR	DOMESTIC PASSENGER MOVEMENTS	GROWTH YOY
2020	12 015 850	0.43%
2021	12 057 383	0.35%
2022	12 098 486	0.34%
2023	12 139 246	0.34%
2024	12 179 661	0.33%

It is, therefore, estimated that international growth would have continued with a weak positive trend for the next 4 years had the Covid Pandemic not occurred. Annual international passenger movements in South Africa were predicted to increase by only 215 147 passengers from 11 964 514 in 2019 to 12 179 661 by the end of 2024. This suggests a predicted counterfactual growth rate of just 1.8% between 2019 and 2024 at an annual growth rate of 0.36% per year.

4.7 COMPARISON: INTERNATIONAL COUNTERFACTUAL VS ACTUAL OBSERVATIONS

Figure 22, below, presents the comparison between international counterfactual observations and the actual international passenger movement observations from the beginning of the intervention in March 2020 up until September 2021, the latest actual ACSA international observation collected and used in this paper.

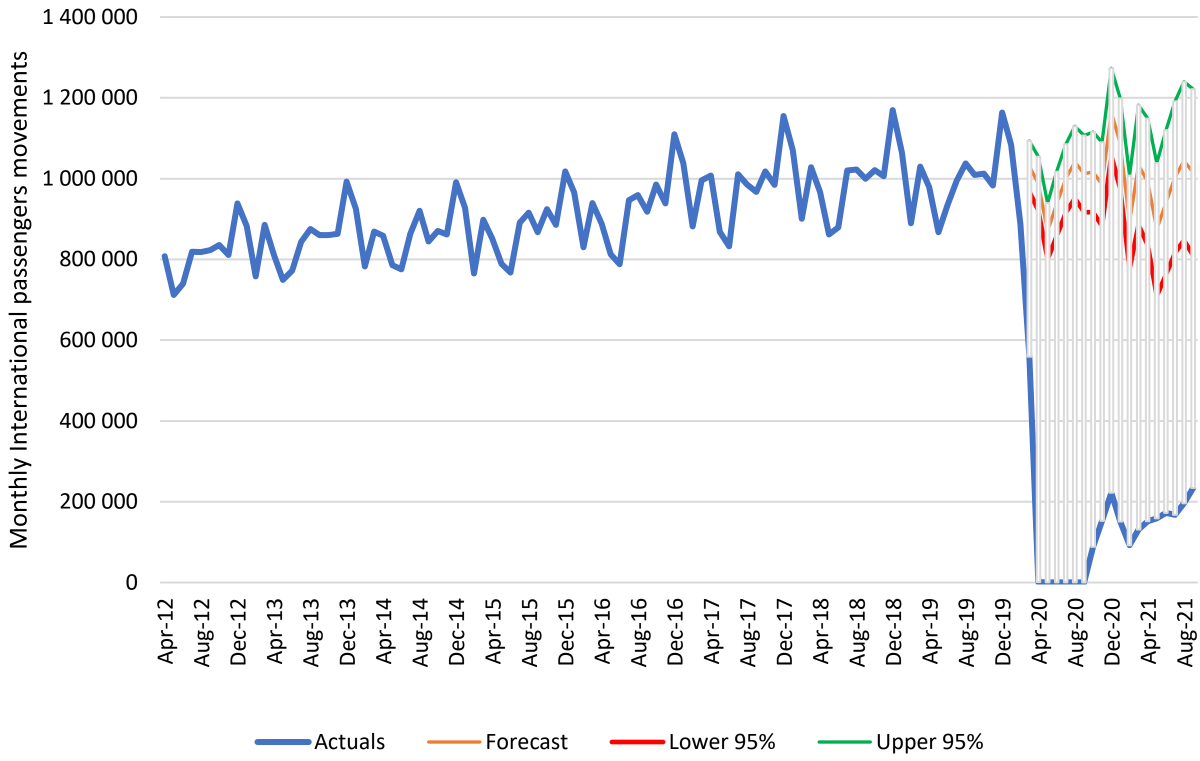

Figure 22: International counterfactual scenario versus actual observations (Source: ACSA, 2021) (Own analysis)

At the start of the intervention in March 2020, 559 172 international passenger movements were recorded. The baseline forecast, in comparison, predicts that between 967 673 and 1 093 225 international passenger movements would have occurred in the same month. This suggests a loss of between 408 501 and 534 053 international passenger movements for March 2020, at the start of the intervention. The period between April 2022 and September 2022 saw only 3 101 international passenger movements take place, resulting in a combined loss of between 5 359 297 and 6 328 715 international passenger movements for those 6 months.

The rest of 2020 saw 463 524 international passenger movements take place, signalling good recovery linked to the cessation of many travel restrictions. The total annual international passenger movements for 2020 came to 2 996 454, a 74.9%

decline on 2019 figures. According to the counterfactual forecast South African international passenger movements would have totalled between 11 157 766 and 12 873 938 for 2020. This comparison between the counterfactual forecast and actual observations suggest that the Pandemic and its associated effects resulted in a decline in South Africa’s 2020 international passenger numbers of between 8 161 312 and 9 877 484.

Like domestic passenger demand, international air travel demand had a relatively positive December 2020. This was followed by stagnated recovery in the first half of 2021. The first half of 2021 saw 857 647 international passenger movements while the counterfactual forecast predicted that between 4 941 943 and 6 694 551 passengers would fly internationally between January 2021 and June 2021. In contrast to the recovery of domestic passenger demand, international recovery growth rates were less effected by the emergence of the Beta and Delta variants and remained relatively stable and less unpredictable. In terms of overall losses in demand however, international air travel movements in South Africa were still more severely affected overall.

While Delta severely affected domestic passenger movements, international passenger movement figures for July, August and September 2021 continued an upward trend at 167 303, 196 237 and 233 994, respectively.

The counterfactual forecast predicted that January 2021 – September 2021 would have seen between 7 414 732 and 10 346 771 international passenger movements. Between January 2021 and September 2021, 1 455 181 actual international passenger movements took place. The results, therefore, suggest that the Pandemic led to a decrease in international passenger movements of between 5 959 551 and 8 891 590 for the first three quarters of 2021.

According to the model results, the total South African international passenger movement losses between March 2020 and September 2021 are estimated to be between 14 120 863 and 18 769 074.

4.8 INTERNATIONAL RECOVERY FORECAST

As explained in the “Intervention Model Impact Pattern Selection” section of chapter 3, the international Abrupt/Temporary model was not recommended for use as the Delta parameter was 1.005. The Delta parameter, used to indicate and model the trend and rate of recovery, cannot be larger than 1 and, thus, it was decided to select the Abrupt/Permanent international intervention model. The Abrupt/Permanent intervention input parameters are presented below in

Table 12.

Table 12: International Abrupt/permanent intervention input parameters (Own analysis completed on Statistica)

	Input: International (ACSA DATA 20211025-Zack Sterley) Transformations: D(1) (Interrupted ARIMA) Model:(2,1,0)(1,0,0) Seasonal lag: 12 MS Residual= 5401E6							
Paramet.	Param.	Asympt. Std.Err.	Asympt. t(109)	p	Lower 95% Conf	Upper 95% Conf	Interv. Case No.	Interv. Type
p(1)	-0,606	0,119	-5,097	0,000001	-0,841	-0,37		
p(2)	-0,246	0,111	-2,2249	0,028145	-0,465	-0,027		
Ps(1)	0,642	0,08	8,023	0	0,483	0,8		
Omega(1)	-736866,812	67259,912	-10,9555	0	-870173,772	-603559,851	96	Abr/Perm

The two estimated autoregressive parameters are then φ1 = -0.606 and φ2 = -0.246 while the seasonal autoregressive parameter is Φ1 = 0.642. The asymptotic standard error, an approximation of the parameters standard error, is 0.119 for φ1, 0.111 for φ2 and 0.08 for Φ1 while the asymptotic t values are -5.097, -2.225 and 8.023 for φ1, φ2 and Φ1, respectively. The p-values indicate that both the estimated autoregressive parameters as well as the seasonal autoregressive parameter are all significantly different from 0.

The Omega (1) parameter, the estimated immediate effect of the intervention, is -736866.812. In other words, the immediate drop in South African international air travel passenger demand at the start of the Pandemic is estimated to be 736 866. The asymptotic standard error and asymptotic t-value of Omega are 67259.912 and -10.9555 respectively while the p-value of Omega (1) is 0. It must be noted that there is no Delta (1) parameter in an Abrupt/Permanent intervention model. This is because an Abrupt/Permanent intervention implies that the overall mean of the series has shifted (donated by Omega).

The model parameters are then used to create the following intervention model results. Table 13, below, presents the 15-month international forecast model results for the period between October 2021 – December 2022.

Table 13: International Abrupt/Permanent intervention model results October 2021 – December 2022 (Own analysis completed on Statistica)

	Forecasts; Model:(2,1,0)(1,0,0) 1 Interventions (ACSA DATA 20211025-Zack Sterley) Input: International Start of origin: 1 End of origin: 114			
CaseNo.	Forecast	Lower 95,00%	Upper 95,00%	Std.Err.
115	260589,6	114936,2	406243	73489,3
116	293315,1	136742,7	449887,5	78998,5
117	357683	184070,8	531295,1	87595,9
118	308252,1	114468,4	502035,8	97773,4
119	272105,4	64294,8	479916	104850,7
120	297149,6	74826,5	519472,7	112172,9
121	310056,1	74003,7	546108,6	119100,1
122	314634,4	65978,1	563290,8	125459,4
123	323317,2	62476,6	584157,9	131606,9
124	320034,8	47581,1	592488,6	137466,3
125	338632,9	55068,4	622197,3	143072,2
126	362857,1	68579,2	657135	148477,7
127	379928	38997,6	720858,3	172016,1
128	400936	40965	760906,9	181623
129	442249,9	60597,4	823902,5	192562,5

According to the “baseline” recovery forecast, international air travel passenger demand will grow from 260 589.6 in October 2021 to 442 249.9 in December 2022. The lower and upper 95% predictions suggest that December 2022 international passenger demand figures will be between 60 597.4 and 823 902.

Due to the variability and unpredictability in the limited post-intervention observations, the prediction interval is wide. As with the domestic results, three potential future scenarios, Optimistic, Neutral and Pessimistic, will be used to aid in the discussion of the forecasted average, upper bound and lower bound predictions.

