Towards a Sustainable Airline Business Model:

Addressing the Forces Impacting on European Based Airlines

Volume 1 of 1

Submitted by:

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Abstract
Since the year 2000 the existing business model of many European airlines has come under extreme financial pressure from a weak and volatile economy, the threat of international conflict, terrorism and pandemics, as well as a high dependence on the supply and price of fossil fuels. Oil based transport is becoming a major sustainability issue due to price and supply fluctuations, geopolitics, and burgeoning environmental concerns. This thesis examines the role of business model innovation in supporting a sustainability transition in the European airline sector.

To achieve this aim, I develop a novel framework that links the Multi-Level Perspective (MLP), the STOF model and business model innovation to understand the drivers affecting the European airline industry. I adopt a four-stage mixed-method approach consisting of a quantitative study of published European airline results, a grey literature review, forty structured interviews and a final triangulation. The findings pinpoint the failings of the industry and detail the major issues concerning its sustainability transition to a low carbon industry.

A fragmentation towards four business model groups is identified. The results of the research indicate that changes to airline business models are reactions to forces arising from the MLP and do not lead industry transition. The study indicates that a long incremental sustainability transition in an internationally regulated industry using evolving complex technologies is difficult to capture by reworking airline business models, but that the adoption of new technology can advance system transition. The separation of these technologies into operating ´parcels´ could offer a valuable understanding of their contribution to the business model construct. A sequenced framework for industry transition is proposed.

The thesis contributes to the limited literature on the role of business model innovation in shaping sustainability transitions and highlights critical issues and challenges facing the airline sector in Europe.

Keywords: Sustainability, Industry Transition, Airline, Regulation, Technology

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Declaration and Inclusion of Material from a Prior Thesis

The author confirms that the thesis is the candidates own work. There are references in Chapter 1 and Chapter 8, which refer to work in two other theses by the author alone and this is clearly indicated in the chapter concerned and in the references section under his own name.

The author confirms that this thesis has not been submitted for a degree at another University.

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List of Abbreviations and Acronyms

Abbreviation	Definition
A4E	Airlines for Europe, airline lobbying body in Europe
ACI	Airports Council International, represents the world's airports
AOC	Air Operators Certificate – a regulatory license granted to operate aircraft
ASK (capacity)	Available Seat Kilometer, aircraft seat number multiplied by distance flown
ATAG	Air Transport Action Group, airport user group body
(S)BMI	(Sustainable) Business Model Innovation
CASK	Cost per Available seat Kilometer (unit cost)
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation (ICAO)
EBIT(DA)	Earnings before Interest and Tax (after Depreciation and Amortisation), or Operating Profit
EC	European Commission, implements European Union (EU) Policy
(EU) ETS	(European Union) Emissions Trading Scheme
FTK (capacity)	Freight Tonne Seat Kilometer, tonnes flown multiplied by distance flown
IAG	International Airlines Group (a major European airline group)
IATA	International Air Transport Association, industry body representing airlines
ICAO	International Civil Aviation Organisation (UN) represents nation states civil aviation traffic bodies
LCC	Low-Cost Carrier airline (Pay as you go Hopper in this thesis)
LCLH	Low-Cost Long-haul airline (Frugal Red Eye model in this thesis)
OCF	Operating Cash Flow, cash generated from operating activities
MLP	Multi-Level Perspective a theoretical model of industry transformation
P2P	Point to Point, direct flight without a stop
PSO	Public Service Obligation – obligation to fly an (uneconomic) service
RASK	Revenue per Available Seat Kilometer, revenues divided by ASK (unit cost)
RPK (capacity)	Revenue Seat Kilometer, filled seat number multiplied by distance flown
(R)RPK (yield)	(Revenue per) Revenue Passenger Kilometer, passenger revenues divided by RPK
(R)RTK (yield)	(Revenue per) Revenue Tonne Kilometer, revenue generated per tonne flown
SLF	Seat Load Factor (RPK divided by ASK), filled capacity
STL	Socio-Technical Landscape (part of the Multi-Level Perspective Model)
STOF	Service, Technology, Organisation, Finance -a theoretical model (Bouwman)
STR	Socio-Technical Regime (part of the Multi-Level Perspective Model)
TN	Technological Niche (part of the Multi-Level Perspective Model)
(UN)FCCC	(United Nations) Framework Convention on Climate Change
VLCC	Very Low-Cost Carrier airline (Frugal Hopper in this thesis)
WTO	World Trade Organisation

Chapter 1 Introduction

1.1 The Significance of Europe's Airline industry

Over one billion passengers fly within Europe each year connecting businesses and individuals, and approximately two million jobs in the European Union (EU) depend directly on the aviation industry (Bulc, 2019). This number has increased by almost 40% since 2009. The aviation industry contributes €110 billion to the EU economy each year with aviation central to the EU's drive to facilitate jobs and growth (Bulc, 2019). The 27,000 flights passing through Europe each day represent 26% of world air traffic and the functioning of the EU's internal market in goods and services is highly dependent on these services. The UK received the most passengers in 2015 with over 230 million travellers, but per domestic inhabitant, Malta and Cyprus received the most, emphasising the importance of tourism to these islands. The UK, Germany, France, Italy and Spain are dependent on air-services to support tourism with an annual contribution of over USD 490 billion to the five states combined GDP. These countries are amongst the most visited worldwide destinations (WTTC, 2018).

Over two hundred airlines worldwide are majority or wholly state-owned (ICAO, 2016) although most of these are not home based in Europe. In Europe, airlines are now largely privately owned, but still dependent on a mostly state-owned infrastructure and subject to services provided by state monopolies or private oligopolies. Even though privately held, airline history means once state-owned national carriers enjoy historic grandfather rights at key hubs and tend to be treated favourably with state support if they encounter financial turbulence. Although not extensively 'market tested' such organisations may not be really be 'free to fail' as seen in the case of Swissair, Sabena and Alitalia. National interest means that some European airlines occupy a space between the state and the private sector, whilst others such as the new low-cost carriers seem to be fully in the private sector (Dobruszkes, 2009; Graham, 2009; Coleman, 2015) - 'a mixed economy'.

This quasi-autonomous status was brought to light after the insolvencies of a several European airlines post 11th September 2001 when three European national and local governments together with some private industry assistance, stepped in to provide financial support to restart national airlines for the economic benefit of the nation. These governments and airlines included Switzerland for Swissair/Swiss International Air Lines in 2001, Italy for Alitalia in 2002, 2004 and 2005, and Belgium for Sabena/Brussels Air Lines in 2002. In the case of Swiss International Air Lines, once central government and cantonal funds had been provided and a majority shareholding purchased, within five years the airline was returned to the private sector having been purchased in stages by Lufthansa in 2005 (49%) and 2007 (100%) (Done, 2008). After a funding injection from the state, Alitalia was sold by the state in 2009 to a consortium of Italian businesses CAI (51%) and Etihad the state airline of Abu Dhabi (49%) (El Gazzar, 2014). In 2015, Brussels Airlines was owned by central and local governments (55%) and Lufthansa (45%), with Lufthansa completing a full purchase of the airline in 2016 (Bryan, 2016). In 2017 the German Government allowed the second biggest German carrier Air Berlin to fail, but allegedly facilitated the transfer of parts of the Group to Lufthansa through a bidding procedure and extended financial credits designed to favour the former state-owned national carrier (DW.org, 2017). The regulator finally ruled that Lufthansa could only purchase parts of Air Berlin and not the NIKI subsidiary, which was part of the Air Berlin Group. International Airlines Group (IAG) then bid for NIKI before the Austrian Courts ruled that Niki Lauda could reacquire the company he formed in 2003 (Noeth, 2018).

European carriers sought state aid in 2002 for SARSCoV, and in 2010 when eruptions of the Icelandic volcano Eyjafjallajökull caused disruption to air travel and national economies across western and northern Europe over an initial period of six days (Sammonds et al., 2010, Wilkinson et al., 2012). Twenty countries closed their airspace to commercial jet traffic and ten million travellers were affected. Flight cancellations to and from Europe created the highest level of air travel disruption since the Second World War (Budd et al., 2010; Woolley-Meza et al., 2013). In 2020 the SARS CoV2 (COVID 19) global pandemic brought European airlines to a standstill, and they again turned to the state for bridging funds, loading them with increased debt obligations of 27 billion Euro (Van Doorn, 2020; Airline Bailout Tracker, 2020). Only three of the twenty bailouts included any green conditions, despite airline dividends and share buybacks of 17 billion Euro in the previous five years. Losses of USD 22.2 and USD 18.5 billion are expected in Europe in 2020 and 2021 with traffic movements down over 60% (Milne, 2020; Garcia, 2020; Eurocontrol, 2021, 2022).

Prior to the pandemic, European air traffic was projected to grow by 50% between 2012 and 2035 creating increasing challenges in the capacity management, safety and sustainability (IATA, 2018). At the same time, European operators face increasing competition within and outside its home market. Middle Eastern carriers have taken equity shares in European carriers, seeking to transfer long-haul passengers though their own, and cheaper, home base hubs (Paylor, 2014). The centre of gravity of the industry is moving towards emerging markets and the US and European dominance in civil aircraft manufacture is threatened by new players in China and Russia.

The European Commission (EC) has played a major role in taking action on airline safety and climate change (Figure 1). Europe is the safest continent to travel by air and has the highest levels of passenger rights and compensation (Bulc, 2019). The continent leads the industry in environmental controls with ongoing programmes to reduce aircraft emissions through better air traffic management (SESAR, 2020) and thus shorter direct flights and emissions taxes as incentives.

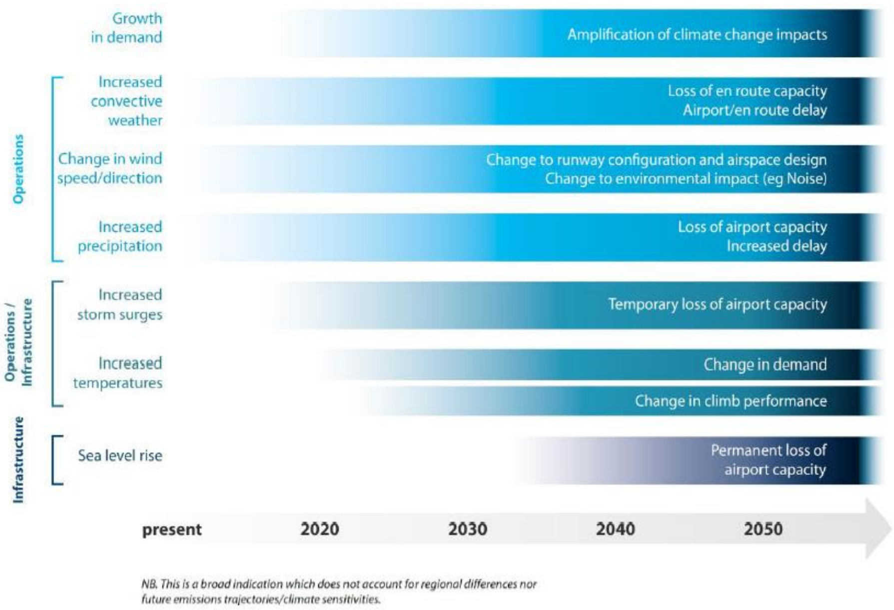


Figure 1: Key Aviation Climate Change Impacts

Source: European Commission and Eurocontrol (2017:183)

1.2 Europe's Airline Industry in a Global Perspective

The airline industry is a major contributor to world trade, not only does it facilitate the `face to face` nature of international business, enable tourism and transport skilled manpower across the globe, airlines also transport approximately 35% of global traded goods by value (Hummels, 2007; ATAG, 2019). Such services and products include high value hard goods, and time or temperature sensitive goods that are hard to transport effectively any other way (Brathen & Halpern, 2012; Lee et al., 2015). This percentage is somewhat higher in the world's developed economies, which have made greater investments in aircraft, navigation systems and airport infrastructure. From 1980 to 2018 global air traffic growth grew at over 5% p.a. (Boeing, 2019; Figure 2, Figure 3), faster than world GDP growth. A further indication of the significance of the importance of the industry is that an interruption to the stream of daily flights has serious consequences for the world economy and the existing lifestyles of first world consumers and aspiring consumers in developing countries.

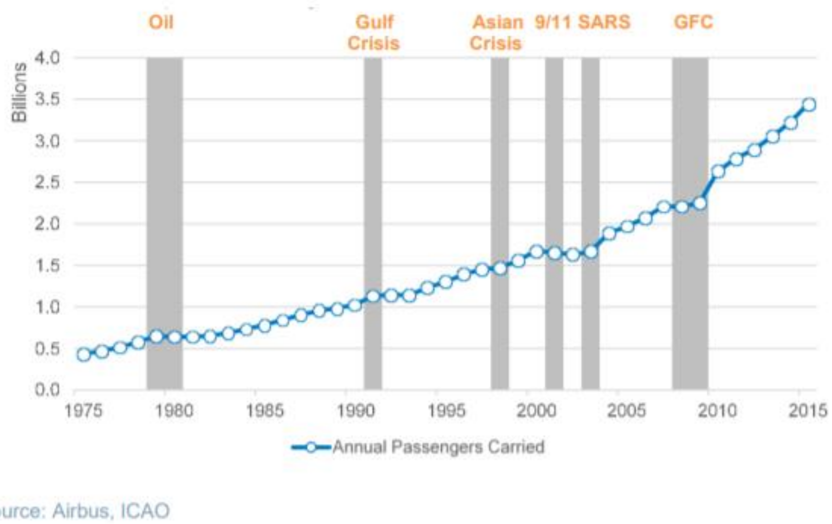


Figure 2: World Annual Traffic in Passengers 1975-2015

Source: European Commission (2017:23)

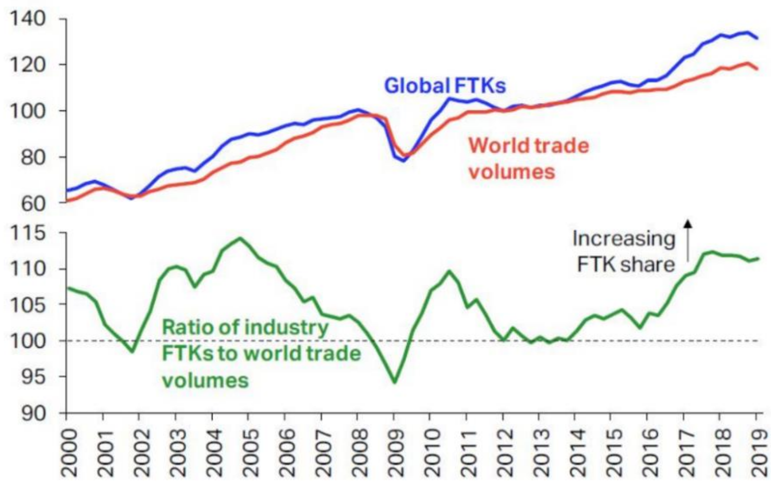


Figure 3: Development of World Cargo moved by Air as FTK (Freight Tonne Kilometer) 2000-2019

Source: CAPA (2019:1)

The link between world/area GDP growth and airline industry growth is well established (Figure 4) in a ratio of approximately 2:1. Over the past four decades, growth in global airline capacity as Revenue Passenger Kilometres (RPKs) has averaged 6% p.a. and world GDP growth has averaged 3.1% p.a. (IATA, 2019). The multiplier collapsed after 1991, but this was in a period beset with economic turmoil and military action in the Middle East. The correlation between economic growth and the growth of passenger numbers and capacity as Available Seat Kilometers (ASK) over the period 1970 to 2005 lies between 0.93 and 0.99, differing by geographical region (Ishutkina & Hansman, 2009; Kluge et al., 2017).

Airlines traditionally lose money when world GDP growth falls below 2% (Figure 5), and above this threshold the ratio of airline post-tax profits to GDP growth is a little more than 1:1. The ratio of capacity growth to profit growth is around 2:1, indicating the difficulty of operating profitability in the current industry environment and with the current business models (Figure 6). The dangers facing airlines of any economic downturns - when fixed costs remain to be paid, irrespective of the strengths of the revenue streams are clear. Governments may be willing to put up with losses of (partially) state owned airlines that serve economic interests, but private investors may be less patient.