Figure 23 below, illustrates the Abrupt/Permanent international intervention forecast. The range of the observations is from April 2012 to December 2022. The actual international passenger movements between April 2012 and September 2021 are illustrated by the blue line while the 95% upper, forecast and 95% lower predicted observations between October 2021 and December 2022 are illustrated by the green, yellow and red lines, respectively.

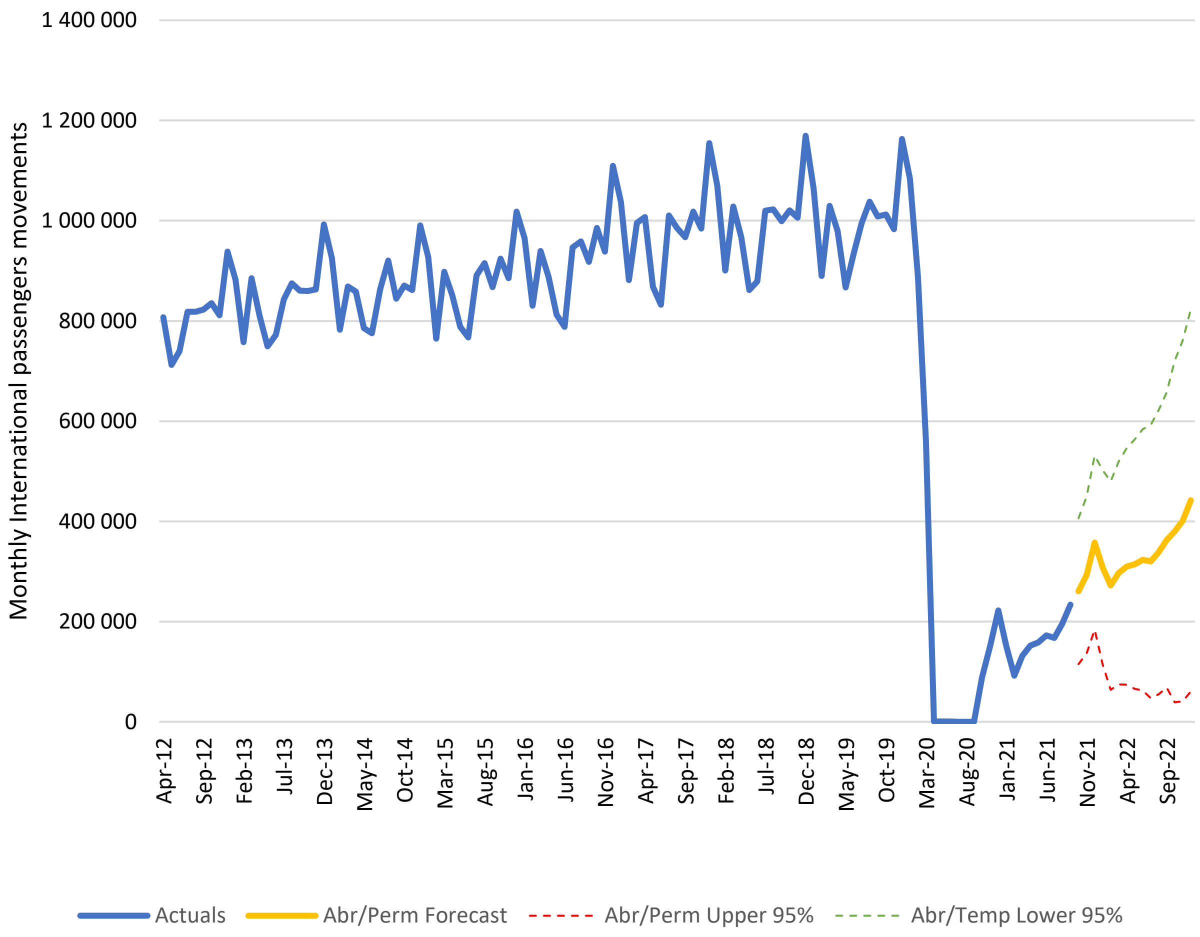

Figure 23: International Abrupt/Permanent intervention forecast (Own analysis completed on Statistica)

Optimistic scenario – This positive forecast, illustrated by the upper 95% prediction interval, is characterized by a strong international passenger demand rebound. The optimistic scenario predicted that South African international passenger movements would reach 531 295 in December 2021, 45,6% of December 2019 figures. The forecast predicts 823 902 international passenger movements in December 2022, 70,8% of 2019 figures for the same month. The optimistic scenario would see a total of 7 372 470 international passenger movements for 2022, 61,6% of 2019's annual figure.

Neutral "current" scenario – The neutral forecast or the average forecast represents the scenario most likely to occur based on the current trajectory and recovery. This scenario predicted international passenger figures to reach 357 683 in December 2021, 30,7% of December 2019 figures. December 2022 would see 442 249 international passenger movements, 38% of December 2019 figures. Overall, the neutral scenario forecasts that 4 070 153 international passenger movements will take place in South Africa in 2022. This would mean that the neutral scenario would see 2022 international air travel numbers return to 34% of 2019 annual figures, up from the recovery of 25% in 2020.

Pessimistic "drifting" – The pessimistic scenario would be characterized by continued developments which negatively impact air travel demand and lead to weak recovery rates. The pessimistic forecast suggests that only 184 070 international passenger movements would be recorded in December 2021, 15,8% of December 2019 figures. The negative scenario suggests that international passenger movements will fall to 60 597 in December 2022, 5,2% of 2019 figures for the same month. The international passenger movements for the pessimistic scenario would total 767 836 for 2022, only 6,4% of 2019 total international passenger movements and below the 25% recovery in 2020.

Table 14, below, illustrates the comparison between this paper's own international intervention models forecast and the forecasts of both ICAO and Bain and Company, discussed in the *Recovery Predictions* section of the literature review. It must again be noted that the ICAO forecast as well as this paper's intervention model are both measured in passenger numbers while the Bain and Company model is measured in RPKs. The comparison still provides insight into the difference between this paper's own model and the recovery predictions of international companies.

Table 14: International intervention forecast compared to ICAO and Bain and Company Forecasts 2022 vs 2019 (Own Graph)

	BAIN AND COMPANY SEPTEMBER 2021 GLOBAL FORECAST (2022 VS 2019) – MEASURED IN RPK				ICAO FORECAST (2022 VS 2019)	INTERVENTION FORECAST, NEUTRAL SCENARIO (2022 VS 2019)		
	Accelerated Vaccine	Coordinated recovery	Baseline	Drifting	International	International Optimistic	International Neutral	International Pessimistic
JAN 2022	57%	52%	49%	41%	43%	47%	29%	11%
DEC 2022	94%	89%	81%	68%	61% to 77%	71%	38%	5%

The neutral intervention analysis prediction for January 2022 of 29% is well under the more optimistic predictions by both Bain and Company (41% - 57%) and ICAO (43%). The intervention model's prediction for December 2022 is 38%, still well below the Bain and Company and ICAO predictions of between 68% to 95% and 61% to 77% respectively. The pessimistic recovery rates for both January and December 2022 are even further off the predictions of Bain and Company and ICAO.

The international intervention model's optimistic scenario results are the closest to predictions supplied by both Bain and Company and ICAO. For January 2022, the optimistic scenario intervention prediction was 47%, close to the Bain and Company baseline prediction of 48% for the same month. The prediction is only 4% higher than the ICAO estimate of 43%. For December 2022, the intervention model prediction of 70.82% shifts away from the baseline prediction and towards the drifting prediction (67.78%) created by Bain and Company. The prediction also fits well into ICAO's recovery prediction of between 61% and 77%.

The optimistic scenario international intervention recovery predictions, therefore, align well with the recovery predictions of Bain and Company and ICAO. It must again be stated that while this does not prove the accuracy of the intervention model whatsoever, it provides insight into how this paper's model shapes up against recovery forecast models created by established companies within the aviation industry.

Figure 9 in the literature review illustrated that Bain and Company forecasted South African total air travel levels (measured as domestic + international passenger numbers) to reach 69% in June 2022. These results are compared to this paper's own neutral total recovery forecast results in Table 15, below.

Table 15: Bain and Company forecast vs intervention analysis results for June 2022 (Own table)

	BAIN AND COMPANY	DOMESTIC FORECAST (NEUTRAL)	INTERNATIONAL FORECAST (NEUTRAL)	TOTAL FORECAST (NEUTRAL)
SOUTH AFRICAN PAX JUN 2022 VS 2019	69%	64%	35%	55%

Domestic (1 522 132 passengers, 63.54% of June 2019 figures) and international (323 317 passengers, 34.61% of June 2019 figures) forecast predictions for June 2022 are added together to give the total prediction for June 2022. The total neutral prediction equals 1 845 449 passengers while June 2019 saw a total of 3 329 853 passengers travel in South Africa. This paper's model, therefore, suggests a total passenger recovery rate of 55.42% in June 2022, 13.58% lower than Bain and Company's June 2022 recovery prediction for South Africa.

4.9 COMPARISON: INTERNATIONAL COUNTERFACTUAL VS INTERNATIONAL ABRUPT/PERMANENT INTERVENTION RECOVERY FORECAST

This section discusses the results drawn from the comparison between the average counterfactual forecast and the neutral scenario for the international abrupt/permanent intervention forecast up until June 2023. With the view to brevity, clarity and practicality of results and for the purposes of this paper, the average predictions for both the counterfactual and intervention forecast will be compared and not the 95% prediction intervals. This comparative analysis therefore assumes that the counterfactual growth trend would have continued in a predictable way and that the neutral or "current" recovery scenario will take place.

Comparative analysis between the counterfactual forecast and the intervention forecast will aid in determining the possible extent of international passenger demand losses caused by the Pandemic should recovery take place as the forecast suggests. The comparison is illustrated below in Figure 24.

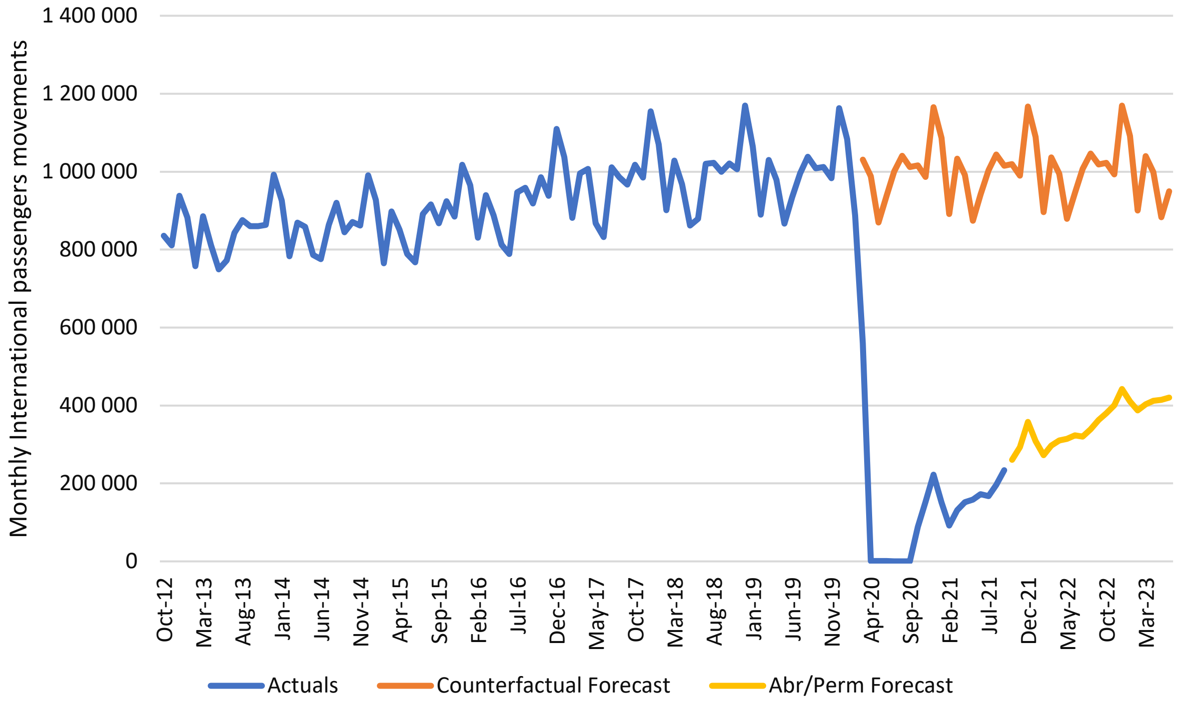

Figure 24: Average international counterfactual and intervention forecast comparison (Own analysis)

Earlier on in this chapter, comparative analysis was conducted on the international counterfactual forecast versus the actual observations up until and including September 2021 (See Figure 22). According to the analysis, for the period of March 2020 to September 2021, between 14 120 863 and 18 769 074 international South African passenger movements were lost as a result of the Covid-19 Pandemic and related travel restrictions. The intervention forecast predicts 4 070 153 international passenger movements in 2022, 34% of 2019 figures. The model's predicted recovery level for 2022 would be up 9% from the recorded recovery rate of 25% in 2020.

The counterfactual scenario predicted that there would be 10 929 042 international passenger movements in 2022. The recovery forecast suggests that 2022 will have 6 858 889 fewer international passenger movements than the counterfactual scenario's estimate of 10 929 042. The model predicts that the first half of 2023 will witness continued yet slowing recovery. The last observation predicted, June 2023, is expected to see 420 192 international passenger movements, putting its recovery figure at 44,3% of the counterfactual scenario's June 2023 predicted figure. When actual observations from March 2020 to September 2021 are combined with the recovery forecast predictions, it is estimated that international passenger movements will total 9 910 449 for the period of March 2020 – June 2023.

The counterfactual forecast for the same period of March 2020 – June 2023 is 40 063 755. The comparative analysis, therefore, suggests that the total international passenger movement losses for South Africa, between March 2020 and June 2023, will be 30 153 306.

4.10 EFFECT ON AIRCRAFT MOVEMENTS

Alongside passenger movements, used in the previous analyses, ACSA also records all domestic and international aircraft movements at its airports. To further analyse the effects of the Pandemic on passenger air travel, the impact on aircraft movements was examined for the period of April 2012 to December 2021. The data was not subject to a cut-off point such as the one used for the intervention analysis model and thus data for October, November and December 2021 could be used for this analysis. Findings relating to the changes in passengers per plane may offer insight into the way airlines have responded in terms of aircraft sizing and capacity utilization.

4.10.1 Domestic Aircraft Movements

Figure 25, below, shows domestic aircraft movements (arrivals and departures) at ACSA airports from April 2012 – December 2021.

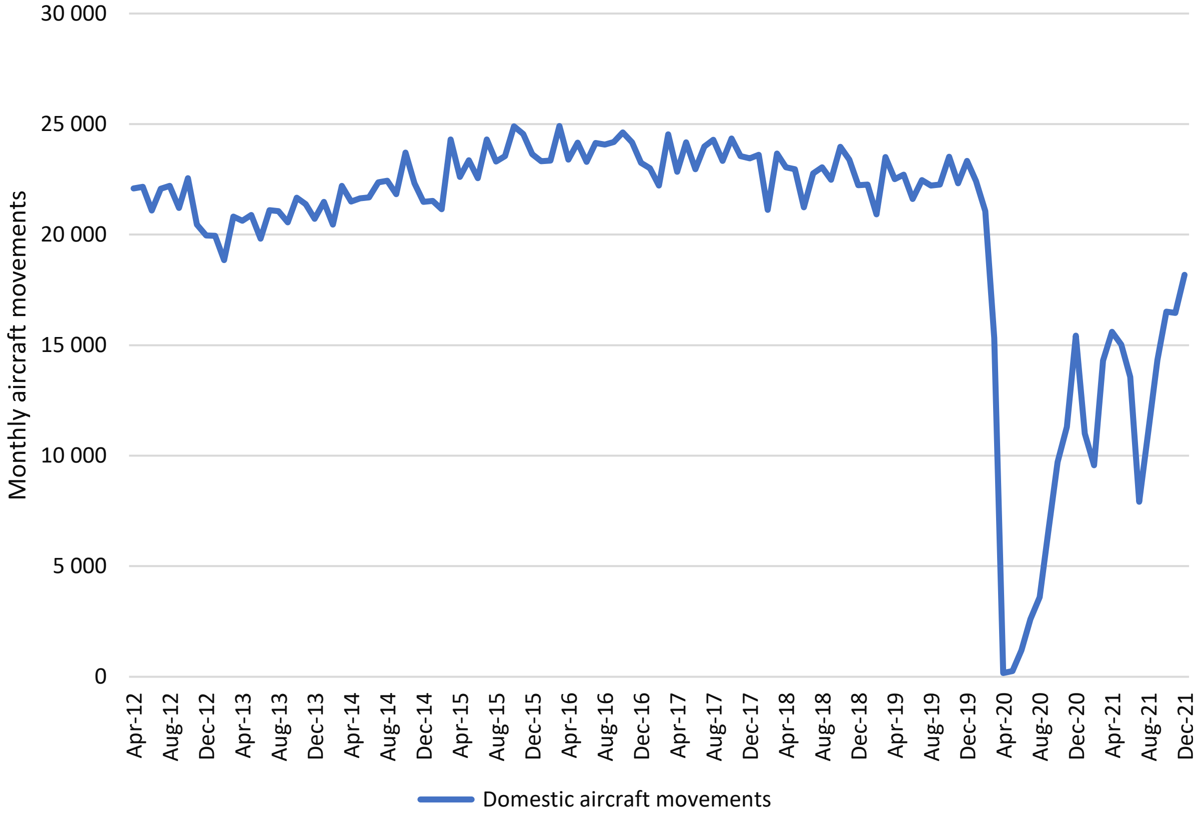

Figure 25: Domestic aircraft movements April 2012 – December 2021 (Source: ACSA, 2022a)

For the years 2013 to 2016, monthly domestic aircraft movements at ACSA steadily rose from the low 20 000's to an all-time high of 24 914 in March 2016. Between 2016 and 2020, monthly domestic aircraft movements remained between 21 000 and 25 000. A slight decrease in aircraft movements can be seen during these years. In contrast to aircraft movements, domestic passenger movements increased over these years, as illustrated in Figure 11.

The fact that more domestic passengers travelled while less flights were conducted suggests that domestic airlines shifted to more efficient operations models which resulted in higher occupancy rates and passenger load factors. This will be further explored later on in the section. At the start of the Covid-19 Pandemic, domestic aircraft movements fell from 21 060 in February 2020 to 15 332 in March 2020 and just 170 in April 2020. Following the cessation of air travel restrictions, domestic aircraft movements showed strong recovery up until December 2020 when 15 427 movements were recorded.

December 2020 domestic aircraft movements therefore saw a recovery of 66.2% compared to December 2019 figures. For comparison, domestic passenger movements reached 53.7% of December 2019 levels. This suggests that the airlines continued to oversupply flights despite the lower passenger demand. It is possible that the airlines conducted these “loyalty-flights” to display reliability and commitment during unprecedented times as an attempt to establish better brand images.

Domestic aircraft movements fell to 9 573, 45.7% of 2019 levels, in February 2021 as the Beta variant gripped South Africa. Domestic aircraft movements climbed to their highest post-Pandemic figure of 15 598 in April 2021 before declining to 7 912 in July 2021 when the Delta variant impacted the nation. September 2021 saw 14 324 domestic aircraft movements take place, 64,3% of 2019 figures. Domestic aircraft movements continued a strong upward trend up until the last data observation used in this analysis, in December 2021. December 2021 saw 18 175 domestic aircraft movements take place, 77.9% of December 2019’s figure and 17.8% above December 2020’s figure. Total domestic flights for 2021 were 163 496, 60.6% of 2019 levels.

To better examine the strategies airlines took to optimize capacity usage, average passengers per plane before and during the Pandemic was calculated. The monthly domestic passenger movements were divided by monthly domestic aircraft movements for the period of April 2012 to December 2021. It must be noted that only average passengers per plane is calculated and not passenger load factors. The reason for this is that passenger load factors are calculated by dividing total passengers on a specific plane by the capacity of that specific plane. Plane specific data is not used in this study.

This analysis rather gives a broad idea of the changes in capacity caused by the Covid-19 Pandemic. Figure 26 below illustrates the average domestic passengers per aircraft movement between April 2012 and December 2021.