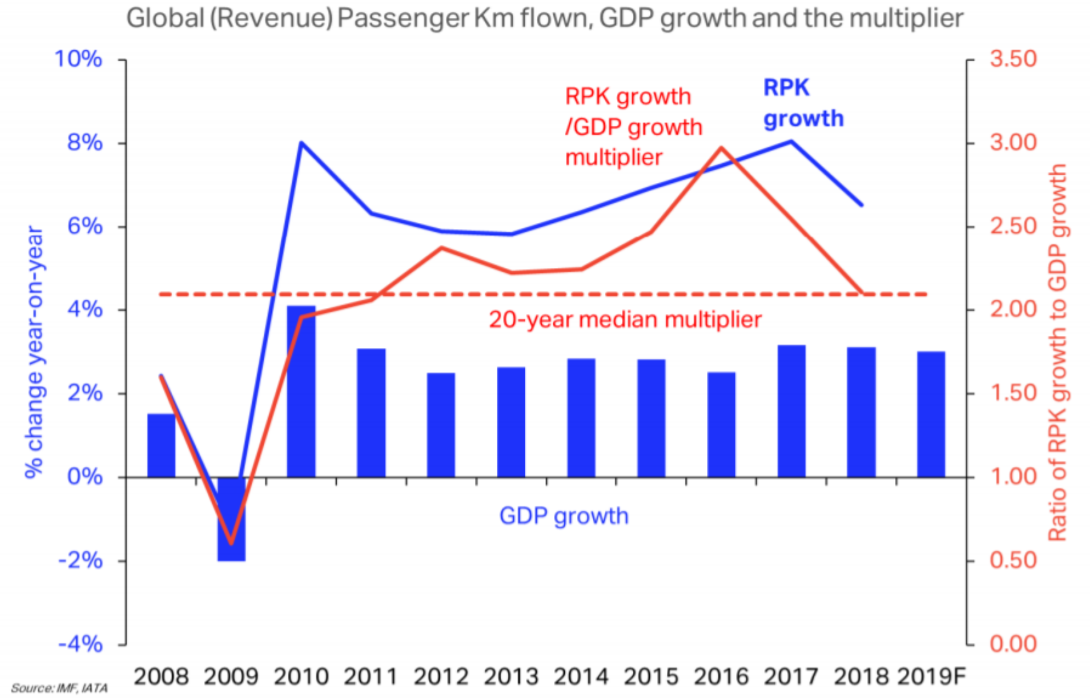


Figure 4: Airline Growth as RPKs and World GDP Growth (Revenue Passenger Kilometer) 2008 to 2019

Source: IATA (2019:1)

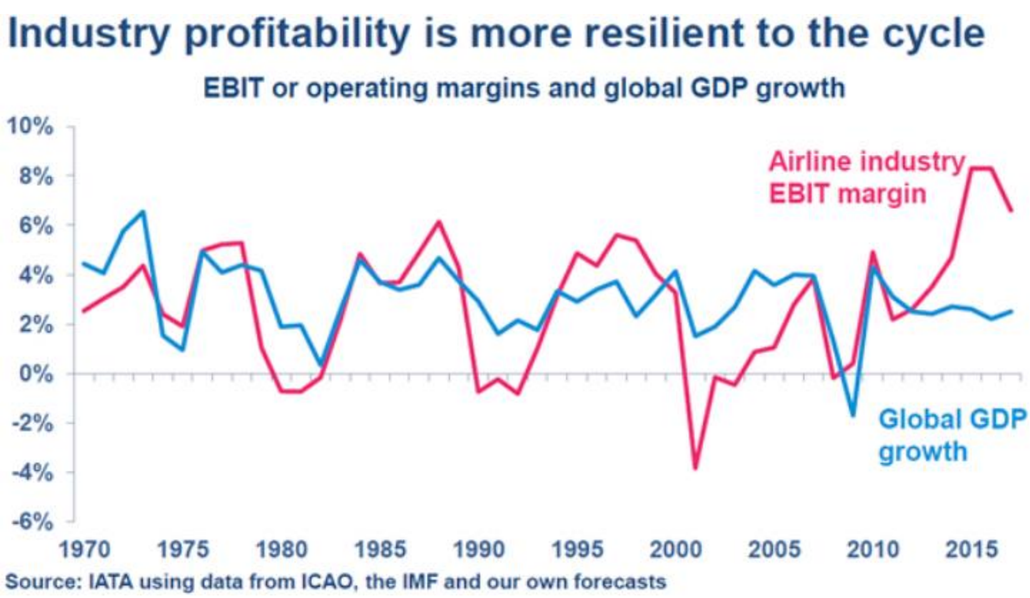


Figure 5: Airline before Tax Profit Profits and World GDP Growth

Source: IATA (2016:9)

The International Air Transport Association (IATA, 2019) make the case for the 'Public Value' of the airline industry by emphasising the value the industry creates in terms of jobs, tax, the transportation of goods (Moore, 1994). Some goods can be transported by rail and ship effectively and whilst high speed rail may well become an effective future competitor for short and medium distance journeys under four hours (Clewlow et al., 2014; Scheelhaase & Grimme, 2007; Chiambaretto & Decker, 2012; Capozza, 2016). Per passenger per kilometre travelled, the Air Transport Action Group (ATAG), an industry coalition, claims civil aviation is more carbon and fuel efficient than ship, rail and automotive transportation (ATAG, 2019).

Transportation accounts for about 23% of anthropogenic global CO2 emissions (World Bank, 2018, 2020) with commercial aviation accounting for about 2% in 2017 and predicted to grow annually to 2050. European emissions account for about a quarter of this. Non-CO2 emissions are broadly at the same level. Transport is the largest component of the fuel burning industries (Chapman, 2007). In the latest IATA (2018) twenty year forecast the industry transported almost 4 billion passengers emitting 815 million tonnes of CO2 in 2016 (with a half-life of more than a century), and this is projected to rise to between 5.7 and 10.3 billion passengers in 2037 (depending on policy scenarios). Annual passenger growth is projected to average 3.5% p.a., driven by increasing living standards, the growth in a young and working age population and middle classes in Asia. Approximately 54 million tonnes of cargo are moved each year and the industry links 40,000 city pairs in the global economy.

Airline growth in an economic environment demanding increasing capital investment in not possible in an industry with profitability that rarely covers the cost of capital (Figure 6, Wills, 2009; Pearce, 2018). The absence of alternative fuels in a business environment with finite fossil fuel resources, together with higher regulation to head-off a climate change disaster is unsustainable - and the challenge for this thesis. The economics of current business models are not financially or environmentally sustainable and new business models must be developed. Ranerup et al. (2016) have explored new structures for the development of business models in quasi markets - and although not in transportation these models might provide useful pointers for managing goals other than purely financial ones.

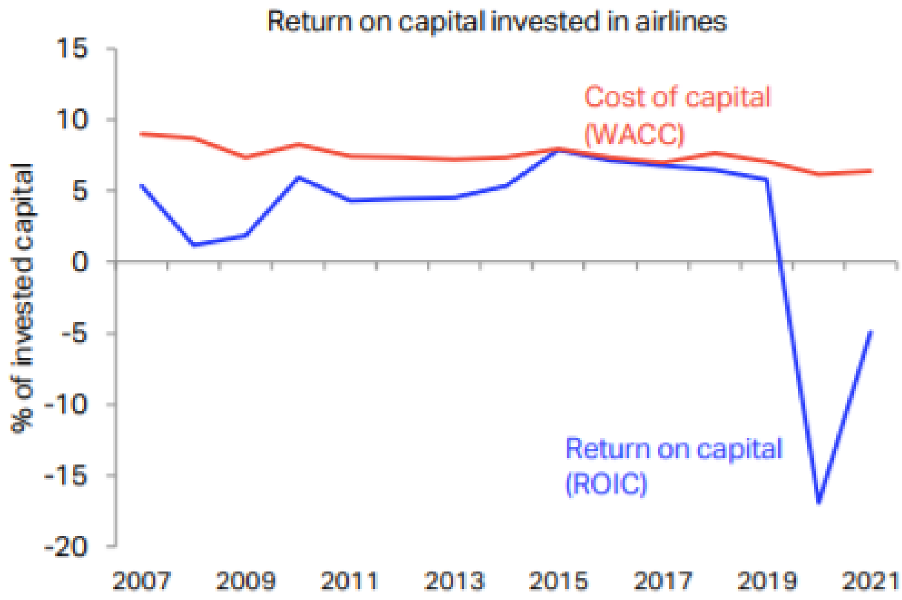


Figure 6: Return on Capital Employed against WACC World Airlines 2007-2020

Source: IATA (2020:3)

1.3 Europe's Airline Industry in Crisis

Dichter et al. (2016), maintain there are four key issues facing European airlines that will determine what the industry will look like post 2030. Firstly, although the industry has recently returned to profitability as a region, this is mainly due to a reduction in fuel prices (Figure 7, Figure 8, Figure 11). Looking closely at the figures only three airlines actually cover their own cost of capital as individual entities. Secondly, Brexit provides a high level of uncertainty as the UK is the largest single air transport market within the region. Thirdly, there is continuing airline consolidation within Europe due to weak profitability amongst the smaller players, while at the same time the low-cost carriers (LCC) and full-service business models are continuing to converge to attract new customers from their competitors. Finally, Europe's openness to airlines outside their home market especially the Middle East and North America and its attitude to fair competition and effective company control will be a major issue.

Nonetheless, the industry in Europe is seen as competitive with airline revenues and unit costs showing extremely high correlation, meaning that cost increases (and falls) are for the most part being passed onto passengers in ticket prices due to the high levels of competition. This is evident in the fact that the LCCs have doubled their capacity in Europe since 2006 leading to a 40% fall in intra-European services while at the same time Emirates, Etihad, Qatar and Turkish Airlines have quadrupled the number of seats offered in Europe and doubled the number of airports they serve in the continent. The effective ´hubbing away´ of traffic out of Europe has resulted in a decline in yield from Europe to Asia of 22% (CAPA, 2010; Dichter et al., 2016).

The profitability of Europe´s airline industry has consistently trailed the North American and Asian markets since 2006. The smaller markets on the Middle East, Latin America and Africa are more affected by direct or indirect government support and do not make for a fair comparison. The industry return on capital during the last forty years has been approximately 4%, half that required for a sustainable business (Pearce, 2018). Although airlines can support economic growth (Barrett, 2008; Mojsoski, 2014), overcapacity on perishable seats and cargo capacity has led to losses at individual carriers. Since 2001, Europe has often been the least profitable continent (Figure 7, Figure 8) with the difficulty in acquiring aircraft take-off and landing slots prompting airlines to fly unprofitable routes to prevent transfers to competitors (Schnell, 2006). In Europe, only the LCCs have shown consistent profitability since 2000 with the only exception 2020. Carriers have often overestimated demand in booms and underestimated the depth of the following slumps (Weatherford, 2014; Kambour, 2014). Traffic forecasts are unreliable given the long lead times in delivery of aircraft, with carriers erring on the side of too much capacity, since margins rise rapidly once fixed costs are covered.

Attempts to increase the variable portion of the cost base have met with resistance from partners in the value chain due to the weak bargaining position of airlines and the rising cost of security (Tretheway and Markhvida, 2004; IATA, 2013; IATA/WATS, 2018; Dichter et al., 2016) and from trade unions resisting the casualization of labour (Bamber et al., 2009 & 2016; Turnbull et al., 2004; Gittell et al., 2004 & 2009; Gittell and Bamber, 2020; Kochan et al., (2005); Harvey, 2009; Harvey & Turnbull, 2006, 2015). Morrell (2005) notes that the LCC offshoots of network carriers have failed to compete effectively with established LCCs due to lack of real separation from the parent and the strength of labour unions. Start-ups have had greater success reducing labour costs (Morrell, 2005; Wober, 2013; Harvey & Turnbull, 2015; Klein et al., 2015), but in Ryanair's case at the cost of fines for social dumping (Dumoulin, 2014).

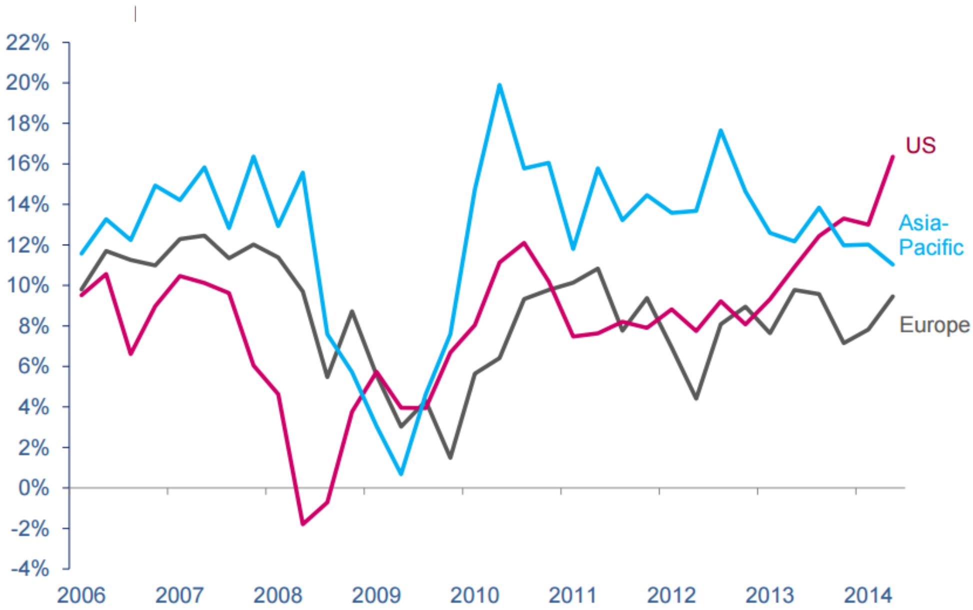


Figure 7: Airline EBITDA Margins by Region 2006-2015

Source: IATA (2015:4)

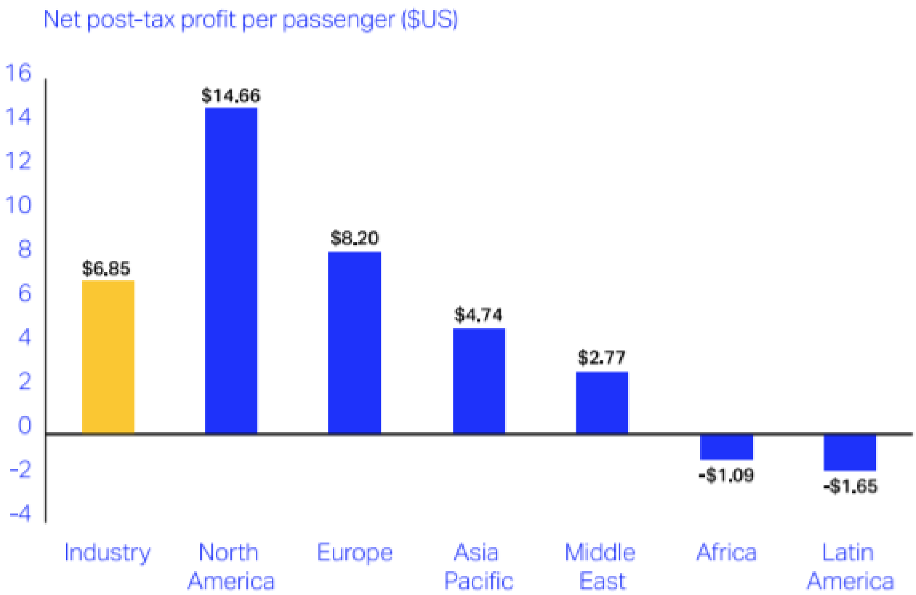


Figure 8: Airline Regional Profitability per Passenger 2018

Source: IATA/WATS (2019:14)

Beginning in the 1980s airlines in the North Atlantic region moved from state control to private ownership and the deregulation of airspace ensued (McGowan et al., 1992; Clougherty, 2006; Macchiati & Siciliano, 2007; Brown, 2014). European industry consolidation followed with three major airline groups now dominating:

- IAG (British Airways, Iberia, Vueling, LEVEL and Aer Lingus)
- Lufthansa Group (Lufthansa German Airlines, Austrian Airlines, Swiss International Air Lines, Eurowings and Brussels Airlines)
- Air France-KLM (Air France, KLM, Hop!, Cityjet and Transavia)

The LCCs emerged to occupy the short-haul market position previously held by the inherently less efficient network carrier model (Figure 12, Dennis, 2007; Alderighi, et al., 2012; Marti et al., 2015). In Europe, and since the demise of Air Berlin in 2017 the segment is now dominated by three large players Ryanair, Easyjet and Norwegian Air Shuttle.

Both business models suffer from high (semi) fixed costs and variable revenues meaning that capacity sold under distress results in cash flow volatility. As a result, margin erosion leads to cost cutting (Collins & Chan, 2011; Potter, 2011). In the years 2011 to 2020 passenger yields declined by 3.9% p.a. (Figure 9, Figure 10) and cargo yields fell more quickly at 4.2% p.a. Cargo typically accounts for 10-12% of Network carrier profits with less for LCCs. The decline in yield was facilitated by flying longer segments where yields are lower but route profitability is higher (Scotti & Volta, 2015; Amizadeh et al., 2016). Surcharges imposed to reflect changes in fuel costs do not translate into profits unless balanced by favourable changes in capacity and demand.

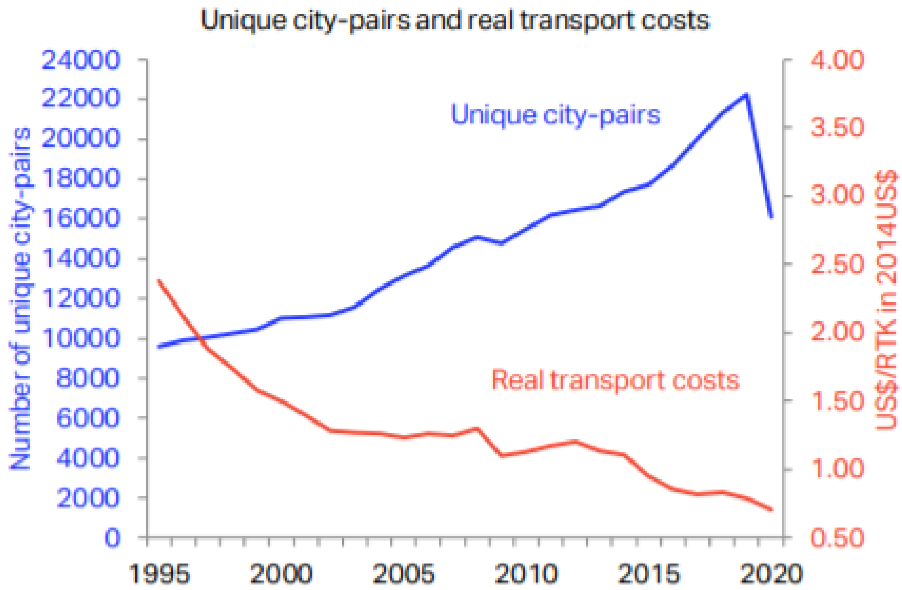


Figure 9: Growth in Air Transport (City Pairs) vs real Air Transport Costs 1995-2020
Source: IATA (2020:2)

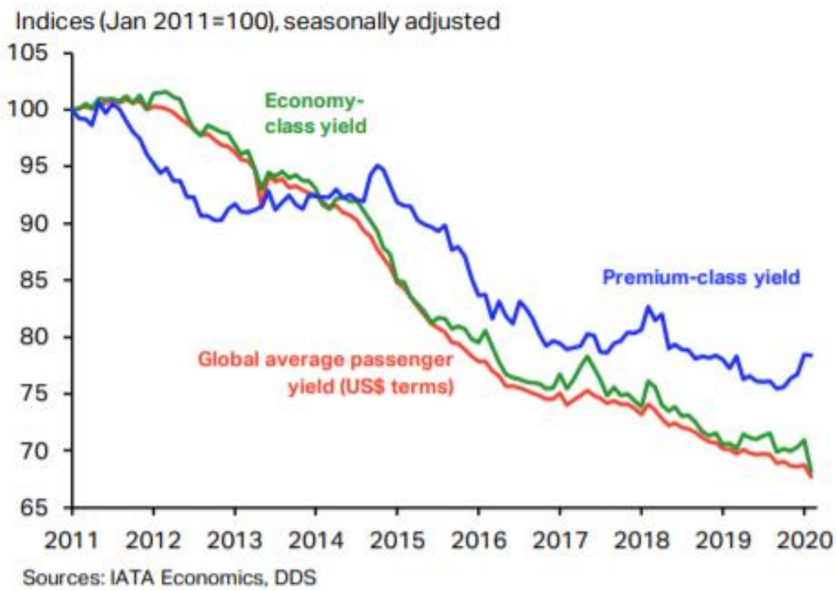


Figure 10: Passenger Yield Decline 2011-2020
Source: IATA (2020:2)

Since 2001, profitability amongst European LCCs has been approximately 5%, while network carriers have averaged 3% (IATA/McKinsey, 2013; AT Kearney 2012, 2014). As a result, Ryanair and Easyjet became the first and third largest airlines in the world respectively measured by passenger numbers (IATA/WATS, 2013). Wober (2013), Klein et al. (2015) and Meade (2014) report that the strategic location and (sometimes illegal) subsidy at secondary airports (Barbiere & White, 2015; OJEU, 2005, 2014), plus low local labour costs have been the principal drivers of LCCs growth (Figure 12). European LCCs might have reached the limits to growth (Francis et al., 2004; Sarker et al., 2012; Button, 2012; De Wit & Zuidberg, 2012) and are seeking markets on the edges of Europe that can be reached with existing fleets and investigating long-haul services, mergers and alliances (Lenartowicz et al., 2013). In 2013 Ryanair stated its intention to offer long-haul services (Wild, 2015), and Air Berlin and Norwegian Air Shuttle began intercontinental services in 2013 and 2014 respectively. IAG started low-cost long-haul services with a newly created airline 'LEVEL' in 2017 and Lufthansa with Eurowings-Discover in 2021.