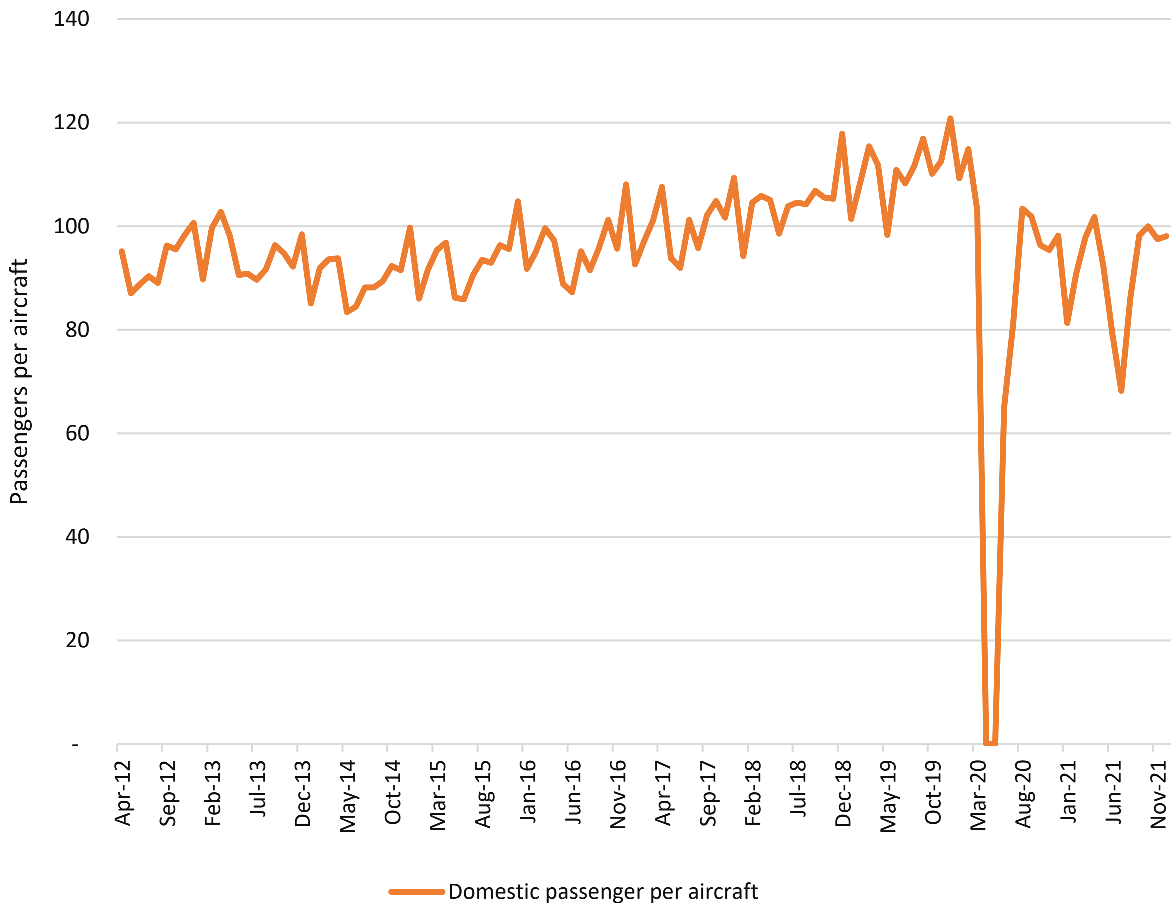

Figure 26: Domestic passengers per aircraft - April 2012 - December 2021 (Own analysis)

Table 16 below, shows average monthly domestic passengers per aircraft recorded between 2012 to 2021.

Table 16: ACSA average domestic passengers per aircraft recorded between 2012 to 2021 ((ACSA, 2022a)

YEAR	DOMESTIC PASSENGERS PER AIRCRAFT	GROWTH YOY
2012	93	
2013	95	2.1%
2014	90	(5.2%)
2015	93	3.3%
2016	96	3.2%
2017	100	4.1%
2018	105	5%
2019	111	5.7%
2020	81	(27%)
2021	91	12.3%

Between 2012 and 2016, monthly average passengers per aircraft fluctuated between 90 and 96 passengers per aircraft. From 2017 – 2019 this grew to 111 domestic passengers per aircraft movement, an increase of 15.6% over the 3 years. The increase in occupancy rates can be attributed to the increase in demand and decrease in the number of aircraft movements. This supports the theory that domestic airlines shifted to a model which aims to increase passenger occupancy rates. Another possibility is that the airlines shifted to larger aircraft on average.

After restrictions were lifted, average domestic passengers per aircraft recovered to 65 in June 2020, 46 fewer than the average of 111 in June 2019. Airlines made impressive recoveries in terms of passengers per aircraft when August and September 2020 saw 103 and 102 domestic passengers per aircraft, respectively. The rest of 2020 saw a respectable average of 97 passengers per domestic flight. The average for the year of 2020 is calculated to be 81, 27% below 2019 figures. Thanks to increases in demand, reductions in restrictions and strategic scheduling and planning, 2021 saw airlines recover 12.3% of lost capacity on 2020 figures, recording an average of 91 passengers per flight, 81.9% of 2019 figures. In December 2021, domestic passengers per movement was 98, 80% of 2019's level and exactly the same as December 2020's figure.

4.10.2 International Aircraft Movements

Figure 27 below, shows international aircraft movements (arrivals and departures) at ACSA airports from April 2012 to September 2021.

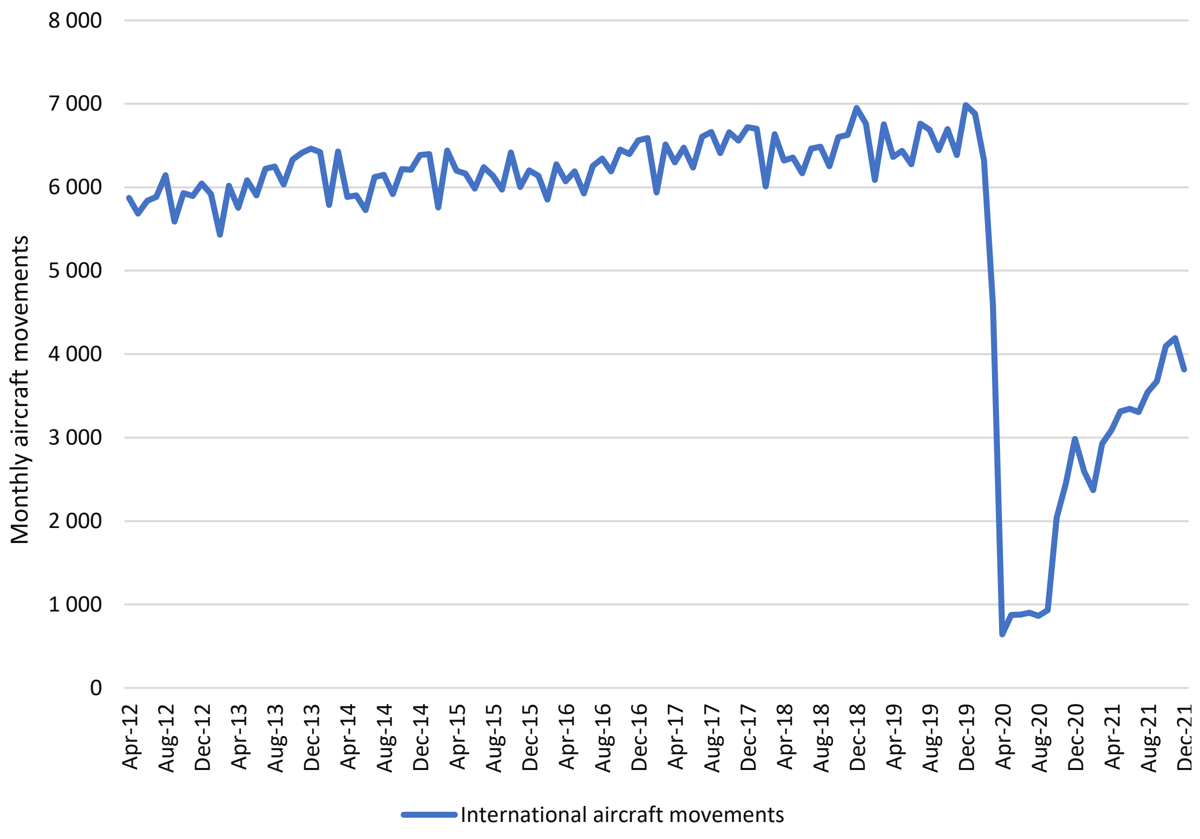

Figure 27: International aircraft movements April 2012 – December 2021 (Source: ACSA, 2022a)

Between April 2012 and March 2020, international aircraft movements at ACSA airports grew steadily each year. International aircraft movements grew from 6 047 in December 2012 to an all-time high of 6 985 in December 2019. Furthermore, 2013 saw total annual international aircraft movements of 72 814. This number grew by 5 832 to 78 646 for 2019. The Covid-19 Pandemic looks to have interrupted an upward trend in international aircraft movements at ACSA airports.

At the start of the Pandemic, international aircraft movements fell to a low of 642 in April 2020. For the months of April 2020 to September 2020, 5 089 international aircraft movements were recorded while only 3 101 international passenger movements were recorded for the same period. This shows that some international aircraft movements occurred without any passengers onboard. This finding can likely be attributed to maintenance flights and the fact that many passenger aircraft were used to transport cargo, often storing the cargo on the seats (South African Civil Aviation Authority, 2020).

International aircraft movements in South Africa started to recover in December 2020, recording 2 986 aircraft movements, a recovery rate of 42.2% compared to 2019 levels for the same month. For comparison, domestic aircraft movements had recovered to 66.2% of 2019 levels by December 2020. Following a decline to 2 369 aircraft movements in February 2021, linked to the Beta variant outbreak in South Africa at the same time, international aircraft movements continued to recover up until November 2021, despite the Delta variant outbreak in mid-2021. In November 2021, 4 192 international aircraft movements took place, a recovery rate of 65.6% versus November 2019 levels. December 2021, the final observation point available and used in the analysis, saw 3 815 international aircraft movements, 54.6% of 2019 levels and

27.7% higher than December 2020 figures. The total annual aircraft movements for 2021 were 40 268, 51.2% of 2019 levels.

Figure 28 below depicts international passengers per aircraft, calculated by dividing monthly passenger movements by monthly aircraft movements.