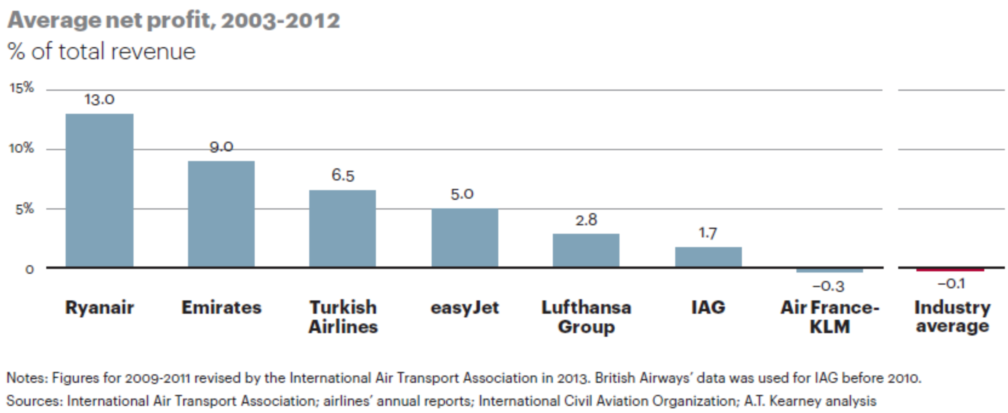


Figure 11: European Airline Industry Profits 2003-2012

Source: AT Kearney (2014:5)

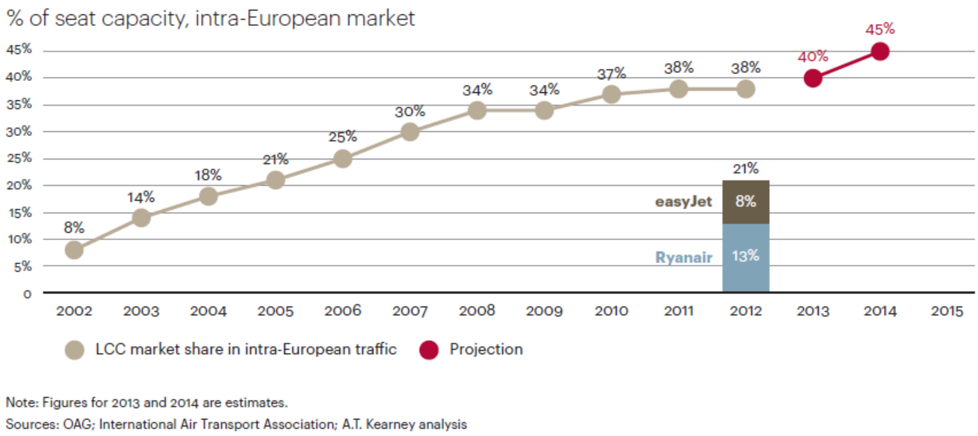


Figure 12: Penetration of Low-Cost Carrier Seat Capacity in European Market

Source: AT Kearney (2014:6)

Over most of the period since 2000, network carriers based in Europe have failed to generate positive cash flow on their short-haul services, with such traffic feeding the more profitable long-haul operations from large and monopolised airport hubs (Wall & Flottau, 2010; Collins & Chan, 2011). For IAG these hubs are at London Heathrow and Madrid; for the Lufthansa Group, Frankfurt, Munich, Vienna, Zurich and Brussels; and for the Air France-KLM Group, Paris and Amsterdam.

In 2012, jet fuel accounted for approximately 33% of airline operating costs (IATA, 2013) following a strong upward cost trend. Research suggests that there could be kerosene shortages by the middle of the next decade (Nygren et al., 2009; Cheze et al., 2011). Cheze et al. (2011) estimate aviation fuel requirements will rise 38% over the period 2008 to 2025 at almost 5% p.a. based on known aircraft deliveries and current fleet sizes (Appendix 12.7). At the same time, kerosene production is expected to fall with no suitable fuel replacements available in sufficient volume (Nygren et al., 2009). Such studies argue fuel shortages will cause industry growth to flat line in the medium term, because the demand for kerosene will outstrip the supply of high-quality oil sources and refining capability. More recent forecasts however indicate that demand is meeting supply in the medium term (IEA, 2020).

In airline profitability sensitivity studies, Nauman & Suhl (2013), Hsu & Eie (2013) and Chao & Hsu (2014) all show that airline network 'break even reliability' decreases dramatically with higher fuel prices. PwC (2015) see European airlines in their current form as unfit to meet the challenges posed by increasing future air transport demand seeing a major restructuring necessary due to long-term fuel price pressure, deficiencies in airline infrastructure and a shortage of technical talent. PwC (2015) opine that a period of low fuel prices offers a unique and limited opportunity for reinvestment in the industry to make it future ready. Ironically low fuel prices appear to lengthen the service lives of less fuel-efficient aircraft and older aircraft deterring reinvestment (Lennane, 2015), whilst it is high fuel prices that appear to encourage operational and technological fuel saving innovations (Adrangi et al., 2014, Jovanovic et al., 2015).

Table 1: The number of airlines that have ceased trading and start-ups by Country of Incorporation in Europe from 2000 to 2018 (excluding Air Taxis)

County of Incorporation	Airlines ceasing trading incl. mergers	Airline start-ups incl. mergers	Major Casualties incl. important mergers and rebranding
Albania	7	2	
Armenia	21	6	
Austria	27	5	Niki, Lauda Air, Tyrolean merged into Austrian Airlines
Azerbaijan	5	1	includes Nagorno Karabakh
Belarus	4	1	
Belgium	20	5	Sabena emerged as SN Brussels Airlines, then Brussels Airlines. Brussels Airlines being part merged into Eurowings (2019)
Bosnia- Herzegovina	10	1	
Bulgaria	20	11	Wizz Air Bulgaria merged with Wizz Air Hungary
Croatia	14	0	Zagal rebranded as Croatia Airlines
Cyprus	8	2	
Czech Republic	12	0	
Denmark	21	3	
Faroe Islands	1	0	
Greenland	9	0	
Estonia	11	4	
Finland	18	1	
France	54	8	Air Inter Europe merged into Air France
Germany	53	7	Air Berlin (2017), Germania, LTU, DBA, Germanwings merged into Eurowings
Georgia	25	5	
Greece	38	9	Olympic brand purchased by Aegean
Hungary	23	3	Malev
Iceland	11	2	WOW Air
Ireland	15	3	
Italy	65	5	Meridiana merged with Air Italy
Latvia	8	0	
Lithuania	13	4	
Luxembourg	5	1	
(North) Macedonia	5	0	
Malta	7	7	
Moldova	18	7	
Montenegro	1	0	
Netherlands	28	3	
North Cyprus	2	2	
Norway	15	1	
Poland	22	7	Air Poland
Portugal	14	8	
Romania	22	6	
Russia	148	8	
Serbia	13	3	
Slovakia	13	2	
Slovenia	7	0	
Spain	50	12	
Sweden	27	4	
Switzerland	29	3	Swissair assets transferred to Crossair - rebranded as Swiss International Air Lines 2002
Turkey	36	6	
Ukraine	40	8	Wizzair Ukraine
United Kingdom	95	7	Air 2000, bmi British Midland, Go-Fly, Monarch
Isle of Man	2	0	
Jersey	0	0	
Total	**1,112**	**183**	

Source: compiled by Author

Table 1 presents a list of over one thousand airlines that have ceased trading in Europe between 2000 to 2018 with under 200 start-ups. Table 1 highlights an issue that business model innovation would seem to be crucial to the airline sector sustaining itself economically, and even before the pressures of addressing climate change begin to severely affect existing models. Airline business model innovation (BMI) has focussed mainly on economic factors until recently, but now sustainability with new technologies add new layers of challenge and complexity. BMI means that changes in the revenue model, the value proposition and the value chain are successfully implemented to meet new demands from the landscape and the regulatory niche (Pereira & Caetano, 2015; Nair et al., 2013; Geels, 2018).

1.4 Sustainability in the Airline Sector

Growing international pressure to introduce carbon taxes means that fuel plus emissions charges is likely to exceed 40% of airline operating costs by 2030 (Wills, 2013). These trends are severely impacting an industry that not only cannot deliver its cost of capital but must also increase its investments in more fuel-efficient systems. Projections on the industry cost of fuel and emissions are in Appendix 12.6

The problems airline businesses face are common to transport and industries that are still highly dependent on oil, for example agriculture, pharmaceuticals and shipping, but those relating to air travel require extensive cross border cooperation as does rail and power generation. Company, industry and nation state agreement will be essential to achieving solutions. These may well be brokered through the airline industry bodies as in the case of finalising International Emissions Agreements in 2016 (ICAO, 2016); the latest in a series of international accords that began with agreements over the use of airspace at the United Nations Chicago Convention 1944 (ICAO, 2006). The Convention on Civil Aviation now has 191 signatories which include all but four small states recognised by the United Nations. New forms of partnerships within and across the industry and working more intensively with public bodies may emerge. This option might seem unusual given the history of moving away from state support in Europe, but there are scenarios that make this co-operation more likely.

In recognition of operating on a planet with finite and increasingly costly raw materials researchers developed the concept of 'sustainable business models' (SBM) to minimise the effect on the environment whilst aiming to ensure long term survival (Jackson, 2009; Bocken et al., 2014). Airlines now face serious environmental and technological issues, with the transformation to replacement fuel sources and the threat of emissions charges severely affecting their viability. Organisations do engage in SBMs models for reasons other than financial ones such as 'corporate reputation' or in the case of 'gaining political power'. The links between supply chain and customer interface, and the value proposition and financial model in SBMs being the most important elements (Gauthier & Gilomen, 2016).

´A sustainable business model can be defined as a business model that creates, delivers, and captures value for all its stakeholders without depleting the natural, economic, and social capital it relies on.´
(Breuer & Lüdeke-Freund, 2014:3).

In practise, sustainability means addressing business models in three dimensions. **Technological Initiatives** that include maximising material and energy efficiency, creating value from waste and the substitution of limited resources with renewables as part of the supply chain. **Social Initiatives** delivering functionality rather than ownership, protective and ethical stewardship, product and service longevity, consumer education and demand management, and **Organisational Initiatives** in terms of the benefits for society, open platforms and collaborative group approaches (Windsor, 2004; Stubbs & Cocklin, 2007; Boons & Lüdeke-Freund, 2014; Bocken et al., 2014; Schaltegger et al., 2016).

It is clear that current business models used by the European airline industry are unsustainable in that they cannot continue in their current form without depleting natural, economic and social capital. There is a need for developing sustainable airline business models that are financially, energy, environmentally and socially sustainable. A world without air travel is hard to contemplate (Bisignani, 2006), but the fossil fuel technology on which it has been dependent since it began will have to be substantially replaced over twenty to forty years (Babu & Subramanian, 2013).

1.5 Aims and objectives of the Study

The overriding aim of the thesis, therefore, is ´***To examine the role of business model innovation in supporting a sustainability transition in the European airline sector*.´**

To achieve this aim, five research objectives have been identified in Table 2.

Table 2: Research Objectives

Research Question	Research Objective
What characteristics have been key in European airline survival since 2000?	1. To carry out a historic quantitative study of the performance of Europe's airlines.
What sustainability challenges face the industry?	2. To conduct qualitative research to understand key stakeholder perspectives on the major challenges facing the European airline industry to 2030. These concern an industry at the interface of market, regulator and technology.
How will airlines negotiate the transfer to a low carbon world through sustainable business model innovation?	3. To use ideas from the literature on industry transformation and sustainable business models together with the analysis of a qualitative data to arrive at recommendations for a more sustainable European airline industry.
What barriers exist and how might they be overcome?	4. To identify the barriers to a successful transformation of Europe's airline industry and provide possible pathways to overcome them.
What are the key insights for sustainability transitions in general?	5. To use the findings of the study to reflect on the efficacy of the concept of 'sustainability transitions' and 'sustainable business models' and to provide portable, durable learning for other industries and particularly those transitioning from hydrocarbons.

1.6 Scope of the Study and Definitions

Europe is the site of the research for reasons of scope, timescale and data availability. The author has also worked as an accountant in the European airline industry for three major airlines. As such, the focus was based on personal interest and expertise to support methodological considerations. Europe is important, as it is a highly regulated market situated between the two other global hubs of North America and the Middle East that both seek its catchment passengers. Europe is also a market having ‘Open Skies’ and may show the way forward to other regions of the globe if deregulation is to continue. ‘Open Skies’ was a deregulatory agreement that allowed both US and European carriers reciprocal rights in flying transatlantic services (OJEU, 2007). This agreement also opens European air space to intra-European flights by US carriers, but critically European carriers were not allowed to fly intra US services in an uneven playing field. Further deregulation may make European carrier profitability even more problematic. For the purpose of this thesis the European Airline Industry means those airlines with a home base registered in Europe. This means that 50% of total flight operations of a ’European’ carrier will begin in Europe. Such operators are subject to European aviation law and EU emissions legislation. Although airlines from other jurisdictions often compete for the same passenger traffic in the capture area, the thesis is limited to those airlines as described due to the complexity of the subject matter. For the purposes of the quantitative study the largest (by passenger revenues) twenty publicly listed scheduled airlines with a long record of financial and operational results are used. These largest twenty carriers account for over 80% of the European market by passenger revenues and passenger numbers. This study focuses on the restructuring options of the airline industry in Europe. On current trends, European airlines are not able to finance their difficult transfer to a low carbon world, meet environmental goals and retain their value to the global economy without a radical transformation.

1.7 Contribution to Knowledge

This thesis aims to make several important contributions to our knowledge. First, from an empirical perspective, the goal of the project is to provide new critical independent insight, propose new ways of thinking, make recommendations and provide practical advice on how the European airline industry can successfully negotiate a difficult transition to sustainable fuels. The study is important and interesting because airlines play a vital role in the functioning of the global economy and in linking the global human population.

Second, from an academic perspective, this thesis contributes to knowledge and theory in two important ways. One is the attempt to examine the role and value of contemporary frameworks for studying the relationship between industry and sustainability transitions in business and management. Specifically, the Multi-Level Perspective is used as a theoretical framework for the analysis of external forces shaping airlines during decarbonisation (Geels, 2018), whereas the Service, Technology, Organisation, Finance (STOF) Model of Bouwman et al. (2008) is employed to structure the critical internal factors for airlines. The linking of these two models is shown in Figure 16 with the purpose of highlighting critical factors, studying the influences on performance and making proposals to redesign business models in an economy facing complex energy choices and regulatory change in Europe. For instance, this study adds to knowledge on how transport industries locked into mature combustion technologies so called 'carbon lock-in' (Unruh, 2000), might be transformed within a framework of corporate sustainability for the airlines. Unruh (2000, 2002) introduced the term 'carbon lock-in' to explain the reinforcement of structural factors that hinder the replacement of fossil fuel dependent technology in what he terms a 'Technoinstitutional Complex (TIC)'. As a result, this study extends existing theory by linking industry transformation with sustainable business models in the air transportation sector.

A second academic contribution derives from developing our understanding of how regulation and technology act as drivers of business model innovation. While this study does not include a discussion of aeronautical engineering, it does consider how regulation and technology affect and contribute to the development of sustainable business models. The research adds to the academic literature in the area of sustainable and comparative business models for global air transport where there is space to develop new thinking. Much of the existing material focuses on the USA and Asia, so a European study has value.

Knowledge and insights are gained that might also be relevant to other mature industries still highly dependent on oil, those facing economic and environmentally unsustainable business models and those requiring cross border co-operation.

Pathways forward for airlines are highlighted and implications for theory, policy and practice are discussed. There is a gap in in the academic literature addressing new business models for airlines in a low carbon world, and an absence of a comprehensive multifaceted study of the specific pressures facing the European air transport market. There is also considerable value in a comprehensive synthesis of the fragmented work on the disciplines of financial performance, airline strategy, industrial relations, airline operations and network management.

The next chapter reviews the academic literature to deepen the understanding of the frameworks in 'Industry Transformation' and 'Sustainable Business Models'. Following the literature review, a four-stage research methodology is explained in Chapter 3. Each stage of the research has a dedicated chapter of analysis (Chapters 4, 5, 6 and 7) before the recommendations are made in the discussion in Chapter 8. Conclusions in the light of the current global Coronavirus epidemic are reviewed in Chapter 9.

Chapter 2 Literature Review

2.1 Introduction

In the previous chapter I introduced the problems currently facing the airline industry in Europe and show how they will likely become more acute. The major issues are profitless industry growth, commoditisation of the service, the lack of investment potential of airlines and the fluidity of the boundaries between the players in the state and market. Given this, plus a dependence on a natural limited resource in kerosene with a transfer to renewables (the fourth energy transformation) and the imposition of emissions taxes, there is reason to believe the industry will have to address the pressure through restructuring the way it does business, a phenomenon studied in other industries (Nidumolu et al., 2009; Kavadias et al., 2016; Christensen et al., 2016). This phenomenon is understood through the process of business model innovation.

The purpose of this chapter is to review the broader academic literature on industry transformation and sustainable business model theory with the aim to identify relevant contributions on industry transformation and the extent to which these are driven or affected by business model change. This chapter is structured in five parts: i. the methodology, ii. an overview of the literature on industry transformation and the frameworks which have been developed to explain the process, iii. a literature review of business models, sustainable business models and sustainable airline industry innovation and, iv. how business model redesign might be accomplished through a discussion of 'change frameworks'. Lastly, v. a summary, research agenda and propositions based on the trends, issues and gaps identified in this review of extant literature concludes the chapter.