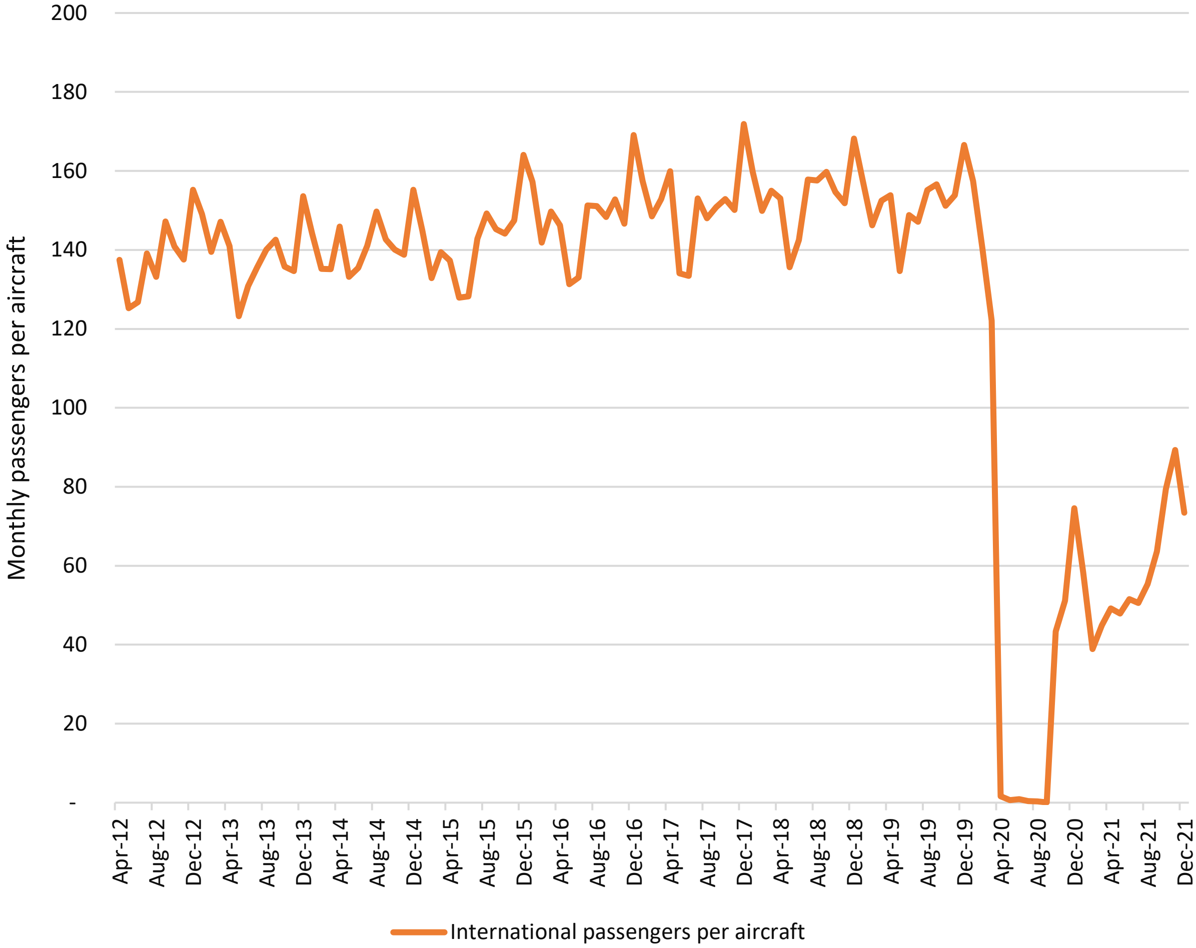

Figure 28: International passengers per aircraft - April 2012 - December 2021 (Own analysis)

ACSA average international passengers per aircraft between 2012 and 2021 are shown below in

Table 17: ACSA average international passengers per aircraft recorded between 2012 to 2021 ((ACSA, 2022a)

YEAR	INTERNATIONAL PASSENGERS PER AIRCRAFT	GROWTH YOY
2012	138	
2013	139	0.7%
2014	141	1.4%
2015	142	0.7%
2016	148	4.2%
2017	151	2%
2018	154	1.9%
2019	152	(1.2%)
2020	49	(67.7%)
2021	59	20.4%

From 2012 to 2019, passengers per international aircraft movement grew 10.1% from an annual average of 138 in 2012 to 152 in 2019. This steady growth aligns well with findings from across the globe regarding the growth in passenger occupancy rates in recent years (Statista, 2022).

During the months of April 2020 to September 2020 international passengers per aircraft reached a maximum of 2. When air travel restrictions were lifted in October 2020, passengers per aircraft rose to 43. The capacity recovery continued until December 2020 when passengers per aircraft reached 75 before falling to 39 in February 2021 amidst the outbreak of South Africa’s second wave of Covid cases caused by the Beta variant. International passengers per aircraft once again started to recover, increasing every month despite the emergence of the third, and most deadly, wave of cases. International passengers per aircraft peaked at 89 in November 2021 before falling to 73 in December due to the emergence of the Omicron variant. The 73 passengers per aircraft recorded in December 2021 equals a recovery rate of 43.7% compared to 2019 and a decline of 0.2% on December 2020's figure. Average passenger per international aircraft movement was 59 for 2021, 38.8% of 2019 levels.

4.11 MODEL ACCURACY FOR THE FIRST NINE MONTHS OF INTERVENTION FORECAST

In order to evaluate the accuracy of the model at the time of writing, actual air passenger movement data at ACSA airports for the months of October 2021 to June 2022 are collected and compared to the intervention recovery forecast.

Table 18 and Table 19 below, show the accuracy of the intervention model predictions for the months of October 2021 to June 2022, the latest available observations at the time of writing.

Table 18: Difference between international air passenger intervention forecast predictions and actual observations Oct 2021-Jun 2022 (Own analysis)

MONTH	INTERNATIONAL FORECAST	INTERNATIONAL ACTUALS	DIFFERENCE
OCT 2021	260 589	325 519	-64 929
NOV 2021	293 315	374 416	-81 101
DEC 2021	357 683	280 217	77 466
JAN 2022	308 252	336 864	-28 612
FEB 2022	272 105	399 461	-127 956
MAR 2022	297 149	548 162	-251 013
APR 2022	310 056	610 508	-300 452

MONTH	INTERNATIONAL FORECAST	INTERNATIONAL ACTUALS	DIFFERENCE
MAY 2022	314 634	560 324	-245 690
JUN 2022	323 317	555 727	-232 410

For October 2021, the first month predicted by the model, the forecast was slightly conservative, with 64 929 more passenger movements taking place than predicted. The difference grew slightly to 81 101 more passenger movements than expected. In December 2021, actual international passenger movements in South Africa dropped resulting in 77 466 fewer international passenger movements than the model predicted. The drop can be linked to the emergence of the Omicron variant in South Africa and the subsequent travel bans placed on the nation. January 2022 saw the most accurate prediction take place so far with passenger movements of just 28 612 more than expected. The final prediction, in June 2022, was 232 410 movements short of the actual movements.

Table 19: Difference between domestic air passenger intervention forecast predictions and actual observations Oct 2021-Jun 2022 (Own analysis)

MONTH	*DOMESTIC FORECAST*	*DOMESTIC ACTUALS*	*DIFFERENCE*
OCT 2021	1 396 978	1 650 532	- 253 554
NOV 2021	1 459 978	1 604 570	-144 592
DEC 2021	1 731 652	1 782 145	-50 493
JAN 2022	1 403 425	1 625 245	-221 820
FEB2022	1 389 823	1 637 806	-247 983
MAR 2022	1 677 784	1 968 039	-290 255

MONTH	*DOMESTIC FORECAST*	*DOMESTIC ACTUALS*	*DIFFERENCE*
APR 2022	1 782 103	1 916 451	-134 348
MAY 2022	1 680 363	1 823 147	-142 784
JUN 2022	1 522 132	1 558 113	-35 981

October 2021 saw 1650 532 South African domestic passenger movements take place, 253 554 more than predicted by the model. Another conservative prediction took place in November 2021 with the model predicting 144 592 fewer movements than actually took place. June 2022's prediction was the most accurate of all the readings, just 35 981 below the actual figure.

Considering the emergence of a new variant within these sample months, the domestic model remained very accurate and completely within the forecast prediction, It should be noted that seasonality pattern of actuals and the neutral forecast is remarkably similar. The international prediction was not as accurate with actuals falling outside of the forecast intervals for March and April 2022. The accuracy of both models is illustrated in Figure 29 and Figure 30 below.

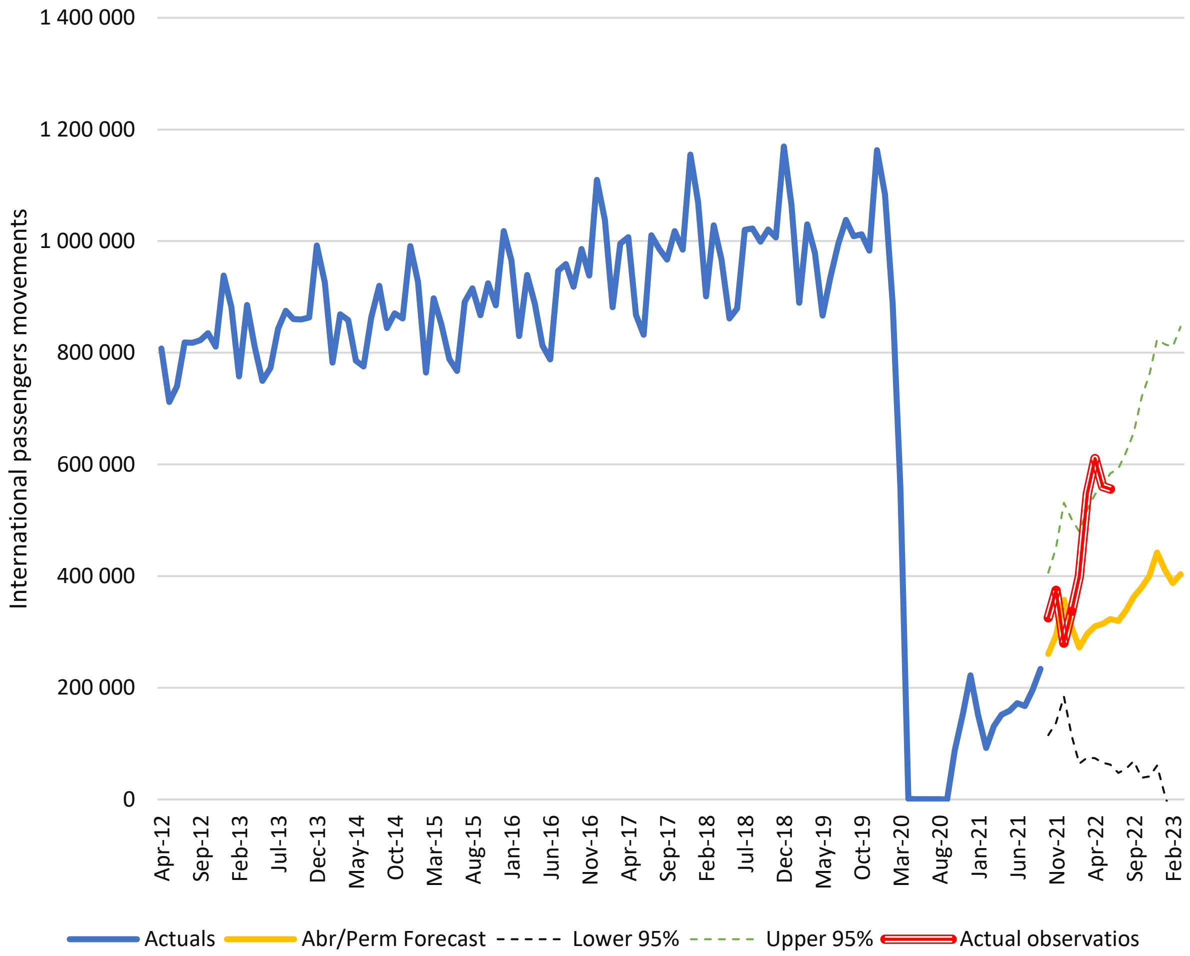

Figure 29: International recovery forecast vs actual observations October 2021 - June 2022

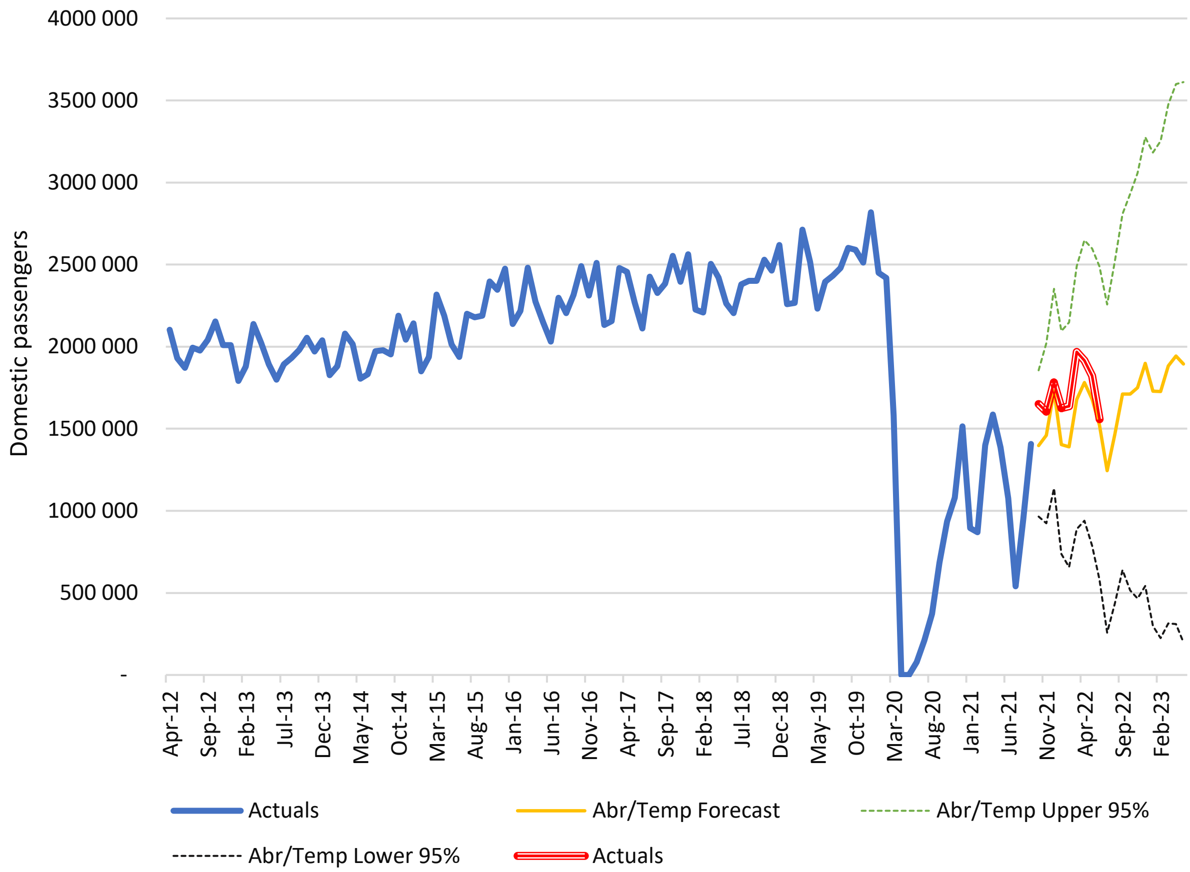

Figure 30: Domestic recovery forecast vs actual observations October 2021 - June 2022

The red “hollow” lines in Figure 29 and Figure 30 illustrate the actual domestic and international passenger numbers which were recorded from October 2021 to February 2022. The gold line is the neutral, abrupt/temporary forecast while the green and grey dotted lines are the 95% prediction intervals. It is clear that the actuals recorded remain very near to the baseline, or neutral scenario, forecast and well within the prediction intervals.

An interesting point to note from the accuracy test is the differing manners in which domestic and international recoveries have taken place. International air travel recovery has followed the more positive upper 95% bound while domestic air travel followed the neutral recovery path very closely. The supposed reason for the unexpectedly positive recovery of international air travel can theoretically be linked to the encouragement by IATA for nations to accelerate the removal of international travel bans in early 2022 (IATA, 2022a). Further research will need to be done to prove this and to identify other possible reasons for the difference in recovery trends. It should also be noted how successful the forecasts, the domestic in particular, were at predicting the seasonality of the recovery.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

The Covid-19 Pandemic has had a disastrous impact on global air travel demand and the industry in general. The initial impact was extremely severe, resulting in a total global RPK drop of 94% in April 2020 (IATA Economics, 2020a). ICAO (2022) found that annual total air travel fell by 60% in 2020 and 49% in 2021. Revenue losses were unprecedented, ICAO reporting that the global industry lost up to $694 billion for 2020 and 2021 combined. Air travel is expected to recover to between 27% and 29% below 2019 levels and suffer revenue losses of up to $181 billion in 2022.

McKinsey & Company (2021) stated in a report that the long-term damage to the air industry cannot be underestimated and that these effects are only now starting to emerge. The report found that the air industry accumulated $180 billion in debt in 2020, half of total industry revenue generated in the same year. The financial burden will most certainly have a negative effect on ticket prices and industry demand growth in the future.

Multiple studies, as discussed in the LITERATURE REVIEW, established that two past significant demand shocks, 9/11 and the 2008 financial crisis, far smaller than the Pandemic, had caused long-term impacts on air travel demand instead of shorter lasting effects (Inglada and Rey, 2004; Ito and Lee, 2005; Blunk, Clark and McGibany, 2006; CAPA, 2009). It is, therefore, wise to assume that the Covid-19 Pandemic will induce a long lasting and negative impact on the air travel industry. The emergence of new, more severe and contagious variants continues to threaten to disrupt recovery trends within the air travel industry, as witnessed with the spread of the Beta, Delta and Omicron variants.

The literature review revealed that the Covid-19 Pandemic has negatively affected the South African industry more severely than most other nations, especially in 2020. South African domestic air travel in 2020 declined by 62%, 12% worse than the average domestic declines of other nations (ACSA, 2022b). Similarly, South African international passenger numbers declined by 75.2% and 72.4% compared to 2019 figures for 2020 and 2021, respectively.

Furthermore, four South African owned airlines, SAA, Mango, British Airways and Kulula, collapsed in 2020. All three of these airlines, SAA, British Airways and Kulula have all engaged in business rescue practices with limited success. It is clear that the South African air travel industry has been brutally impacted by the Covid-19 Pandemic. The effects of the Pandemic on the industry are unlikely to subside in the near future. The impact and its full potential effects on the industry therefore needed to be investigated. To the author's knowledge there is no openly available analysis on the impact of the Pandemic on South African air travel demand nor an openly available recovery forecast model for South African air travel demand. It is crucial to analyse the impact that the Pandemic has had on the South African air travel industry so far, as well as the potential short-term future impact that can be expected.

Therefore, the primary aim of this research study was to examine the impact of the Pandemic on domestic and international South African air travel demand through the development of an intervention analysis model. The examination included the analysis of actual and current air travel demand losses suffered so far, as well as the construction of a recovery forecast model to establish the full short term predicted impact. An analysis of the impact on South African air travel demand was conducted and an intervention analysis model was created. After its successful creation, the model was used to forecast recovery predictions for South African domestic and international air travel. It can therefore be stated that the main aim of the study was achieved.

The first objective of the research study entailed investigating the counterfactual scenarios (had the Pandemic not occurred) for both domestic and international air travel. A SARIMA model was successfully created to produce the counterfactual scenarios. The scenarios were used as a baseline for comparison with the actual observations and recovery predictions. It was determined that a SARIMA (2,1,0) x (1,0,0)12 model was the appropriate model to be fitted. The counterfactual scenario illustrated that South African domestic air travel passengers would have grown strongly from 29.8 million in 2019 to 38.2 million in 2024 at an annual growth rate of 5.6%. International air travel would have maintained weak but positive growth trends with predictions suggesting growth from 11.9 million movements to 12.1 million by the end of 2024 (0.36% annually).

Once the first objective had been completed, focus shifted to the second objective - to construct a parsimonious intervention analysis model capable of forecasting the recovery of domestic and international South African air travel demand. The literature review confirmed that intervention analysis has been successfully used in many studies to accurately measure the impact of demand shocks on forecast variables (Box and Tiao, 1975; Montgomery and Weatherby, 1980; Izenman, Alan and Zabell, Sandy, 1981; Lee, Oh and O'leary, 2005; Bonham and Gangnes, 2010; Min *et al.*, 2011). More specifically, SARIMA with intervention analysis was compared to eight other time series modelling techniques and found to be the most accurate in predicting tourist demand levels (Goh and Law, 2002). With the assistance of the Stellenbosch University Centre for Statistical Consultation, the intervention model was fitted to the SARIMA(2,1,0) x(1,0,0)12 model and recovery forecasts were successfully created.