2.1.1 Methodology

To review the literature for this thesis I employed a thematic approach (Braun & Clarke, 2012). This means that the methodology was driven by a desire to identify key peer reviewed papers, authors and concepts of relevance to the broader debate while applying a replicable methodology. To that end, I followed the following steps: Firstly, I identified two key themes: i) Industry Transformation; and ii) Business Model Theory and within this theme Sustainable Business Models. Based on these themes, I then listed forty key search words, summarised in Table 3. I employed key word driven searches using the following search engines for business and economics journals: (Warwick) Library Search, Classic Catalogue and Google Scholar. I further delimited the literature searches by setting a time frame for publication post 2000 to ensure the works reflect latest developments. This search revealed more than 500 relevant papers. I first read their abstracts and key words to determine whether papers related to the key themes. I then organised this literature by publication date and placing papers under subsidiary themes, which I summarised to draw out key learning and gaps in the literature (Boote & Beile, 2005).

In the literature review section on Industry Transformation, I focused the search on ‘Energy Transformation´ and ´Business and Economics’ related journals, and in the Business Model literature review section I used a wider approach not limiting the search to leading journals given the specialist nature of the subject matter for example in air transport and energy. By employing this systematic and structured approach the search was conducted amongst globally published peer reviewed academic journals and other directly relevant publications. Cascades from summary papers, critiques and citations were used to gain a comprehensive and bias free summary from the full body of literature. Relevant findings within key papers were used to source earlier references prior to 2000. The full academic paper was acquired with the summary and conclusions proving most useful for gleaning insights. I summarise the findings of the academic literature in two ways, firstly in reviewing the literature on industry transformation and secondly linking this to business model theory in particular sustainable business models (Figure 13).

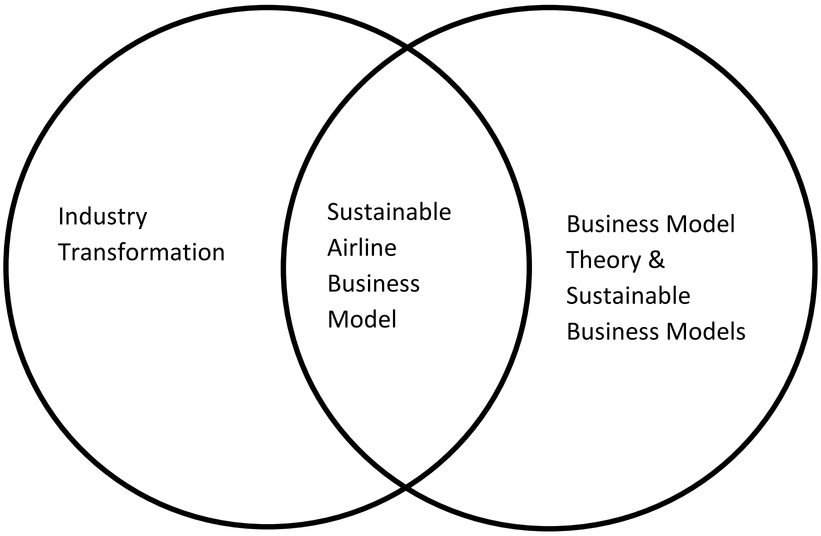


Figure 13: Venn Diagram of the Literature Review

Table 3: Key Words used in Literature Search

1.	Business Model
2.	Airline Business Model
3.	Sustainable Business Model, Multiple Business Model, Collaborative Business Model
4.	(Corporate) Sustainability Framework
5.	Green Business Model
6.	Business Model regeneration
7.	Business Model transformation
8.	Business Model roadmap
9.	Triple Bottom Line
10.	Corporate Governance
11.	Airline Corporate Governance
12.	Airline Regulation
13.	Models of Capitalism
14.	Low Carbon Transport
15.	Airline fuel efficiency
16.	(European) airline finances
17.	Airline margin
18.	Airline cost of capital
19.	Airline technology
20.	Business Model reengineering/transformation
21.	Airline fuel
22.	Oil crisis
23.	Carbon Lock-in
24.	Food Biofuel
25.	Nonmarket Strategy (airlines)
26.	Fracking and new sources of oil
27.	Industry transformation
28.	Energy transformation
29.	Industry renewal
30.	Energy renewal
31.	Transport transformation
32.	Transport renewal
33.	Business Model and Industry/Transformation/Transition
34.	Industry Transition
35.	Multi-Level Perspective
36.	Transition Management
37.	Strategic Niche Management
38.	Technological Innovation Systems
39.	Sustainable Business Model Measurement
40.	Airline financial / service measurement

2.2 Industry and Technological Transformation

There is an increasing literature in the structure and models of industry and technological transformation which reflects the importance of the subject matter, the rapidity of change in markets and growing environmental concerns. 'Sustainable Industry Transformations' differ from 'Industry Transformations' in that the former recognise global finite resources, seeking to replace them with renewable sources, and with an emphasis on substituting short term gains for long term performance (Jackson, 2009; Bocken et al., 2014). In the decade 1991 to 2000 I located 111 peer reviewed academic papers published in English containing the keywords ‘sustainable industry transformation´ or ´sustainable industry transition’. In the decade 2001-2010 this increased to 652, and in the period 2011-2020 this increased to 4,984. The greatest growth has been in sustainability, (industry) production and energy related journals (Table 4).

Table 4: Growth in Industry Transformation/Transition Publications in Peer Reviewed Academic Journals in English 1991-2020

Journal Title	**1991-2000**	**2001-2010**	**2011-2020**	**Total 1991-2020**
Sustainability	0	13	1,070	1,083
Journal of Cleaner Production	1	14	427	442
Energy Policy	1	39	255	295
Renewable and Sustainable Energy Reviews	0	0	133	133
Transactions on Sustainable Energy	0	0	40	40
Resources Policy	0	7	28	35
Ecological Economics	0	11	24	35
World Development	0	0	18	18
International Journal of Production Economics	0	0	16	16
Other peer reviewed	109	568	2,973	3,650
Total	**111**	**652**	**4,984**	**5,747**

Three major industrial energy transformations have already taken place in human history - from water and wind to wood, from wood to coal, and from coal to oil. Each seems to take place over two generations or approximately fifty years with total replacement taking up to 100 years (Kemp & Loorbach, 2003; Fouquet, 2010; Fouquet & Pearson, 2012; Alkemade et al., 2011) with old and new technologies coexisting until the newcomer reached superiority (Kerr, 2010; Aarapostathis et al., 2013). The transition from oil to renewables might have to take place more quickly than previous industry transformations to prevent serious environmental problems (York, 2011). Here lies the value of the study, because the transformation to renewables in air transportation is important to the maintaining of global trade and also the future life cycle of human health (Baldwin, 2014; Weldu, 2017; Klein, 2014).

Sustainability in (air) transportation will need to address issues of traffic congestion, greenhouse gas emissions, fossil fuel depletion and accident risk, as well as infrastructure renewal in an environment of public budget deficits (Markard & Truffer, 2012; Gil & Beckman, 2009). Existing path dependencies are highly linked to user practises, existing business models, safety, ´carbon lock-in´ technologies, regulation and the organisational structures of companies and institutions. This legacy of complexity points towards incremental and not radical change, (Rip et al., 1998; Markard & Truffer, 2006) at least initially.

2.2.1 Characteristics of Industry Transitions

Rotmans (2001) has defined the characteristics of Industry Transitions, noting they take place in multiple dimensions - economic, technological, political and social. They thus involve actors at all dimension levels. Radical shifts occur from the old to the new configuration. They are complex, uncertain and are long term processes. Because of the complexity and uncertainty of transition Kemp & Loorbach (2003) believe they cannot be imposed, or designed, they can only be managed. Raven (2006) and Geels (2011) add that 'sustainable transitions' need multiple solutions, are guided by principle rather than evolve, and the benefits are seen only decades after implementation. Benefits might be realised more quickly at the level of the company if there are incentives to transformation. For clarity I will use the word 'transition' to mean part of larger industry 'transformation'.

2.2.2 Levels of Industry Transformation

The meaning of industry transition and transformation has been discussed in the literature (Hölscher et al., 2017). There are two main theoretical camps with Geels & Schot (2007) and Davies (2013) arguing that transition occurs at multiple levels at the social, political, economic and cultural level, and Hicks (2014) and Pisano et al. (2015)

referring to small transition stages of a larger overall transformation akin to evolution in the natural sciences. Evidence shows that industry transformation is subject to the drag of the vested interests and an uneasy relationship with politics (Hess, 2014), with Van den Bergh et al. (2011) and Markard & Truffer (2012) showing the transformation process links political sociology, economics and technology. Unruh (2002) and Geels (2014) show companies are embedded in a ´triple lock-in´ - in economic, socio-political (external) environments and in (internal) industry regimes which prevent agility in the change process.

De Bruijn & Hofman (2000) hypothesise three possible transformation policy paradigms – ‘bottom up’ where the market framework is set and policy evolves using incentives and penalties; ‘top down’ where policy is given and enforced; and ‘interactive’ a combination of the two where debate settles the direction of policy. It is likely that in the case of the airline industry that policy will be enforced by the overriding goals of mitigating climate change while minimising serious economic effects, but that the airlines would be consulted particularly in relation to fairness amongst the players and drawing up a timescale for policy changes (ICAO, 2019).

Models attempting to describe industry transformation began in the 1990s with literature on Technological Systems (Carlsson & Stankiewiecz, 1991), Technological Regimes (Kemp et al., 1998; Rip & Kemp, 1996) and Transitions Management (Rotmans et al., 2001). Four major frameworks of analysis have emerged, i. The Multi-Level Perspective, ii. Transition Management, iii. Strategic Niche Management, and iv. Technological Innovation Systems.

2.2.3 The Multi-Level Perspective (MLP)

Several authors promote the use of a MLP approach to modelling with change occurring at three distinct levels: the Socio-Technical Landscape (STL), the Socio-Technical Regime (STR) and the Technological Niche (TN) (Rip & Kemp, 1996; Kemp et al., 2001; Geels, 2002; Geels & Schot, 2007; Budde et al., 2012; Konrad et al., 2008; Wesseling et al., 2015) (Figure 14).

Socio-Technical Landscapes refer to exogenous contexts that change slowly (e.g., demographics, macro-ideologies, climate change, macro-economics, material organisation of infrastructure and cities), but can occasionally change quickly such as in time of war, economic or other shocks or oil price volatility.

Socio-Technical Regimes represent the tangible systems; the intangible rules, shared cognitive assumptions, regulations and standards which structure but do not determine action. They develop over long time periods between regime elements and also as a response to exogenous landscape pressures and niche-innovations (Kemp, 2010; Kemp & Pontoglio, 2011; Geels, 2011).

Technological Niches are spaces where radical innovations are nurtured. These may be in research and development functions in private industry or in public hands such as a University or Government Agency. Geels et al. (2010) propose that technological transitions focus on how multiple innovations are experimented with, are combined and reconfigured and the governance of such structures. Turnheim & Geels (2012) show transitions are most effectively accomplished at destabilising crisis points with Boons & Wagner (2009) indicating that the level of analysis of economic boundaries and measurement of post transition performance occurs at the level of the company, market, supply chain and economy. This is an idea I return to this idea at the end of this chapter.

Industry transitions come about by following four phases in the three MLP levels (Geels, 2002). In the first phase, radical innovations emerge in small niches on the fringe of existing regimes (Kemp et al., 1998) developed by innovator networks or by entrants from other industries. Radical innovations may be supported by policy instruments if deemed vital, as in energy infrastructure. In the airline industry this probably makes innovation from airlines unlikely, unless working in an innovator network probably with manufacturers. In a second phase, the innovation enters market niches that provide resources for further development and specialisation, allowing the emergence of a dominant design and the stabilisation of industry standards and rules. The third phase is a wider diffusion and competition with the existing regime. This diffusion depends upon drivers such as price and performance improvements, scale and learning benefits, the development of complementary technologies and infrastructures, positive experiences and support from the powerful players (Smith & Raven, 2012). The incumbent regime becomes unstable due to internal problems, landscape pressures or a combination of both (Roberts, 2017). The final and fourth phase involves system substitution and institutionalisation in new regimes. Research suggests that transitions are not driven by single policies, but by policy mixes (Kivimaa & Virkamäki, 2014; Kivimaa & Kern, 2016; Rogge & Reichardt, 2016).

While the MLP may seem to focus on the diffusion of technological innovation through the niche and landscape it is important to remember that innovation might also be applied in the revenue model, in the value proposition and in the value chain of the business model - something this thesis aims to capture.

Multi-Level Perspectives have been applied to sustainable transitions in the electricity industry (Verbong & Geels, 2007; Hofman & Elzen, 2010; Cameron & Geels, 2019), to materials recycling (Jackson, 2014), food production and housing (Smith et al., 2010), vehicle transportation (van Bree et al., 2010) and aviation systems (Geels, 2006). Typically, industry transition occurs when technology developed in a niche tries to be accommodated in both the landscape and regime through a repetitive process of evolutionary variation and selection. Skellern et al. (2017) praise the MLP model for its clarity in separating innovation from regime and landscape, while the criticisms of the approach are that they rely on bottom-up activity, that the agents of change and level boundaries not clearly identified (Smith et al., 2010; Geels, 2011), while Shove & Walker (2007) regard the model as too abstract. Markard & Truffer (2008) link Technological Innovation Systems and the MLP comparing their similarities.

Geels (2018) draws comparisons between the MLP and the disruptive innovation framework of Christensen (1992, 2016) concluding that the MLP is a more appropriate framework for examining transitions to a low carbon landscape. There are three reasons for this. Firstly, in the case of the European airline industry the MLP model includes a level of state activity in the form of operating licenses, consolidation and emissions legislation, industry standards and financial transactions in the form of taxes and incentives. The financial, social and technological barriers to industry transformation will have to be addressed, negotiated and co-ordinated with the regulator as a central agent of change.

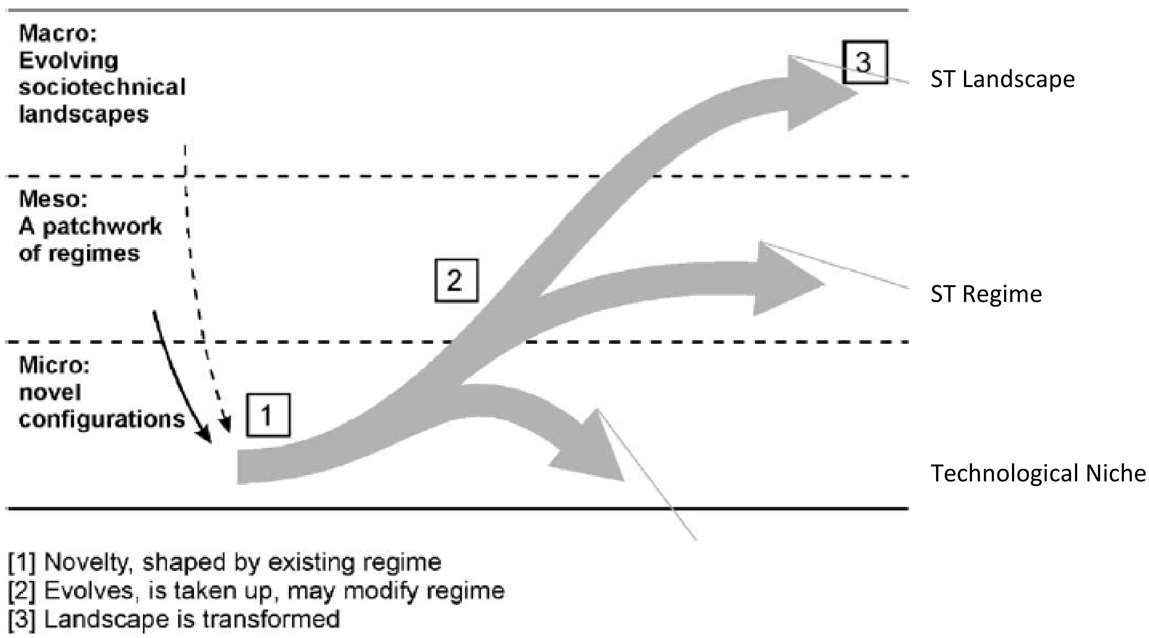


Figure 14: The Multi-Level Perspective

Source: Geels (2002:1262)

Secondly, the MLP model accommodates an understanding that it is not necessarily single innovations that cause changes in the niche - but a linked series of innovations and innovation hubs working together in co-operation with one another. In the case of the European airline industry there are a series of actors being established within private industry and in state and academic institutions whose co-operation must be coordinated. The innovations must align with politics, pressure from activists in society, lobby interests and the corporate strategies of all players.

Thirdly, Christensen's disruptive framework assumes that it is the most cost-effective innovations that succeed and are adopted. This may not be the case with innovations in a decarbonising landscape, since first generation technology is often expensive, inefficient and uncommercial, but reducing in price and increasing in efficiency with each successive level of innovation.

2.2.4 Transition Management (TM)

TM is an approach that aims to facilitate and speed sustainability transitions through a participatory process of visioning, learning and experimenting. TM seeks to bring together multiple actors, multiple viewpoints and multiple approaches in a 'transition arena'. Participants are invited to structure their shared problems with the current system and develop shared visions and goals which are then tested for practicality through the use of experimentation, learning and reflexivity. TM takes a long-term approach creating long term visions and short-term objectives. TM focuses on learning at the niche level, experiments are used to identify how successful a particular pathway could be and uses the concept of ´learning by doing, doing by learning´. Systems thinking approaches identifying problems are used that span multiple domains, levels and actors (Rotmans et al., 2001; Smith et al., 2005).

Transition Management models (Rotmans et al., 2001; Smith et al., 2005) maintain it is the actors which influence the transformation process by experimentation and incremental improvement and by gaining stakeholder buy-in, creating productive networks and the coordination of short-and-long term plans. It is the actors, stakeholders and coalitions that adapt to changes and deliver transition (Kemp et al. 2007; Nill & Kemp, 2009). Loorbach & Rotmans (2010) studied successful TM processes in the housing, healthcare and waste management sectors, but acknowledge that the theory focuses on the start of the innovation process and the actors at this level, without reaching to more complex levels of interaction in transitions such as with the state or regulator. It is thus probably less useful as a framework for an airline industry transition.

2.2.5 Strategic Niche Management

SNM refers to the process of managing niche formation processes through real-life experiments. The concept was developed by Arie Rip a philosopher and sociologist of technology interested in the evolutionary approaches of socio-technical change.

The central premise is that through experiments with new technologies and new socio-technical arrangements, processes of evolution can be stimulated (Hoogma et al., 2002). New technologies, as well as user preferences, networks, regulation, complementary technologies and expectations are all worked upon simultaneously. Thus, SNM aims to align both technical and social arenas. As a consequence, new and more sustainable patterns are encouraged to emerge, partly embodied as new technologies but also in new practices based on new experiences and ideas. Such experiments can be envisaged as part of a niche in which technologies are specified and consumers are defined and formed. Experiments make it possible to establish an open-ended search and learning process, and also to work towards societal embedding and adoption of new technology (Hoogma et al., 2002). SNM is based on the assumption that user needs and wants are not fixed, and that consumer wants are based on their reflection of past experiences and that new experiences may alter perceived future needs.

Strategic Niche Management (SNM) models rely on concepts designed to encourage the support and development of technological niches as a way of 'jump starting' changes in industries (Hoogma et al., 2002; Kemp et al., 1998). The work on SNM models later developed into MLPs particularly in the work of Geels. The SNM studies in the work of Hoogma et al. (2002), and Truffer et al. (2002) are notable in the sectors of electric vehicles, and that of Kemp et al. (1998) in the analysis of transition in transportation. Kemp et al. (2001), Hoogma et al. (2002) and Truffer et al. (2002) believe the strength of the theory is in explaining unlocking technological regimes and therein lies its limitation, with other actors in the framework diminished. This strong focus on technology and not on the landscape or the regulator makes it less useful in this study.

2.2.6 Technological Innovation Systems (TIS)

TIS theory maintains that the determinants of technological change are to be found in individual firms or in research institutes and in a broad societal structure in which firms, as well as knowledge institutes are embedded. Since the 1980s, innovation system studies have pointed out the influence of societal structures on technological change, and indirectly on long-term economic growth, within nations, sectors or technological fields. TIS are defined in terms of knowledge and competence flows rather than in flows of goods and services. Such flows are enshrined in knowledge and competence networks. In the presence of an innovator plus critical mass, networks can be transformed into development blocks such as synergistic clusters of firms and technologies within an industry or a group of industries (Aldersey-Williams et al., 2020).

TIS concepts originated from the work of Carlsson & Stankiewicz (1991) and embody the key principle that it is the institutional infrastructure that drives the generation, implementation and diffusion of innovation, because it is the companies that work within this framework. Innovation occurs not just with new technologies but in organisation and in institutional change. Studies in this field have mainly focussed on specific industries in localised markets such as pharmaceuticals in Switzerland (Kukk et al., 2016); wind power in Scandinavia (Wieczoreka et al., 2013), photo-voltaic energy in Taiwan (Huang & Wu, 2007) and in natural gas in the Netherlands (Suurs et al., 2010). Proponents of the field of study are able to explain the networks of actors' effect on developing technology and the 'motors of innovation' (Suurs et al., 2010), but less so to interrelationships at the macro-environment or landscape level. This strong focus on technology driving industry transition makes it a seemingly unsuitable framework for an airline industry highly focused on regulator timetables and the competitive landscape.

2.2.7 The Regulator as an Agent of Change

The state or regulator can greatly affect a positive transformation of industries (Rip & Kemp, 1996; Nill & Kemp, 2009). The barriers to, and reluctance of companies to adopt and implement new technologies can be incentivised by government policy and the posting of an open regulatory roadmap (Blumstein et al., 2000; Zhou et al., 2013; Kemfert, 2004; Ericsson et al., 2004; Ryan & Alexander, 2006; Hafsi & Tian, 2005; Zhou et al., 2013; Tombe & Winter, 2013; Kivimaa & Virkamäki, 2014). Financial measures such as the subsidy of relevant capital expenditure, penalties through the system of taxation, supporting infrastructure phase out costs and charging for environmental despoliation are common policies. A policy of guaranteeing long-term income streams was noted in Germany and Japan for energy providers, by the direct feed of ‘perishable energy’ into the national grid which avoided some storage issues around renewable sources (Kemfert, 2004; Chowdhury et al., 2014). Progress towards low carbon technology in the automotive industry slowed when regulatory pressure and the clarity of the policymakers decreased (Levy & Rothenberg, 2002; Wesseling, 2015; Penna & Geels, 2015).

New markets can be created by the regulator by setting national and international goals, adjusting or eliminating (in)direct subsidies, and promoting policies of energy efficiency and conservation (Blumstein et al., 2000; Maertens, 2012; Kappes & Merkert, 2013; Chowdhury et al., 2014). The creation of a new market can then bring in consumers and competitors to expand it through economies of scale (van Bree et al., 2010; Mazur et al., 2015; Erlinghagen & Markard, 2012). Aligning policy efforts with the interests of all relevant parties has proved effective in the EU (Matos & Silvestre, 2013; Kemp & Pontoglio, 2011). Martensson & Westerberg (2012) and Akrich et al. (2002) term this ‘shared visions’ with Martensson & Westerberg (2007) proposing the extension of the ´shared vision’ through the value chain. For relevant environmental aviation legislation see 5.2.

The acknowledgement if the ‘technological ignorance’ of the regulator has been studied and has been addressed by large scale data collection from industry and customers, the use of selected foreign direct investment from the more skilled developed world, and by industry experts in advising the state on policy (Veal and Mouzas, 2010; Zhou et al., 2013; Engelken et al., 2016).

Seven policy lessons from their empirical analyses of sustainable innovation transfers have been summarised from the academic literature by Geels et al. (2008). Firstly, early market formation for new technologies is an important process (Kemp et al., 1998). Secondly, consistent and stable policy frameworks are important because innovators need stability to make cost/benefit calculations for strategic investments, reducing uncertainty (Engau et al., 2011). Thirdly, the social embedding of technology and socio-political legitimacy are important for both early market formation and scaling up. Policy makers often fail to handle this challenge, or recognise its importance when it is too late. Agterbosch & Breukers (2008) found such policy failures for wind power and it may become an issue for renewable fuels. Fourthly, multiple innovation technologies may reinforce each other, especially when they collectively provide legitimacy for certain normative visions such as sustainable development and build support for policy changes. Fifthly, the important role of incumbents and new entrants in social networks. Large incumbent firms may not be supportive of sustainable innovation migrations, because these may threaten their existing products or because they are unprofitable. This may lead to a lack of investments and difficulties in forming early markets. The technology management literature therefore suggests that new entrants (often small start-ups) are important for developing radical innovations, but new entrants often fail, because of low legitimacy, lack of political influence, limited resources or insufficient skills. The incumbent and new entrant issue is a policy dilemma Schot & Geels (2008) identify. Incumbents with resources may speed up innovation transfers if they commit themselves with policy makers who often rely on them to foster new technologies. Sixthly, policy makers should have sufficient competence & expertise of the technologies and the social networks. Lastly, because sustainable innovation transfers are multifaceted, policies need not be limited to economic machinery - they are shaped by social, political and cultural factors too.

2.2.8 Approaches to Tackle Barriers to Transformation

With the growing importance of a fourth energy transformation there is a recent literature related to the barriers to energy transformation and how these have been addressed. This material is relevant for a transformation of the European airline industry. The barriers fall mainly into three groups - financial and competitive, skills based and confidence in new products and with a new supporting infrastructure. The financial barriers include those related to higher risk new capital investment and costs perceived to bring competitive disadvantage, and the horizon of the delivery of the return on investment. Skills based barriers are concerned with lack of expertise in the new technologies and managing new technologies, the complexity and stretching of organisations in introducing new technology parallel to retaining existing systems. Infrastructure related barriers are those concerned with energy storage, technology performance and the consistency and quality of supply.

Cherp & Jewell, (2014), Brown et al. (2014), Winfield & Dolter (2014), Muench et al. (2014) and Helms (2016) have drawn attention to the possible cost disadvantages of adopting new technologies and show industry examples of overcoming this by stressing energy security, lowering risk and the proposal of separating tangible from intangible assets into different business units in order to more efficiently manage both assets and services with focus.

Erlinghagen & Markard (2012), Martensson & Westerberg (2007), and Weber & Monge (2014) address lack of skills-based factors by promoting the acquisition of special technology companies and note that cross sector purchases also bring benefits. Networking and hyperlinking outside the same industry and with external suppliers has a similar effect but with a lower financial risk attached (Berzosa et al., 2012; Kivimaa & Virkamäki, 2014; Weber & Monge, 2014).

Infrastructure issues relating to the safety, performance, reliable supply and quality of new energy sources can be addressed by the promotion and adoption of industry standards, platforms and certification that reduces barriers to risk for companies (Koonin & Gopstein, 2011). This may be accomplished with the assistance of the state or trade body. In the case of new technologies blending new and existing technologies and parallel operation has improved the acceptance of, and confidence in new fuels by the consumers of them (Bomb et al., 2007). Industry transformations present barriers put up by the incumbents who resist change. The summary of the barriers and their historical solutions is summarised in Table 5.

Table 5: Summary of literature on overcoming barriers to industry transformation

Authors	Barriers to Industry Transformation	Breaking down of barrier/success factors
Blumstein, 2000 Kemfert, 2004 Ericsson et al., 2004 Hafsi & Tian, 2005 Ryan et al., 2006 Wang, 2007 Zhou et al., 2013	New technology a cost disadvantage	Accept reality of incremental change Create state incentives/penalties State to build new markets Support of CAPEX, phase in/out Reframe costs of despoliation/waste to environment, to future generations
Martensson & Westerberg, 2007 Berzosa et al., 2012 Erlinghagen & Markard, 2012 Weber & Monge, 2017	Lack of knowledge, skills base, complexity	Building networks, involve suppliers, hyperlinking Invest/acquire relevant start-ups for their skills, purchase alien sector expertise Intra and inter Industry cooperation Knowledge diffusion
Callon, 1986 Akrich et al., 2002 Binera & Martinot 2005 Kemp & Pontoglio, 2011 Matos & Silvestre, 2013 Muench et al., 2014	Vested interests prevail	Re-alignment of actor´s interests Adjust regulatory regime State to build new markets Shared visions Aligning goals of multiple regimes (national, international)
Winfield & Dolter, 2014	Lack of switching incentive	State and sector legislation, setting of sector targets Supporting energy efficiency Emphasise energy security Provide state long term regulatory pathway
Kemfert, 2004 Chowdhury, 2014	Energy storage problems or fuel availability	Direct grid feed of non-storable energy Investments in storage technology Incentivise/increase fuel availability
Helms, 2016	Financial Risk or Capital Expenditure excessive	Move to managing intangible assets by separating infrastructure and services State support for infrastructure (phase in/out)
Kemp, 1997 Nill & Kemp, 2009 Engelken et al., 2016	Poor existing infrastructure Corruption/lack of expertise of regulator	Selective Foreign Direct Investment (FDI) Communicating shared visions Information collection from industry experts and innovators
Bomb et al., 2007 Koonin & Gopstein, 2011	Lack of confidence in safety, reliability or timeliness in new technology/fuels	Standardisation & certification of new technology platforms/fuels and suppliers Blending new and existing technology

In summary, industry transitions have been explained with several theoretical models notably the MLP, TM, SNM and TIS. In this thesis, the key importance of the regulator in developing a low carbon landscape draws me to use the MLP to interpret global arguments and proposals around industry renewal (see 2.4.4). Notably, the management of a cross border energy policy linked to developing technologies in sustainable fuels will be key in the successful transition. The state has been shown to be a major change agent in industry transformation through setting policy direction, direct incentives and penalties, indirectly through policy instruments and by aligning legislation that stimulates transformative processes and creates new markets. Such facilitation has been demonstrated at a national and international level (Fagerberg, 2018; Roberts & Geels, 2019).

2.3 Business Model Literature Review

This section introduces the concept of the 'business model', ´sustainable business model´(SBM) and sustainable initiatives, and explains the advantages in illustrating how business´ generate value through the interlinking of discrete components. As shifts in the MLP occur, airlines will have to respond with adjustments to their business models. Relevant learning is captured below.

2.3.1 Introduction - Why Business Models?

As businesses became more networked and interdependent in the 1990s, and as western economies began to focus on services as the major generator of economic wealth, it became necessary to evolve organisation models of value creation. In particular 'The Value Chain' (Porter, 1985) was considered insufficiently useful, as it was designed mainly for manufacturing (Stabell & Fjeldstad, 1998). The phrase 'business model' entered common usage to express these new constructs. The business model abstraction extends Porters Value Chain, the Value Net (Brandenburger & Nalebuff, 1996) and Value Networks (Normann & Ramirez, 1993; Allee, 2000) and focuses on Total Value Creation (Brandenburger & Stuart, 1996). It extended these ideas by combining the essential business processes, the customer proposition and the major business partners in a single coherent whole. The business model thus emphasizes three key ideas; i. value creation and delivery dynamics, ii. that multiple (internal and external) sources of value matter, and iii. the mapping of nonlinear sequences of interdependent activities. The Business Model concept is relevant for remodelling complex industries because the external factors influencing the industry can be shown acting upon a high number of interconnected business processes within an organisation and explains this with a high level of clarity.

> 'A Business Model describes the rationale of how an organisation creates, delivers and captures value.'
> (Osterwalder & Pigneur, 2010:14)

In reviewing the use of the term 'business model' Magretta (2002), Yip (2004), Casadesus-Masanell & Ricart (2010) and Klang et al. (2014) differentiate between the terms 'business model' and 'strategy', noting that the 'business models' focus on logic, organisation and process, and 'strategy' focuses on choice of products, services, customers and competitors. Business models are thus independent of their market and tactical options become limited by the choice of business model. Business models are the consequences of deliberate strategic choice and their design follows a distinct logic-set demanding a different core competence (Nair et al., 2013).

The business model concept has been argued to be a powerful concept in Strategic Management literature adding both clarity and understanding to how successful companies operate (Zott & Amit, 2008, 2014; Coombes & Nicholson, 2013; Mezger, 2014). Mitchell & Coles (2003, 2004); Johnson et al. (2008), Spector (2011) and Casadesus-Masanell & Ricart (2010) believe it may be **the starting point** for developing future sustainable competitive advantage as it is an unexplored discipline which involves the search for new innovative frameworks and logics to create and capture value for customers, suppliers and partners. It extends and supplements existing work because it enhances single concepts such as value chains, revenue creation and business partnership networks in a single logic that explains business success (or failure) and adds to the ability to reproduce success.

The current developments in the discipline are facilitated by developments in market (de)regulation, advancements in technology and changes in customer preferences.

The complexity of the demands on businesses from multiple stakeholders to meet changing requirements for products and services, profitability and sustainability, means that structured solutions to solve a multiplicity of factors have driven academic work in business model theory. Shafer et al. (2005) and Zott & Amit (2007) have shown that a distinct business model can be the major determinant of company market value and a new, distinct and level of business analysis. Zott & Amit (2012) believe the business model concept is a robust one and a sound basis for understanding wealth creation and future research. Zott & Amit's (2007) faith in the stability of the business model concept comes from a statistical analysis of a multi-year regression analysis showing the superior performance of companies adopting 'novel' and 'efficiency' based forms.

> 'A Business Model depicts the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities.'
> (Amit & Zott, 2001:511)

There is much work to be done on the business modelling process (de Oca et al., 2015) with no generally accepted methodology and structure dominating. Most research in the area seems to be in improving the design of 'single process quality' (Zott & Amit, 2010). The successful business model must manage three types of 'fit' - between activities and strategy to generate competitive advantage, developing mutually reinforcing activities (virtuous circles/cycles), and optimizing the entire set of activities to eliminate redundancies and minimise waste.

Akkermans & Van Helden (2002) and Casadesus-Masanell & Ricart (2010, 2011) emphasize the importance of developing 'virtuous cycles' within business models to deliver success. Such cycles are feedback loops that, with every turn strengthen the value of the components of the model, and are essential to effective business model design. Virtuous cycles, if aligned to the company's goals add to robustness and move organisations towards their targets. Milgrom & Roberts (1990, 1995) define activities as complementary when the marginal value of one activity increases as the other activity is increased. ‘Virtuous circles’ emerge when knowledge is shared, feedback loops modify process and behaviour, and process control is shared by all those involved in the process. ‘Vicious circles’ emerge when there is information overload, knowledge is not shared, and process control is narrow (Garud & Kumaraswamy, 2005). Developing business models with loosely held information in organisations encourages agility, renewal and flexibility in execution, and tightly held information encourages inefficiencies in scale and scope (Malhotra, 2005).

Markides (2006), Chesbrough (2007), Kim & Mauborgne (1997) and Chesbrough (2010) believe that ´better business models´ outperform ´better ideas or better technology´. These authors note that business models´ success occurs in three main types of situations, i. breaking the stranglehold on the market of established and entrenched competitors (noting Southwest Airlines), ii. during crisis situations such as economic, industry and company transformation and, iii. scaling up a new product or service to a mass market offer.

Developments in business model innovation cannot be patented or copyrighted. Existing mature industry players may seek to react to the core elements of the success of the new breed and imitate them, or new business model operators may try to conceal the key elements of their model by adopting a sheen of established business logic (Casadesus-Masanell & Zhu, 2013) with the terms ‘strategic revelation’ and ‘strategic concealment’ used. Casadesus-Masanell & Zhu (2013) find that revealing or concealing business model features is an important strategic decision for innovators.

> ’When a new model changes the economics of an industry and is difficult to replicate, it can by itself provide a strong competitive advantage.‘
> (Magretta, 2002:7)

Kim & Mauborgne (2007), Morris et al. (2005), Osterwalder & Pigneur (2005), Chesbrough (2007), Johnson et al. (2008), Teece (2010), Bocken et al. (2013), Da Silva

& Trkman. (2013) and Klang et al. (2014) identify the core elements of a business model shown in Table 6 selecting up to five common components from each author(s).