Objective three aimed to examine the abovementioned recovery forecast predictions and to discuss possible recovery scenarios. The domestic optimistic scenario suggests that air travel demand levels would fully recover by April 2022 and end the year with annual levels of 105% of 2019 figures. The domestic neutral scenario predicted that there will be 64.5% recovery in 2022, up from 37.9% in 2021. The domestic neutral scenario is similar to recovery predictions created by Bain and Company but more conservative than forecasts made by ICAO. Further detailed discussion of the comparison of these predictions can be found in section 4.5 of Chapter 4: The pessimistic prediction suggests that domestic air travel will slump to 25% of 2019 levels.

For international recovery, the optimistic scenario proposes that 2022 total international air travel will reach 62% of 2019 levels while the neutral scenario suggests that recovery will settle at 34%. The pessimistic scenario predicts a crash in recovery to 6.4%. Bain and Company also made a specific prediction for South African air travel recovery. Their forecast suggests 69% recovery in June 2022 for South African domestic and international passenger demand. This paper's intervention analysis predictions for domestic and international air travel were combined to give a total passenger recovery forecast of 55% for June 2022, 13.6% below Bain and Companies forecast.

The fourth objective was to comparatively analyse the counterfactual scenarios with the actual observations so far as well as the recovery predictions. Doing so established the full decline in passenger air travel so far as well as decreases that can be expected in the short-term future. The intervention analysis showed that in 2020 there were 11.3 million South African domestic passenger movements, a 62% decline on 2019 levels.

Comparison with the domestic counterfactual scenario reveals that South African domestic air traveller losses for 2020 were between 17.9 million and 22.9 million.

For the period from January 2021 to September 2021, between 10.4 million and 18.8 million domestic passenger movements were lost. The total domestic passenger losses between March 2020 and September 2021 were therefore between 28.4 million and 41.6 million.

The extended domestic neutral recovery forecast was compared to the extended neutral counterfactual forecast for the period of March 2020 to June 2023 to determine total losses attributed to the Pandemic up until the middle of June 2023. The prediction extracted from the comparative analysis is that total domestic passenger losses for this period will be 62 177 117.

South African International air travel demand for 2020 totalled 2 996 454, 74.9% below 2019's figures. The comparison between actual observations and the counterfactual scenario suggests that international passenger number losses were between 8.1 million and 9.8 million for 2020 and between 5.9 million and 8.8 million for Jan 2021 to September 2021. Therefore, the South African international air travel industry suffered passenger number losses of between 14.1 million and 18.7 million for the period of March 2020 to September 2021.

Comparison between the extended recovery forecast and counterfactual scenario suggests that 30 153 306 international passenger losses will be suffered in total for the period from March 2020 – June 2023. The research study therefore predicts that total South African (international + domestic) air travel passenger losses will reach 92 330 423 by June 2023. These findings prove that the South African air travel industry has been severely impacted by the Covid-19 Pandemic. The future implications, which could potentially result from the impact, will be severe. Implications could range from higher ticket prices, reduced safety adherence by airlines in an attempt to cut costs and declines in network coverage and overall air connectivity. The impact of the Pandemic on the air travel industry will undoubtably filter down to the economy through the loss of revenue and jobs within the industry.

Supplementary analysis was conducted on the impact of the Pandemic on aircraft movements at ACSA airports. It was found that 2020 domestic aircraft movements were 40.7% of 2019 figures (ACSA, 2022a). This increased to 60.6% in 2021. Passenger per aircraft rates also improved from 81 in 2020 to 91 in 2021, 81.9% higher than 2019 average passenger numbers per movements. This suggests some capacity recovery and optimisation by domestic airlines especially if the Beta and Delta variant disruptions are considered.

International aircraft movements recovered to 51% in 2021, up from 38.6% in 2020. International airlines have struggled to optimise capacity in the manner that domestic airlines have. The average international passenger per aircraft movement was 59 in 2021. This suggests passenger capacity average recovery of only 38.8% given that the 2019 average was 152 passengers per aircraft movement. December 2021 showed passenger per aircraft recovery of 43.7%, 0.2% lower than December 2020. This stagnated summer recovery can be attributed to the Omicron variant. International air travel recovery remains vulnerable to the emergence of new variants.

Objective six aimed to investigate the model accuracy for the period from October 2021 to June 2022. Actual domestic and international passenger movement observations were compared to the predictions in this study’s recovery forecast. The international recovery forecast was slightly conservative for October and November

2021, 64 929 and 81 100 below actual figures respectively, while December 2021's prediction overestimated by 77 466 movements. January 2022 presented the most accurate prediction at 92%, only 28 612 movements below actual figures. April 2022 was the least accurate of predictions, 30 452 short of actual passenger movements. May and June's predictions improved in accuracy, 245 690 and 232 410 movements short, respectively.

It was found that the domestic model was slightly conservative in all of its predictions. June 2022 was the most accurate observation with the model predicting 1 558 113 passenger movements, only 35 891 movements, or 2.3%, short of the actual figure. The observation which was furthest off was October 2021 when the recovery model forecasted 1 396 978 domestic traveller movements, but 1 650 532 actually took place. All actual observations for October 2021 to June 2022 fall well within the prediction intervals of both the international and domestic models created for this study. This showcases acceptable short-term accuracy when taking into consideration the unpredictable nature of the industry.

Reasons for some inaccuracy of the international forecast can be linked to limited post intervention observations and an unexpected and almost universal cessation of international travel bans, encouraged by IATA at the start of 2022. The objective of the forecast is to provide a quick forecasting solution during the exogenous event. Therefore, waiting for further post-intervention observations will delay the forecast output, thereby nullifying the advantage of the simplistic model. This creates a trade-off between model accuracy and timeliness of results.

The Covid-19 Pandemic continues to impact the global air travel industry. Many uncertainties exist relating to the recovery of air travel and any hopes for a resumption of pre-Pandemic operations are still on hold. Therefore, the results of this air travel demand research study are relevant, valuable, well-timed and add to the current knowledge pool. The research study is the first to analyse the impact of the Pandemic on air travel from a South African perspective. Crucially, the study helps illustrate the total losses in passenger demand experienced so far, as well as the potential losses that are still to be suffered in the near future.

This study offers results and findings which create a deeper understanding of the severe consequences that the South African air travel industry faces as a result of the Covid-19 Pandemic. Moreover, this study successfully creates the first openly available, post-Pandemic South African air travel recovery forecast. The forecast overcame some obstacles presented by the currently unpredictable Pandemic to emerge as a simple, reliable and accurate tool. South African air travel industry stakeholders can use the findings of this study to prepare for future demand shocks.

The study acts as a proof test for the use of a simple and univariate intervention analysis to forecast recovery in the midst of a Pandemic. This study's model can be used in emergency cases and at short notice to forecast short term demand. It is recommended that future researchers build on this study's model to enhance accuracy and forecasting range. It is also recommended that the implications for the aviation industry, resulting from the decline in passenger demand in South Africa, be focused on in future research.

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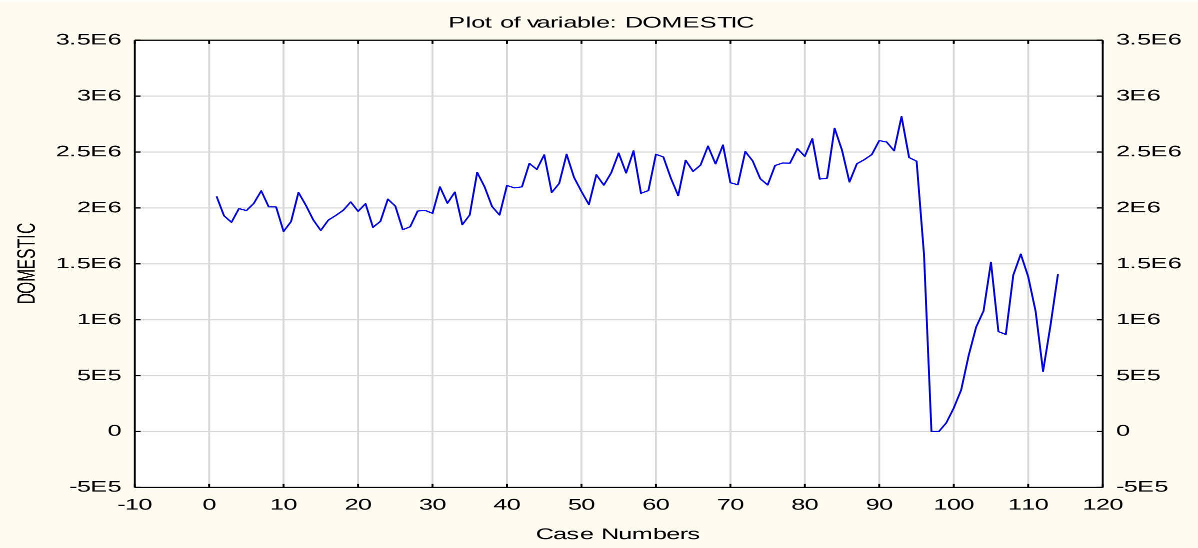
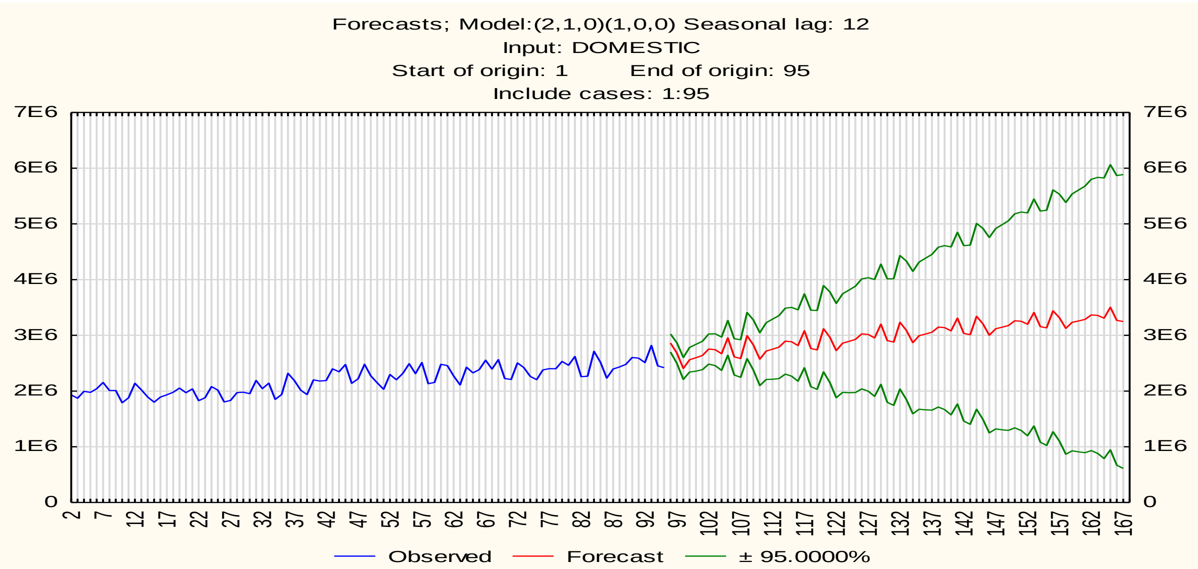
Annexure A: Domestic model