Table 6: Functions and Parts of a Business Model after Key Author showing Five Common Components

Source Author by date:	**Specific Components (number)**	**Common Components between authors**
Hamel, 2000	Core strategy, strategic resources, value network, customer interface (4)	• Customer Value Proposition • Strategic Resources • Partnership Network
Chesborough & Rosenbaum, 2000	Value proposition, target market, internal value chain structure, cost structure and profit model, value network, competitive strategy (6)	• Customer Value Proposition • Profit Model • Partnership Network • Internal Value Chain
Amit & Zott, 2001	Transaction content, transaction structure, transaction governance (3)	• Internal Value Chain
Morris et al., 2005	Customer offering, market factors, internal capabilities, competitive strategy, economic factors, personal and investor factors (6)	• Customer Value Proposition • Partnership Network • Internal Value Chain
Richardson, 2008	Value proposition, value creation and delivery, value capture (3)	• Customer Value Proposition • Internal Value Chain
Johnson, Christensen & Kagerman, 2008	Key Resources, key processes, profit formula, customer value proposition (4)	• Customer Value Proposition • Profit Model • Strategic Resources • Internal Value Chain
Osterwalder & Pigneur, 2009	Customer segment, value proposition, channel, customer relationship, revenue stream, cost structure, key resources, key activities, key partnerships (9)	• Customer Value Proposition • Profit Model • Strategic Resources • Partnership Network • Internal Value Chain

Source: after Morris et al. (2005)

2.3.2 Business Model Terminology

Zott & Amit (2007), Chesbrough (2010) and Cheng & Huizingh (2014) introduce the terms **'novelty'** and **'efficiency centred'** business model. Novelty models define new markets, new products and new delivery methods and are disruptive to the existing market players. Efficiency centred models focus on incremental improvements in existing markets with existing products, and on reducing delivery and transaction costs. Novel business model design has been shown to positively associated with higher performance at levels of resource abundance or 'munificence' (Zott & Amit, 2007). The performance of any firm might be increased by an efficiency centred model, and during periods of limited resources (energy) efficiency centred models seem to perform better. There appears to be a negative association between choosing a business model that operates both sets of mechanisms, suggesting that a clear choice might be inevitable for maximum performance (Zott & Amit, 2007). Zott & Amit (2007) posit that the 'highest potential value' may lay within a novelty-based approach. Novelty or efficiency centred models may be more valuable when applied in distinct industry sectors. Slow moving sectors seem more suited to efficiency centred approaches whilst innovative and fast-moving sectors seem more suited to novelty-based approaches. Cheng & Huizingh (2014) find novelty centred business models encourage service innovation whilst efficiency centred models discourage it. Such findings have implications for this study because it might imply that the incremental improvement in regulated, mature and slow-moving airlines might be insufficient in finding the 'higher potential value' of a novelty-based model. For example, a limitation on the use of fossil fuels or operational restrictions point to the ongoing development of efficiency centred business models, which are likely to remain until breakthrough technologies emerge.

Business Model types have proliferated since the concept became established, with classification based on typology or taxonomy (Christensen & Carlile, 2009; Lambert, 2015). Chatterjee (2013) categorises models based on the Porter (1979) generic strategy of competition - cost or differentiation focussed. **Efficiency based models** involve high utilisation of assets being driven by process innovation. LCCs feature in this group with a striving for the lowest unit costs. **Value based models** focus on differentiation and expertise and can leverage a price differential through real need (expert services) or perceived want (luxury). **Network Value models** are those that generate repeat purchases through operating loyalty schemes. **Network Efficiency models** capitalise on economy of scale and volume by offering platforms for exchange. A summary of the key Business Model literature, with conceptual types is shown in Table 8. A University of St Gallen spin-off has developed a framework which summarises more than 55 commonly operated business models (Gassmann, Frankenberger & Csik, 2014; https://bmilab.com).

2.3.3 Why Business Model Innovation?

Despite some markets being constricted by oligopolies and regulation, new entrants can drive business model innovation. Casadesus-Masanell & Zhu (2013) have shown that the imitation process together with the lack of intellectual protection drives new business model innovation. Since profitable innovations are often copied, they then go into decline, die and are reborn as a new generation of business models and organisations. Some innovations in airlines are easier to copy than others with customer service, operational process, revenue/cost and human resource innovations relatively easy, and patented technology and market (contract price) or non-market advantages (landing slots and traffic rights) gained from negotiations, lobbying or national origin much less so.

Rindova & Kotha (2001), Johnson et al. (2008) and Thomas & D'Aveni (2009) cite 'hyper competition' as the need to change or 'morph' the business model at regular intervals due to the increasing standard deviation of corporate profits in a phenomenon they term 'temporary profitability'. Bouwman et al. (2008), Sentance (2009), Ventresca & Hayek (2010) and De Reuver & Bouwman (2009) see Technological, Regulatory and Market pressures as forcing regular business model review. Similarly, Rindova & Kotha (2001) and Siggelkow & Levinthal (2003) cite shifting markets and competition, evolving regulations and changes in technology as innovation drivers with continuous morphing leading to competitive business model migration. Mitchell & Coles (2003) and Chesbrough (2007, 2010) show that once a company has merged continuous innovation into its business model and become a platform for its own and its partners development, it made them profitable and hard to compete against. Such models might only be superseded by disruptive innovation (Christensen & Rosenbloom, 1995; Denning, 2016).

2.3.4 Design Elements of a Business Model

The concept of 'business model re-design' has been credited to several authors notably Mayo & Brown (1999), and Osterwalder & Pigneur (2005), and involves designing businesses from abstract discrete elements that function as a coherent whole. Timmers (1998) classifies business models between degree of innovation and degree of integration, and Tapscott et al. (2000) between economic control and value integration. Taking the elements of business models in Table 6, and referencing from Osterwalder (2004) and Osterwalder & Pigneur (2009) it is possible to select a series of nine design elements that highlight the differences between simple and complex business models (Table 7). I note that multi component and complex business models more closely capture the facets of airline interactions with the regulator, suppliers and the providers of industry technology.

Table 7: Nine Characteristics and Elements of a Simple and Complex Business Model

Element of Business Model	Simple Business Model	Complex Business Model
Value Proposition/Product Value Leadership	Price/Value leadership low	Price/Value leadership high
Target Customer/Market Share	Low market share in segment/markets. Few markets	High Market Share in segment/markets. Many markets
Distribution Channel Complexity	Low complexity few or single channel	High complexity many channels
Customer Relationship	Few, not involved in value creation no tailoring, everyone gets the same product	Many, highly involved in value creation with product and service tailoring
Value configuration and degree of Business Model integration	Low integrated model within supply chain	Highly integrated model with in supply chain
Capabilities and spread	Few and similar capability and skills needed	Many and diverse capabilities and skills needed
Partnerships and Networks used	Few partners used in Business Model, simple arrangements and low interdependence	Many partners used in Business Model, complex arrangements and high interdependence
Cost Structure	Low-cost due simplicity. Low-cost leadership	High(er) cost due complexity. Value leadership
Revenue Model	Simple with few/single revenue streams	Complex with many revenue streams

Source: adapted from Osterwalder (2004), Osterwalder & Pigneur (2009)

Table 8: Key Papers in Business Model Literature

Business Model Type	Author(s)	Title	Key Ideas
Business Model Definition and Design	Magretta J., (2002)	Why Business Models Matter	Difference between Strategy and Business Model
	Osterwalder A. & Pigneur Y., (2005)	Clarifying Business Models: Origins, present and future of the concept	Concept and Parts of a Business Model
	Casadesus-Masanell R. & Ricart R., (2010)	From Strategy to Business Models and on to Tactics	Difference between Strategy, Business Model and Tactics
	Klang D., Wallnöfer M. & Hacklin F., (2014)	The Business Model Paradox: A Systematic Review and Exploration of Antecedents	Difference between Strategy and Business Model
Multiple Business Models	Markides C. C., (2013)	Business Model Innovation; What can the ambidexterity literature teach us?	Running Business Models appealing to multiple market segments
Sustainable Business Models	Jackson T., (2009)	Prosperity without Growth: Economics for a Finite Planet	Maximising resources, minimising and reusing waste. Questioning limitless growth. State intervention through taxation and infrastructure investment
	Bocken N., Short S., Padmakshi R. & Evans S., (2013)	A value mapping tool for Sustainable Business Modelling	Business Model design and content, minimising the effect on the environment
	Bocken N. M. P.; Short S. W., Rana P. & Evans S., (2014)	A literature and practise review to develop sustainable business model archetypes	Review of Sustainable Business Model Types
	Boons F. & Lüdeke-Freund F., (2013)	Business Models for sustainable innovation: state of the art and steps towards a research agenda	Sustainable Business Model Archetypes
	Klewitz J. & Hansen E. G., (2014)	Sustainability orientation innovation of SMEs - a systematic review	SMEs as drivers of Sustainable Business Model Innovation
Sustainable Business Models. Value Proposition and Value Capture	Maas S. & Reniers G., (2014)	Development of a CSR model for practise: connecting five inherent areas of sustainable business	Embedding sustainability in organisations

Table 8 continued: Key Papers in Business Model Literature

Business Model Type	Author(s)	Title	Key Ideas
Collaborative Business Models	Brandenburger A. M. & Nalebuff B. J., (1995)	The Right Game- using Game Theory to Shape Strategy	Strategic Alliances between Organisations
	Ritala P., Golnam A. & Wegmann A., (2014)	Co-opetition Based Business Models – the case of Amazon.com	Collaborative Business Models after Brandenburger & Nalebuff
	Dahan N. M., Doh J. P., Oetzel J. & Yazil M., (2010)	Corporate NGO Cooperation: Co creating new Business Models for Developing Markets	Corporate and NGO Cooperation
	Todeva E. & Knoke D., (2005)	Strategic Alliances and Models of Cooperation	Strategic Alliances between Organisations
	Jimenez G., Galeano N., Najera T., Aguirre J. M., Rodriguez C. & Molina A., (2005)	Methodology for Business Model Definition of Collaborative Networked Organizations	Collaborative Networks of Organisations
Building Virtuous Circles in Business Models	Akkermans H. & Van Helden K., (2002)	Vicious and Virtuous Circles in ERP implementation; a case study of interrelations between critical success factors	Building Business Models
Business Model Change	Nair S., Paulose H., Palacios M. & Tafur J., (2013)	Service Orientation: effectuating business model innovation	Morphing the Business Model in a changing environment
	Kaplan R. S. & Norton D. P., (2001)	The Strategy Focused Organisation: How Balanced Scorecard Companies thrive in the new Business Environment	Balanced Scorecard approaches to implementing corporate strategy and corporate sustainability
	Thomas L. G. & D'Aveni R., (2009)	The changing nature of competition in the US manufacturing sector, 1950 to 2002	The Business Model in a changing environment
	Teece D. J., (1986) & (2010)	Business Models, Business Strategy and Innovation	Innovation in the Business Model in a changing environment

2.3.5 Moving Towards Sustainable Business Models

The number of articles in peer reviewed journals in English including the keywords 'sustainable business model' in the decade 1991 to 2000 was 227. In the decade 2001-2010 2,713 and in the period 2011-2020 this increased to 16,365. There is evidently increasing interest in this body of study with Production, Sustainability, Energy and Strategy related journals showing the greatest growth (Table 9). Sustainable business models differ in emphasis from circular or regenerative business models in that the former aim to benefit the economy, society and the environment whereas the latter focus on the economic benefits of environmental performance (Geissdoerfer et al., 2017).

Table 9: Growth in Sustainable Business Model Papers published in Peer Reviewed Academic Journals in English 1991-2020

Journal Title	**1991-2000**	**2001-2010**	**2011-2020**	**Total 1991-2020**
Journal of Cleaner Production	0	52	1,458	1,510
Sustainability	0	0	989	989
Business Strategy and the Environment	21	47	372	440
Energy Policy	0	43	303	346
Renewable and Sustainable Energy Reviews	0	0	270	270
Journal of Business Ethics	10	93	162	265
International Journal of Production Economics	0	17	188	205
Ecological Economics	3	50	89	142
Journal of Management Development	0	8	58	66
Other peer reviewed	193	2,403	12,476	15,072
Total	**227**	**2,713**	**16,365**	**19,305**

Research amongst 900 CEOs shows they see sustainability as increasingly important for long-term success, and believe that sustainability programmes should be fully integrated into the foundations of design, strategy and operations of their company (Lacy et al., 2012). Business model innovation is recognised as the core activity to the creation of a sustainable business (Arend, 2013; Bocken et al., 2013, 2014; Boons & Lüdeke-Freund, 2013; Girotra & Netessine, 2013; Hart & Milstein, 2003; Carayannis et al., 2014, 2015 and Schaltegger et al., 2016) with technological, social and organisational initiatives characteristic of the genre (Table 10, Table 13). For Nidumolu et al. (2009) and Maas & Reniers (2014) BMI means innovation in business processes. Innovative and sustainable business models have adverse effects on incumbents (Johnson & Suskewicz, 2009), with early movers enjoying advantages in terms of patents, control over supply networks, deeper integration with partners and setting new regulations.

Barriers to the creation and diffusion of sustainable business models have been identified as falling into three main groups i. legal and regulatory, ii. market and financial and, iii. behavioural and social (Laukkanen & Patala, 2014; Enev & Liao, 2014). Laukkanen & Patala (2014) did not identify technological barriers as limiting believing them enabling in many cases. The authors identify stakeholder education as a methodology to overcome behavioural and social barriers. Legal and regulatory, and market and financial barriers are most effectively be addressed by incentives and partnership activities, plus the creation of long-term regulatory frameworks to lower uncertainty and risk from decision making early in the design process. Chapman Wood (2007) and Jackson (2009) propose external SBM support through taxation, investment and changes in macro-economic accounting citing a lack of resources and organisational inertia as the defining blocking issues.

Table 10: Features of the Design Foundations for Four Business Models

Business Model: Design Foundation	**Key Feature 1**	**Key Feature 2**	**Key Feature 3**	**Key Feature 4**
General, Simple	Segmented customer value proposition (what?)	Value creation/value chain (how?)	Value capture and revenue model (value?)	Distinct logic and core competence
Multiple	Capture growth in several market segments	Take initiative from competitors	Core skills development	Maximise efficiency of existing value chain
Sustainable	Long term viability of business	Maximise use of energy, raw materials, inputs, waste	Increase product and service life	Societal benefit, stewardship
Collaborative	Build key expertise in (new) markets	Share development risks	Economies of scale and scope	Improve competitive position

Source: Compiled by Author

2.3.6 Business Model Innovation (BMI) in Airlines

Customer patterns of hybrid or dual consumption in the European air transport industry began to be identified in the early 2000's with the consumers adopting different purchasing patterns based on different sets of circumstances (Casabayo & Martin, 2009; Sengur & Sengur, 2017). Evidence seems to suggest that customer price sensitivity was heightened, but deeper study showed that this was 'value sensitivity' (Nagle & Holden, 2002; Valls et al., 2011). Customers realised that own brands were often the same products as premium brands, just within a different wrapper. Consumers began to believe that higher price is not always associated with higher quality (Santos et al., 2015). In the travel industry, fragmentation occurred with some customers prepared to pay more for brands and prestige, some for environmental protection, some for tailored travel needs and some purely on price (Valls, 2013; Valls et al., 2014). Low cost airline models developed and untapped new markets in air transport brought price wars with established players, and increased the customer's willingness to choose between offerings and to demand more from airlines (Eslava, 2007; Fageda et al., 2015; Pereira & Caetano, 2015; Corbo, 2017). Table 11 and Table 12 describe key airline business model literature by author and component.

Table 11. Key Components of an Airline Business Model by Author

Authors	Key Components	Business Model strategy
Daft & Albers (2013, 2015)	Core logics, value chain and assets	Value creation system
Gassmann et al. (2014)	Target customer, value proposition, value chain and revenue generation	Creating and capturing value for stakeholders
Lohmann & Koo (2013)	Revenue, connectivity, convenience, comfort, aircraft and labour	Hybrid strategy for airlines
Markides & Geroski (2005)	Consumers, relationship with customers, distribution channels, partnerships, resources and protectionism	Market and exploiting the advantages of anticipation
Mason & Spring (2011)	Technology, market offering and network architecture	Market and sustainability advantages of anticipation
O'Connell & Williams (2005)	Customer characteristics, journey purpose, booking methods, fares, connecting traffic, carrier choice criteria and types of trips undertaken	Hybrid strategy for airlines
Osterwalder (2005)	Key activities, client relationships, partner network, value proposition, client segments, key resources, distribution channels, cost structure and revenue flows	Revenue generation

Source: after Pereira & Caetano (2015)

Table 12. Airline Business Model Framework by Component

Business Model Component	Elements of the Components	Description	Authors
Network structure	P2P only Short-haul only	Direct flights only Short-haul flights only	Klophaus et al. (2015) Fageda et al. (2015)
Revenue Steams	Fare Logic Single Class Cabin	Static fares (one price at one time) Dynamic fares (demand led pricing, fares restrictions)	Daft & Albers (2013) Fageda et al. (2015) Morandi et al. (2015)
Distribution Channels	Internet Global Distribution System	% purchased on the internet Uses a GDS provider	Daft & Albers (2013)
Alliances & Partnerships	Code Sharing Global Alliances	Codes shares with other carriers Global Alliance member	Fageda et al. (2015)
Fleet Structure	Fleet homogeneity	Share of aircraft of same type	Morandi et al. (2015)
Value Proposition	Focus on experience, focus on price or mix	Products and Services representing the best value per segment	Gassmann et al. (2014)

Source: Corbo (2017)

Within the largest airlines, several multi-brand/multi business model (premium, low cost, regional, cargo, leisure) groups exist with a level of success, notably in the Singapore Airlines, Qantas and Lufthansa Groups. In these three cases, target markets, operational services, hubs, business and operational processes and profit responsibility are clearly separated but coordinated. The main benefit of group multi business models has been to take advantage of lower unit payroll costs, improved operational efficiencies and to compete directly with the LCCs in their own backyard (Franke, 2007). The selection of a LCC in Air Berlin in joining the 'oneworld' alliance in 2012 and the formation of a low-cost carrier alliance in Asia (Value Alliance) are interesting moves in business model co-operation (Middleton, 2016). Multiple business models have found success in Australasia, the USA (Morrell, 2005; Homsobat et al., 2014) and Europe (Mason & Morrison, 2008; Fageda et al., 2011). In Europe the Lufthansa Group operates a LCC model Eurowings alongside the full-service models branded Lufthansa, SWISS, Austrian and Brussels airlines (Spohr, 2014). British Airways sold their GOFly LCC founded in 1998 to a 'Management Buyout' consortium in 2001 (reselling it to Easyjet in 2002) citing a devaluation of the core brand and yield dilution as the reasons for the sale (Daily Telegraph, 2002; BBC, 2001) and despite evidence that multiple business models within an airline group can function. Heracleous & Wirtz (2009, 2014) note the successful case of Singapore Airlines pursuing four ambidextrous strategies within a single organisation in terms of service quality and cost, personalised and standardised service, centralised and decentralised innovation and follower and leader in service design through a vertical strategy alignment.

Bogers et al. (2015) showed that airline BMI required fresh external management for reinvention, while Lange et al. (2015) showed BMI at two European full-service network carriers to be dependent on the full participation of staff and trades unions. Das et al. (2016) and Saporito (2014) report that fuel and design technology can drive new business models in aviation by lowering unit costs in efficiency-based models citing WOW, La Compagnie and Norwegian Air Shuttle in 'ultra-low cost' models. Ultra-low-cost carriers have taken 30% of the expanding European market in the last ten years, but longer term it remains to be seen if a competitive advantage can be maintained through a fleet renewal.

Competition on long haul air services into Europe has been limited until the recent encroachment of the Gulf carriers (Dresner et al. 2015; McGinley, 2010), but the business model of Ryanair and Easyjet has radically changed short haul services within Europe. Legacy airlines at crowded European main hubs with grandfather rights limited the growth of LCCs by adopting a 'use it or lose it approach' – the LCCs thus chose to use secondary airports as a result, assisted by lower operating costs (Sieg, 2010; OJEU, 2005, 2014). Sieg (2010) also notes ´public and social value' is reduced. In the shorter segments the LCC model seems to have the winning formulation in Europe (Diaconu, 2012; Kilinc et al., 2012). However, the network airline business model in many markets is probably not economically sustainable in its current form (Hansson et al., 2003; Tretheway, 2004). It involves massive economic infrastructures, complex fleets of ageing aircraft, legacy information systems and expensive employment contracts. Tied to a weak economic climate and increasing competition from LCCs, this will drive the development of less costly and less complex business models. Not only are costs under pressure at the network models, revenues also appear to be weakening too with premium passengers unwilling to pay the high differential enjoyed in the 1990s and 2000s (Harteveldt, 2016). Excessive customisation and complexity must be eliminated from the network model, certainly in that its delivery adds no incremental profitability (Bieger et al., 2007).

2.3.7 Literature on Sustainable Airline Business Innovation (SBMI)

This next section looks at the **sparse literature** on sustainable airline business models. Bocken et al. (2014) present a summary of the SBM literature (Table 13) grouping initiatives into Technological, Social and Organisational archetypes and the business model benefits in terms of the value proposition, value creation/delivery and value capture. I have sorted the airline literature into the same three categories.

2.3.8 Sustainable Technological Initiatives

The cost of renewable energy is falling with solar energy costs falling by 30% annually (Sims et al., 2003; Fthenakis et al., 2009). Since energy is a primary economic driver for airlines the development renewable energy is of great importance. Akpan et al. (2015) believe it is the speed of technological development in energy will determine the rate of reducing global GHG emissions. Arjomandi & Seufert (2014) note that Europe leads the way in environmental sensitive aviation.

2.3.8.1 Sustainable Aviation Fuel (SAF)

Conventional (fossil fuel sourced) jet fuel for commercial airlines must meet tight internationally agreed specifications. Sustainable/renewable fuels must meet the same specifications but are manufactured differently and are not derived from oil (Lobo et al., 2011). 'Biofuels' refer to fuels produced from plant or animal materials. Current technology also allows fuel to be produced from industrial waste materials and gases (power to liquid). Using waste may solve the potential problem of methane production from dumping in landfill. If the chemical and physical characteristics of SAF are identical to those of kerosene they can be mixed and in varying proportions and are termed ´drop-in´ (Zhou et al., 2015). They can also use the same supply infrastructure and do not require the major adaptation of aircraft or engines. Despite the emissions produced during the production of SAF, there is an approximately 80% reduction in CO2 plus a reduction in sulphur dioxide and particulate matter compared to fossil fuels over the lifecycle. SAF is an attractive alternative to kerosene as production is not limited to drilling location, enabling greater energy security for states and airlines (Winfield & Dolter, 2014; Muench et al., 2014; Helms, 2016).

Gielen et al. (2002), Grahn et al. (2007, 2009), King et al. (2009) and Nair & Paulose (2014) review biomass and algal sourced fuels for sustainable aviation business models using existing oil refineries and oil industry logistics. Algal fuels produced in countries that are not currently economically or socially developed could enhance local economic prosperity. Such models would involve a combination of novel technology driven partnerships comprising of biofuel companies, oil companies, airlines and governmental and non-governmental organisations to work effectively.

Wiesenthal et al. (2009) have proposed additional fuel taxes to encourage industry moves to alternative fuels. Government intervention should take the form of carbon credits and incentives to cultivate non arable land (Gerbens-Leenes & Hoekstra, 2011). Because the prices of new fuels are normally higher than the current prices of fossil fuels, industries and government sectors might direct funds, such as those from carbon offsetting, to subsidize transformation ensuring that SAF technology adoption is more expeditious. Some companies not related to the aviation industry might choose to participate by providing economic support that would enable them to link their brand to positive publicity or for gaining transferable knowledge (Jaeger & Egelkraut, 2011).

Table 13: Sustainable Business Model Archetypes

Source: Bocken et al. (2014) with *emphasis for airlines in italics*

Grouping	Technological			Social			Organisational	
Business Model Archetype	**Maximise material and energy efficiency**	**Create value from waste**	**Substitute with renewables, and natural processes**	**Deliver functionality rather than ownership**	**Adopt a stewardship role**	**Encourage sufficiency**	**Repurpose for society**	**Develop scale-up solutions**
Value Proposition	*Low carbon production*	Closed loop planning, circular economy	*Move to renewable energy*	Product orientated PSS (Product, Support, Services) maintenance and extended warranty	Protection of biodiversity	*Consumer education. Communication and awareness*	Not for profit model	*Collaborative approaches, lobbying, sourcing, production*
Value Proposition, Delivery	Lean manufacture	Cradle to cradle	Solar and wind energy technology	Use orientated PSS – rental, lease, share	Promote consumer care	*Demand management, Cap and Trade*	Hybrid business and Social Enterprise (for profit)	Incubator and entrepreneurship support
Value Proposition	Additive manufacture	Industrial symbiosis	*Zero emissions models*	Results oriented PSS, pay to use	*Ethical and fair trade*	Slow fashion, slow movement	Alternative ownership, cooperatives and collectives	Licensing & Franchising
Value Proposition, Delivery, Capture	*Dematerialisation of product and packaging*	*Reuse, recycle, remanufacture*	Blue Economy	Private Finance Initiative PFI	Choice editing by retailers	*Product longevity*	Social and bio-diversity regeneration	Open innovation platforms
Value Proposition, Delivery	Increase functionality to reduce total no. of products required	Take back management	Biomimicry	Design, Build, Finance, Operated (DFBO)	*Transparency about environmental and societal impact*	Premium branding with limited availability	Base of pyramid solutions	Crowd sourcing and funding
Value Proposition, Delivery, Capture		*Use excess capacity*	The natural step	Chemical Management Services	Resource stewardship	Frugal business	*Localised solutions*	Patient and slow capital collaborations
Value Proposition, Delivery, Capture		*Asset sharing*	Slow manufacture/ movement			Responsible product distribution and promotion	*Home based and flexible working*	
Value Proposition		Extend producer responsibility	Green chemistry					

2.3.8.2 Other Sustainable Airline Technologies

Other industry technologies that are aimed at reducing operating costs and improving emissions efficiency fall into three main groups: i. lowering aircraft weight using new materials, ii. improving fuel consumption through better combustion technology, technical operations (incl. SESAR) and improved aerodynamics (currently 1.5% p.a.) (Williams, 2007; Morrell, 2009) and, iii. the increased use of batteries to power aircraft operations reducing fuel burn (Williams, 2007). Radical technologies such as gas/electric hybrid aircraft and new aircraft and engine designs not based on existing combustion technology seem a long way from effective operational use, and are likely to occur first on short-haul services after 2040. Please see Chapter 5 for more industry sourced information.

2.3.9 Sustainable Social Initiatives

Airbus Industries is pursuing a programme with Virgin Australia, China Eastern Airlines and Chinese Tsinghua University to connect farmers and refiners across the world to form regional, sustainable, alternative fuel value chains (Faizan, 2012; Prahalad, 2012). Air France/KLM's partnership (2014) with the World Wildlife Fund to make aviation more sustainable by developing an international market for sustainable bio-fuel which has helped the airline fulfil its corporate social responsibility goals. Airlines using renewable fuels can advertise effectively and attract customers who value green travel, thus adding to overall brand value (Laroche et al., 2001; Bigne-Alcaniz et al., 2009; Downing, 2014). O'Connell (2011) believes that Emirates association with green, health and sport sponsorship has given it a favourable public image and generated new business.

Phillipps et al. (2019) and Rotondo and Giovanelli (2019) find integrating social sustainability in the airline business model, i. does not adversely influence short term financial performance and may enhance it long term, ii. must be accompanied by intelligent managerial activity to be effective, and iii. makes an airline more resilient to operational disruption. Falk & Hagsten (2019) notes that as a group LCCs and the secondary airports they mostly use, are far less likely to be involved carbon reduction initiatives than the large airports for regional economic reasons.

In the case of the purchase of airline tickets post COVID19, Bulchand-Gidumal & Melián-González (2021) indicate that regulation can act to reduce the risk that travellers foresee for the coming years regarding the purchase of airline tickets. Such action might include guaranteeing ticket refunds or exchange for equivalent ground travel. Doing so could mitigate a detected change in consumer behaviour towards late booking. Given the thin margins on which many airlines operate, such behaviour could have an impact on the viability of airlines with lowest cash reserves (IATA, 2020; Shamshiripour et al., 2020).

2.3.10 Sustainable Organisational Initiatives

Bowen (2000), Lohmann et al. (2009) and Wang & Heinonen (2015) show that a triangle of airline, airport and state sponsored economic development has been a key feature in driving the collaborative and sustainable airline business models of both Singapore and Dubai. Government investment, long term planning and administrative continuity were the key factors in the provision of world class infrastructure and effective corporate governance. Hubs were transformed into destinations by a network of attractions, trade centres and accommodation provision with supportive transport policies. Minato & Morimoto (2013), Albalate et al. (2015) and Cadarso et al. (2017) propose collaborative and sustainable business models between airports and airlines to stabilise passenger numbers for airlines and infrastructure use at airports by facilitating rail/air transport networks. Connectivity was again highlighted several further studies. Heinz & O'Connell (2013) isolated the factors associated with financial sustainability amongst African airlines concluding network density, connectivity and yield were defined as the key drivers of profitability. Hooper et al. (2011), O'Connell (2011) and Uddin et al. (2014) attribute similar factors to the financial success of Middle Eastern carriers, (Emirates, Qatar and Etihad) noting hub and spoke depth, passenger and cargo connectivity, competitive labour costs and branding strengths.

Nair et al. (2012, 2013, 2014) show that it is possible for airlines to achieve sustainable competitive advantage in highly uncertain environments by the constant innovation in service focussed business models and by building a knowledge brokerage. Wensveen & Leick (2009) argue that simplicity in airline business models equates with flexibility and sustainability, but Hazeldine (2011) has shown that simplicity could be a weakness that can be exploited by a network carrier determined to extract full value from its more complex pool of fixed assets through appealing to more passenger segments. Thus, operational efficiencies must be weighed against the risks associated with complexity for a truly flexible business model to emerge (Wensveen & Leick, 2009). Hence an understanding of core competences and business model innovation are central in an airline´s goal to gain sustainable competitive advantage. Similarly, Corbo (2017) argues that innovation in business models is essential to airline success but notes that hybrid business models (noting Air Berlin) suffered discongruities between the value proposition and the business model leading to eventual failure. It does not mean that hybrid business models cannot work, but suggests that ´airlines within airlines´ may be a more successful strategy (Homsombat et al., 2014; Materna & Tomova, 2016).

Soyk et al. (2017) in an examination of low cost longhaul models over the high volume North Atlantic show that their evidently lower unit costs of approximately one third compared to legacy carriers, are only partly sustainable with around 24% (of the 33%) likely to prevail long term. The long-term advantage is attributed to the choice of business model and higher seat densities supplemented by the delivery of new aircraft types with even lower operating costs.

In a US airline study Lohmann & Koo (2013) found that business model parameter variation was low amongst full-service network carriers, but greater amongst LCCs and hybrid models deriving from the characteristics of their main operating base and catchment area, and in a European airline study Chang (2012) opines slow growing airlines have the greatest chance of sustainable success with fast growing airlines exhausting their resources before achieving stability. Any requirement for speedy growth likely favours the mature players or merger activity with them.

In summarising the BMI and SBMI initiatives for airlines - sustainable airline business models must focus on long term viability by maximising energy efficiency, considering new technology and materials to extend product and service life, and offer some societal benefit. There is evidence from the academic literature that reducing complexity in the value proposition and in business model operations offers the best path. Knowledge brokering, organic growth and cooperation with infrastructure providers offers longer term advantages. Low-cost carriers seem most exposed to emissions free advances in ground transportation, emissions taxes and delays in the volume delivery of SAFs. New management might even be necessary.

2.4 Sustainable Business Model Transitions

This penultimate section examines the frameworks surrounding SBMs, their measurement and remodelling which points a way to the conceptual development and research methodology that follows.

2.4.1 Literature on Sustainable Business Model Transitions

Section 2.3.3 identified the most important authors and drivers of the necessity of business model innovation. Spector (2011) defines this his more precisely showing that changing the value proposition, the targeted market segment, distribution method, key resources needed, customer relations models, revenue models or the cost structure may release old models from a status quo that can make new ones viable. Spiess-Knafl et al. (2015) expressed similar findings after reworking social business models finding effective innovation in developing new market segments, underutilised distribution resources, ecosytem building, sourcing, smart pricing and inclusive production.

> ‘The purposeful weaving together of interdependent activities performed by the firm itself or by its suppliers, partners and/or customers - is the essence of the business model design.’
>
> (Zott & Amit, 2010:218)

Demil & Lecocq (2010), Cavalcante (2014) and Girotra & Netessine (2014) showed that business model change is most effectively accomplished at the experimental and learning stage (performative) before resources are committed. This allows for the change obstacles to be addressed before old models are terminated. Chesborough (2010) notes the need to identify internal leaders for business model change, in order to implement the results of planning and that the coexistence of two models may be necessary during the transition process. Importantly new business models involve the risk of breaking away from dominant industry logic and embracing emerging technology. Thus, Volberda (1996), Doz & Kosonen, 2010; Bock et al. (2012) and Spieth et al., (2013) emphasise the importance of developing strategic flexibility in the process of business model innovation to prevail over the internal resistance to change and during the turbulence of hyper competition.

Since the business model contains the two elements of 'value created' and 'value captured', the maximum value capture of the firm is closely related to the bargaining skills of the firm with its stakeholders (Porter, 1980; Francis et al., 2004; Zott & Amit, 2007, 2012). If business model change is best accomplished at the points that value creation and value capture are touched; then new business models may possibly best be designed through a spontaneous and emergent approach given fewer stakeholders (McGrath, 2010; Svejenova et al., 2010; Sosna et al., 2010), whilst in mature and complex industries they may be better delivered only after careful analysis and with multiple stakeholders (MacInnes, 2005; Demil & Lecocq, 2010; Chesbrough, 2010; Cavalcante et al., 2011; Chesbrough & Schwartz, 2007; Rock et al., 2009; Sentance, 2009). Hence, an analytical and planned approach will probably be more useful for the airline industry.

In the majority of business model innovations, existing products are supplied to existing customers in existing markets and using existing technologies. Business models involving new technology and new products are in the minority (Girotra & Netessine, 2013, 2014). In appealing to customers, companies can choose a narrow focus, looking for commonality amongst many markets, or hedging a portfolio of products to appeal to several markets. Decisions surrounding price might be postponed by offering dynamic pricing and investment risk reduced by back ending capital expenditure and sharing investment costs. Decision makers should be the most skilled (even if external) and be able to manage the consequences of the decision outcomes as well driving dovetailed and aligned incentives. Service business model innovation such as in airlines, commonly involves the continuous involvement of internal and external transaction partners, since partnership activity is a common feature of services. This implies that the development of a new service business model evolves organisational learning and restructuring among the major transaction partners (Sinkula, 1994; Foss & Pedersen, 2002; Zott & Amit, 2008). Besides internal learning, external learning depends on the company interactions with external partners (Cohen & Levinthal, 1990; Chesbrough, 2010), implying that service business model innovation such as in transportation, is more complex than say, in manufacturing.

2.4.2 The Performance of Sustainable Business Models (SBM)

The information in this section informs the creation of a conceptual model for airline business model transformation and to generate hypotheses for testing of a multiple linear regression model in a quantitative study of airline performance.

Epstein & Roy (2001) and Lüdeke-Freund & Dembek (2017) propose that SBMs must capture performance in at least three aspects - financial, stakeholder and environment. SBM measurement has been reviewed by Ehrenfeld (2004), Bocken et al. (2014), Klewitz & Hansen (2014), Upward & Jones (2016) and Lüdeke-Freund & Dembek (2017). These researchers concur that the discipline is in the early stages of development and needs anchoring in the literature to establish itself as a distinct academic field. They propose a new and integrative discipline would maximise the potential of the new concept and break down barriers between existing disciplines such as energy, material recycling, the using renewable materials and business model design. Placing SBM initiatives into existing silos would discourage the development of new theory and practise. SBMs draw ideas from fields as disparate as supply chain management, construction, transportation and energy supply (Hogevold & Svensson, 2012; Dincer et al., 2017; Kalendar & Vayvay, 2016; Rabbani et al., 2014; Tubis et al., 2017; Fauzi et al., 2010; Zott & Amit, 2011). Sarasini & Lindner (2018) and Buganova & Luskova (2009) studying SBMs in the fields of energy and transport, reflect comprehensive business performance in scorecard reviews by adding a fifth perspective of 'environment' (Table 14).

Table 14: Generic Measures for Assessing Sustainable Business Performance

Scorecard Perspective	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5
Customer	Market share	Service satisfaction and quality	Customer loyalty	Customer complaints and processing time	
Internal Processes	Speed of core internal processes	Unfounded customer claims %	Punctuality	Generation of non-core revenues	Sustainable supply chains
Financial	Profitability (overall and by route)	Operating costs of vehicles	Cost of Fuel consumption and emissions	Unit Costs of operation	Returns for shareholders
R&D/Learning	Operator efficiency	Worker´s skills base	Staff retention and attraction	IT efficiency	
Environment	Community initiatives and relationships	Recycled raw materials	Use of renewable energy and raw materials		

Source: Dincer et al. (2017); Kalendar & Vayvay (2016); Rabbani et al. (2014); Tubis et al. (2017); Buganova & Luskova (2009); Barros & Dieke (2007); Wu & Liao, (2014) after Kaplan & Norton (2001)

2.4.3 Remodelling to Sustainable Business Models

Zott & Amit (2012), Bouwman et al. (2008), Sommer (2012) and Roome & Louche (2016) have all developed multi staged concepts for remodelling businesses with a series of defined inputs.