<u>Plot of variables</u>

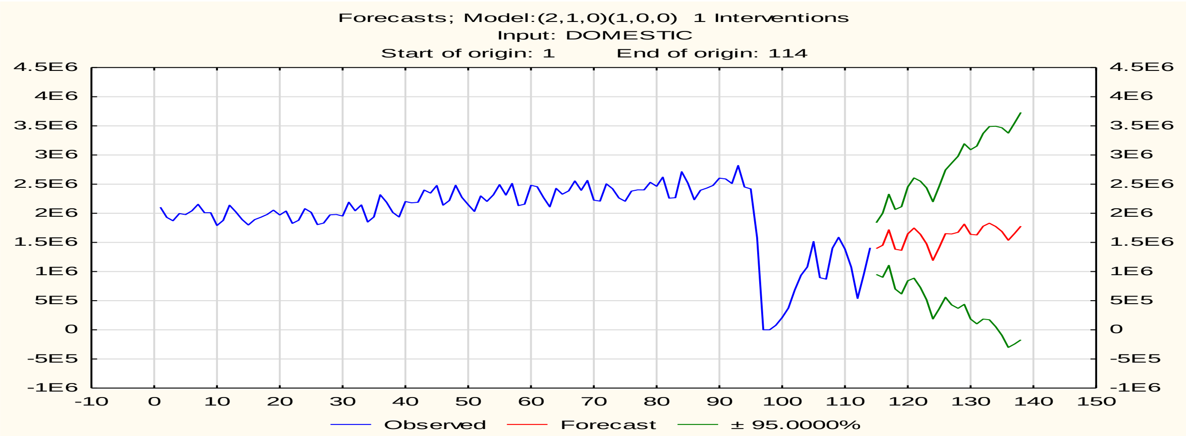


Pre-intervention forecast



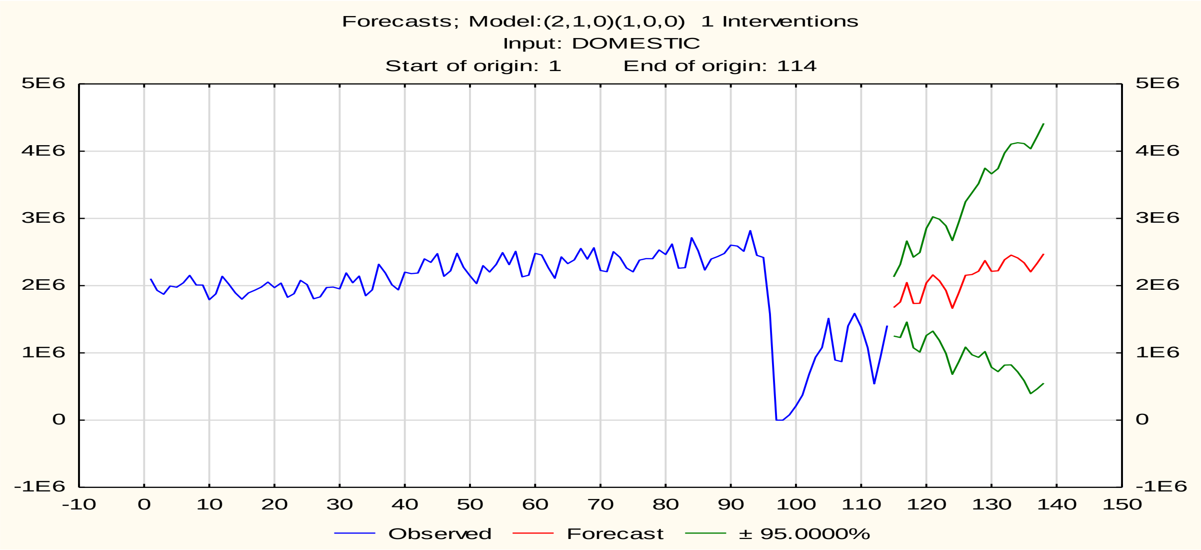
Abrupt/permanent model

	Input: TOTAL (ACSA DATA 20211025-Zack Sterley) Transformations: D(1) (Interrupted ARIMA) Model:(2,1,0)(1,0,0) Seasonal lag: 12 MS Residual= 8379E7							
Paramet.	Param.	Asympt. Std.Err.	Asympt. t(109)	p	Lower 95% Conf	Upper 95% Conf	Interv. Case No.	Interv. Type
p(1)	-0,434	0,134	-3,24393	0,001565	-0,699	-0,169		
p(2)	-0,228	0,108	-2,11321	0,036865	-0,443	-0,014		
Ps(1)	0,538	0,1	5,36935	0	0,34	0,737		
Omega(1)	-2618711,822	327453,364	-7,99721	0	-3267713,748	-1969709,896	96	Abr/Perm



Abrupt/temporary

Paramet.	Param.	Asympt. Std.Err.	Asympt. t(108)	p	Lower 95% Conf	Upper 95% Conf	Interv. Case No.	Interv. Type
	Input: DOMESTIC (ACSA DATA 20211025-Zack Sterley) Transformations: D(1) (Interrupted ARIMA) Model:(2,1,0)(1,0,0) Seasonal lag: 12 MS Residual= 5059E7							
p(1)	-0,283	0,151	-1,87171	0,063953	-0,584	0,017		
p(2)	-0,21	0,105	-2,00966	0,046961	-0,417	-0,003		
Ps(1)	0,527	0,105	5,01317	0,000002	0,319	0,736		
Omega(1)	-1682498,632	299229,687	-5,62277	0	-2275623,785	-1089373,478	96	Abr/Temp
Delta(1)	0,99	0,023	44,00281	0	0,946	1,035	96	Abr/Temp



Forecasts; Model:(2,1,0)(1,0,0) 1 Interventions
Input: DOMESTIC
Start of origin: 1 End of origin: 114
5E6
4E6
3E6
2E6
1E6
0
-1E6
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Observed
Forecast
± 95.0000%

Domestic extended baseline

Forecasts; Model:(2,1,0)(1,0,0) Seasonal lag: 12 (ACSA DATA 20210721-Zack Sterley)
Input: DOMESTIC
Start of origin: 1 End of origin: 95
Include cases: 1:95

CaseNo.	Forecast	Lower 95,00%	Upper 95,00%	Std.Err.
96	2861839	2700606	3023073	81170
97	2681334	2495773	2866895	93417
98	2406078	2209696	2602459	98864
99	2562172	2341404	2782939	111141
100	2598695	2358380	2839010	120982
101	2638660	2383935	2893386	128236
102	2754253	2483735	3024772	136187
103	2742748	2457026	3028471	143841
104	2669939	2370609	2969268	150691
105	2955000	2642407	3267592	157368
106	2613527	2288044	2939009	163858
107	2584184	2246454	2921914	170023
108	2995190	2580979	3409402	208526
109	2827680	2377783	3277576	226491
110	2572183	2097964	3046403	238736
111	2717059	2208451	3225666	256048
112	2750966	2211982	3289950	271340
113	2788064	2223308	3352820	284315
114	2895356	2304171	3486541	297620
115	2884677	2267960	3501394	310473
116	2817095	2176553	3457638	322468
117	3081692	2417970	3745414	334137
118	2764732	2078471	3450993	345484
119	2737496	2029543	3445450	356404
120	3118997	2344999	3892996	389653
121	2963512	2149136	3777888	409980
122	2726357	1880285	3572430	425938
123	2860832	1975448	3746217	445728
124	2892305	1970699	3813912	463963
125	2926740	1972659	3880821	480312
126	3026330	2039404	4013256	496847
127	3016418	1997515	4035321	512945
128	2953687	1904347	4003028	528269
129	3199289	2120196	4278382	543247
130	2905084	1796919	4013248	557882
131	2879803	1743418	4016187	572089
132	3233916	2035476	4432357	603330
133	3089593	1847782	4331404	625164
134	2869463	1591174	4147753	643528
135	2994285	1673479	4315090	664932
136	3023498	1662642	4384355	685095
137	3055461	1657638	4453284	703704
138	3147901	1712880	4582923	722431
139	3138701	1667264	4610138	740764
140	3080474	1573971	4586977	758417
141	3308444	1767529	4849359	775741
142	3035359	1460685	4610034	792737
143	3011893	1404259	4619527	809330
144	3340585	1672879	5008292	839572
145	3206623	1493415	4919831	862478
146	3002296	1249233	4755359	882543
147	3118157	1320302	4916011	905092
148	3145273	1304656	4985890	926620
149	3174941	1294148	5055735	946846
150	3260745	1339623	5181868	967149
151	3252205	1291451	5212959	987101
152	3198158	1198955	5197362	1006457
153	3409763	1372714	5446812	1025510
154	3156282	1081993	5230571	1044257
155	3134501	1023707	5245295	1062635
156	3439597	1269934	5609260	1092272
157	3315251	1098533	5531970	1115961
158	3125593	866546	5384639	1137270
159	3233136	927645	5538627	1160651
160	3258306	908076	5608536	1183174
161	3285844	893078	5678610	1204588
162	3365489	930087	5800890	1226052
163	3357562	880144	5834979	1247204
164	3307395	789002	5825787	1267832
165	3503808	944992	6062625	1288183
166	3268525	669841	5867209	1308253
167	3248307	610425	5886190	1327987