The Zott & Amit (2012) model contains three design elements: Content (what), Structure (how with linking and sequencing), and Governance (who and where) plus four design themes: i. novelty (innovation), ii. lock-in (retaining stakeholders), iii. complementarity (bundling) and, iv. efficiency (reducing transaction costs).

Bouwman et al. (2006, 2008) and De Reuver et al. (2013) have proposed a business model change process termed 'Business Model Road Mapping` using a Service, Technology, Organisation and Finance (STOF) framework, which is a stage led process taking the designer from the existing model to a new business model driven by understanding the future critical success factors (Figure 15). The four elements used are located within the business environment. The Service element identifies the market segment and customer value proposition. The Technology element includes the novelty and technology required for service delivery. The Organisation element clarifies the processes and the value network necessary, and the Finance element defines the cost and revenue models with profit and reinvestment potential. The structure is logical and structured with examples of its use in the medical and IT service industries (Bouwman, 2006, 2008; Menko et al, 2013; Günzel & Holm, 2013).

Sommer (2012) has developed a six-stage model for developing green and sustainable business models. The stages are: i. scenario building, ii. idea generation, iii. idea selection for maximum economic and operational potential, iv. draft business model planning, v. aligning business model to organisation and vi. testing and modifying in the real world.

The Roome & Louche (2016) four stage model focuses on, i. identifying problems and assumptions, ii. translating concepts and knowledge, iii. embedding outputs in a new business model and, iv. sharing these outputs with business partners and the creation of new partner networks. These four change frameworks are shown in Table 15 with common elements supporting the Bouwman et al. (2008) STOF framework.

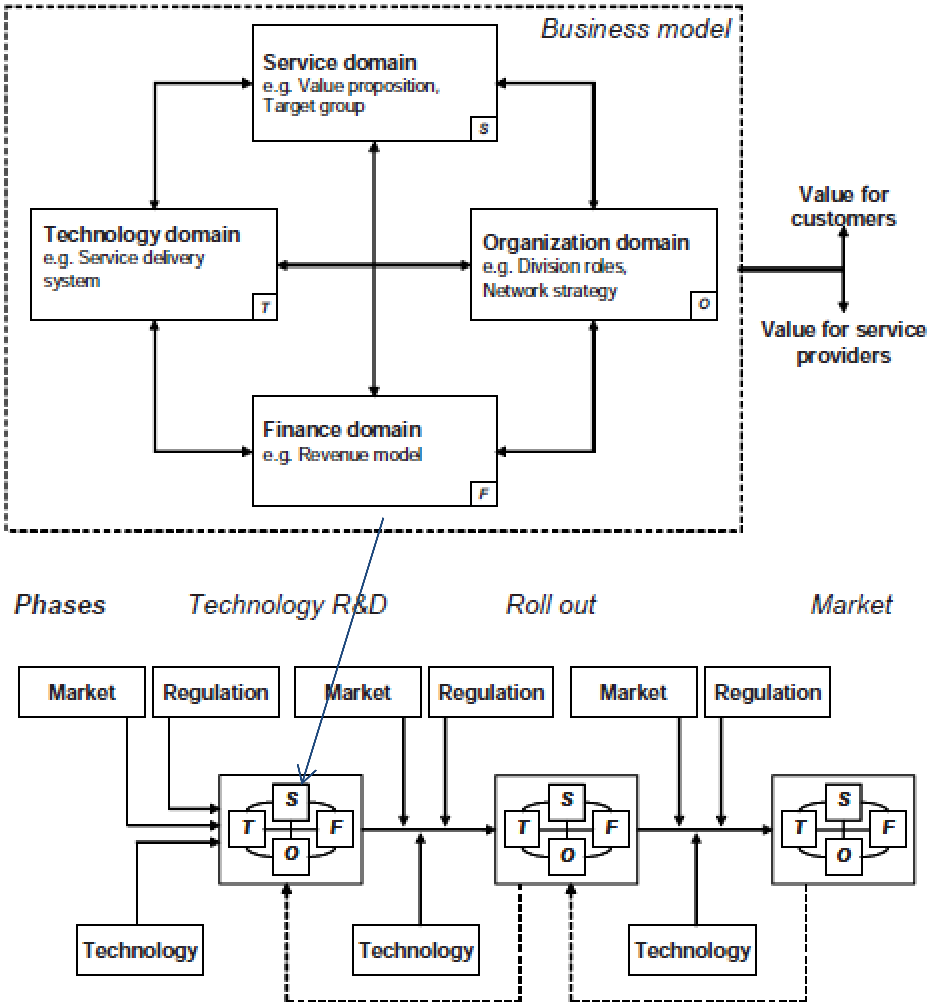


Figure 15: Service, Technology, Organisation, Finance (STOF) Business Model Road Mapping Design

Source: Bouwman et al. (2008:2)

Table 15: Common Features of Four Business Model Redesign Frameworks

Stages of Business Model evolution	**Bouwman et al., 2008**	**Zott & Amit, 2009**	**Sommer, 2012**	**Roome & Louche, 2016**	*Reduction to key parameter for STOF modelling*
Environmental assessment	Assess Market, Technological and Legal Developments	None	Building environmental scenarios	Identifying Problems and assumptions	*Environment of Technology*
Novelty and Ideas	Introducing Technology, Novelty	Introducing Novelty	Idea generation	None	*Service, Technology*
Value Proposition	Service, Market Segment, Value proposition	Model Content, features	Idea selection	Translating concepts and knowledge	*Service, Finance*
Business Model Design	in Value Proposition	Structure, Design, Complementarity	Draft Business model	Embedding outputs in Business Models	*Organisation*
Organisation alignment. Value Networks	Organisation Structure, Process; Developing Value Network	Creating lock-in, retaining stakeholders	Align organisation to Business Model	Sharing outputs in new networks	*Organisation*
Governance and modification	Redefine Cost & Revenue Structure	Entity Governance, Driving Efficiency	Testing and modifying Business Model after in vivo feedback	None	*Organisation, Finance*

2.4.4 Linking Transformation, Sustainability Measurement and Business Models

Industry transformation demands new ways of doing business and occasions the review and redesign of the interlinking of the critical elements of business models. I choose to use the MLP as a lens for analysis in the next chapters. The Technological Niche, the Socio-Technical Regime and the Socio-Technical Landscape fit the complexity and reality of the forces of the within the international aviation industry more appropriately than the other models. Geels et al. (2017) and Geels (2018) shows the way by promoting the MLP in understanding decarbonising landscapes. I make this choice as other the major frameworks TM, SNM and TIS do not reflect the likely scenario of the regulator as the key driver of the transformation. TM, SNM and TIS frameworks focus on early phases of transitions and they have severe limitations in addressing the issue of diffusion from the niche (Roberts & Geels, 2019). In TM models, the focus on iterative processes in the Technological Niche and ´doing by learning and learning by doing´ does not reflect the reality of the airline industry transformation which will likely initially be incremental and only radical over the longer term. In SNM models, balancing social and technological consumer preferences I believe will play a secondary role in the way the industry transforms with the dominant force the regulator. In TIS models, the ultimate determiners of change will not be found in companies and research institutes, they will be facilitators to a process driven from the Socio-Technical Regime. Airline leaders sandwiched between landscape and technology niche outside their immediate control and are left to manage forces within their control, i. strategically in terms of operating their choice of business model and activities with their major partners, and, ii. tactically with responses to the competition and the regulator.

Sustainable Business Model transformations occur and are measured at the **Company** level, the level of the **Market**, at the level of the **Supply Chain** and at the (macro) **Economic** level. Airline models of the future are unlikely to emerge and are likely to involve the multi-factor approaches of Chesborough & Rosenbaum (2000) and Osterwalder & Pigneur (2009). The evaluation of SBMs must include more than financial metrics with sustainability demonstrated to stakeholders.

Unruh (2002) suggests that only government policy and educational initiatives with a major environmental crisis offer a break carbon lock-in with Akerman (2005) and Karlsson (2012) believing that only breakthrough technologies can achieve this. Tomlinson et al. (2008) note there is increasing tension between the companies that finance energy research and wish to patent it, and its scale delivery, thus Tongur & Engwall (2014) show that technology shifts must be brought into governmental and company strategic plans early to have any chance of success, and organisational ambidexterity is vital to managing decarbonisation. Skills in 'managing evolving technologies and shaping coalitions towards industry standards' will be sought (Anderson & Tushman, 1990; Capoccitti et al., 2010). Oswald (2006), Chakarova (2010) and Chai & Xu (2014), Jovanovic et al. (2015) and Sentance (2009) believe that cooperation and brokering in new technologies could offer solutions. This could persuade developing nations with little interest in emissions politics to accept limits on CO2. I propose to link airline industry transformation and SBMs using the framework in Table 16.

Table 16: Matrix for Analysing Sustainability within the MLP

Industry Transformation →

Sustainability ↓

Levels of Analysis	Transformation Socio-Technical Landscape (Market)	Transformation Socio-Technical Regime (Non-Market)	Transformation Technological Niche (Technology)
Sustainable Company	Similar/dissimilar local competition, local stakeholder relationships, choice of business model	National regulations, standards, rules, norms	Small scale local and company innovation
Sustainable Market	Similar/dissimilar international competition, international stakeholders and alliances. International market growth	Cross border & international regulations, standards, rules	Larger scale international cooperation and innovation
Sustainable Economy	Demographics, disposable income, Climate change, Macro economy, Trade flows	International bodies agreements, goals, standards	Innovation with/from assistance from State or similar

Source: after Rip & Kemp (2010); Kemp et al. (2011); Geels (2011); and Boons & Lüdecke Freund (2013)

2.4.5 A Conceptual Development

I propose a model linking industry transformation and changes to the business model in Figure 16. The MLP in the centre of the model reflects the external factors affecting airlines, while the STOF model at the extremes characterises airlines' internal responses to these external forces. Thus, the two models are linked with both external and internal factors driving the changes to airline business models. Understanding these forces is the key to making practical suggestions for sustainable airline business models. For later analysis I will use the nine-point Osterwalder & Pigneur (2009) matrix to illustrate the STOF forces effects on business models.

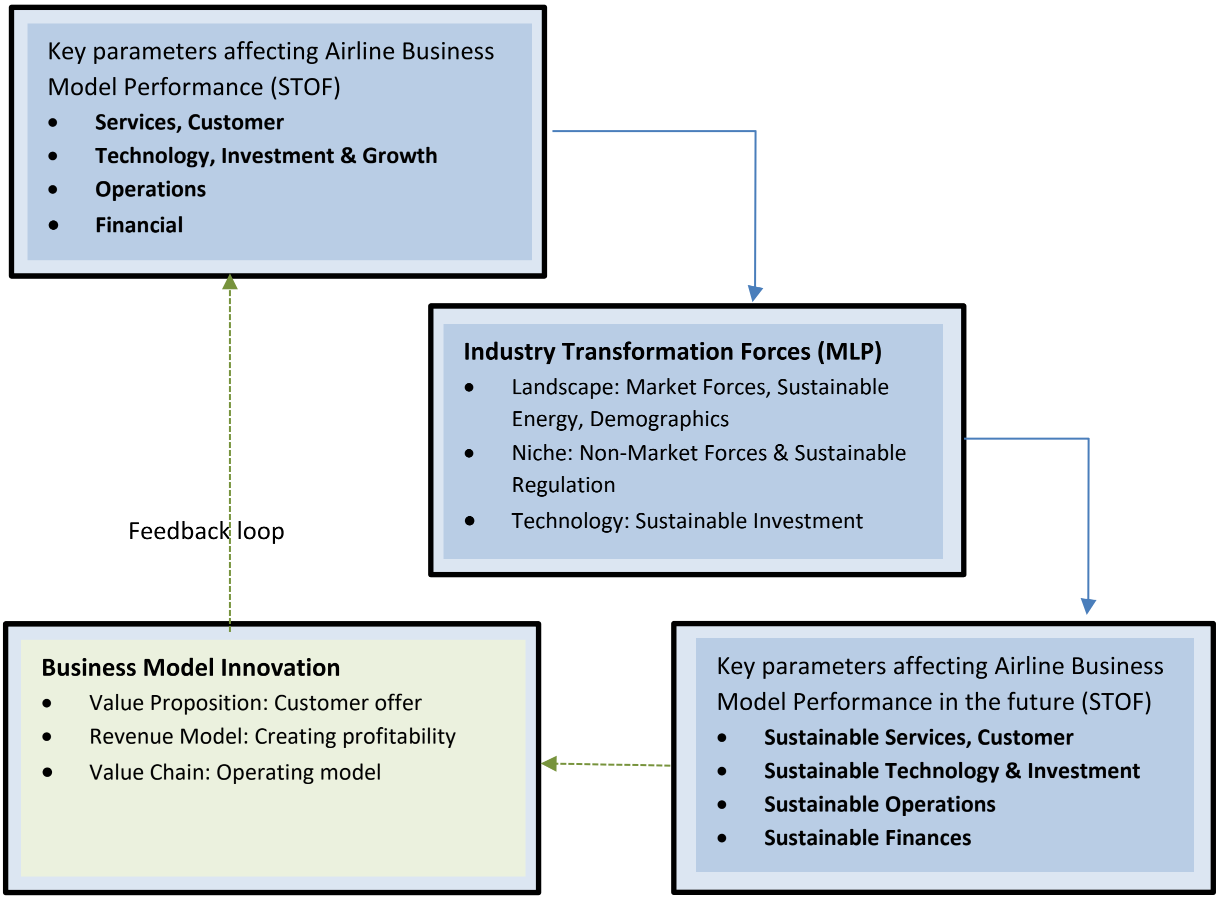


Figure 16: Conceptual Model for Understanding Airline Business Model Innovation by Linking the Multi-Level Perspective and STOF models

Source: Author, adapted from Bouwman et al. (2008)

2.5 Summary

This last section summarises the relevant literature for the study and makes a proposal for a research agenda.

2.5.1 The Literature Review and a Research Agenda

This chapter has reviewed extant literature on industry transformation, business models and their transformation with a focus on airlines. The review revealed four models of industry transformation, four design foundations of business models and four frameworks for business model re-engineering. It highlighted the potential for greater convergence of different themes and conceptualisations because the frameworks share many common features. The literature review reveals the absence of a comprehensive, recent understanding and combining of the factors affecting industry transformation in the European airline industry and in business model redesign in air transportation. Where partly relevant studies exist, they are not located in Europe and focus on single issues. It is demonstrated that industries in transition will need to reinvent their business models to remain relevant. A particular problem facing airlines the transfer to new fuels and the imposition of environmental taxes which threaten the viability of existing models and questions the sustainable growth of the industry. In this regard I seek to learn from other industries which experienced complex transformations, and from previous industry crises. New business models have emerged in the European airline industry but they have not developed to a point to secure economic and environmental stability (Bieger & Wittmer, 2006).

In the context of sustainability transitions, there is a gap in our understanding of how mature industry transformations affect complex organisation business models in the areas of economics, energy, social and environmental dimensions and technology which together determine long term performance. While SBMs are studied in the literature, sustainable **airline** business models are not. There is no study that explores airline industry transformation through the lens of a framework such as TM, SNM, TIS or the MLP. I choose to use the MLP because it includes such vital aspects as the actions of the airline regulator, changes in demographics, energy technology and a complex networking of players. I choose to link the MLP to Bouwman´s STOF model because this captures the external and internal factors affecting BMI. There is a lack of research that identifies the key parameters affecting the performance of European airlines in the four aspects relevant to BMI. To fill this gap in our understanding, I have presented a conceptual model for the transformation of the airline business model. This study seeks to examine the validity and usefulness of this integrated model and in doing so contributes to the academic literature by producing a comprehensive modern study of European airlines. This chapter thus lays the foundations for the subsequent methodology and next empirical research chapters.

Chapter 3 Research Methodology

3.1 Introduction

This chapter consists of six sections. Firstly, it introduces a four-stage research process (Figure 17) and explains the motivation for using a mixed method approach of the research undertaken. Then it describes the methodology of the four-stage research, the sources of the data collected, and the methods of analysis employed. Finally, a summary closes the chapter.

3.2 The Research Process and a Mixed Methods Methodology

Following the ´Research Methods Onion Model´´ of Saunders et al. (2009). The research philosophy for this project is **pragmatic**. Pragmatist philosophy holds that human actions cannot be separated from the past experiences and from the beliefs that have originated from past experiences. People take actions based on the possible consequences of their action, and they use the results of their actions to predict the consequences of similar actions in the future. As a research concept, pragmatism is based on the proposition that researchers should use the philosophical and methodological approach that works best for the research problem that is being investigated and is associated with mixed methods (Creswell & Plano Clark, 2011; Johnson & Onwuegbuzie, 2004). The focus is on the consequences of research and on the research questions rather than on the methods. The choice of this pragmatic methodology is driven by the epistemological school deriving from the work of Peirce, James, Mead & Dewey (Creswell, 2009) and one which considers situations, actions and consequences. All research methods are considered valid. A **deductive** approach to research such as in testing the framework in Figure 16 requires the use of quantitative and qualitative approaches, as in combination this provides a better understanding of research problems than either approach alone (Creswell & Plano Clark, 2011). **Mixed research methods** enable the comparison, validation and triangulation of the results adding credibility and confirmation to the understanding and validating the analysis and conclusions. Understanding the recent historic **(longitudinal)** performance of European airlines, and how airlines address movements in the MLP in the coming decades from grey literature and time spaced interviews, requires both quantitative and qualitative data for an optimum study.

The study is an `explanatory sequential` one (Creswell & Plano Clark, 2011) in that it the research is initially quantitatively orientated before using this understanding to inform several parts of a qualitative study. It is a four-phase research design, where the results of the quantitative study form background, develop theme-based questions and probe other variables driving business performance during crises, business models and strategy for a second, third and fourth stage research exercise involving both secondary data and expert interviews. The information from these four stages and a theoretical framework is proposed for industry transformation is discussed in Chapter 8. I summarise the research stages:

- Phase 1: Primary Quantitative Analysis from published airline data
- Phase 2: Secondary Qualitative Analysis using industry, company, consultancy and governmental/regulator publications
- Phase 3: Primary Qualitative Analysis from interview
- Phase 4: Primary Qualitative Analysis from interview

With mixed methods research the quantitative and qualitative approaches chosen need to be justified and their mixing explained. In this case quantitative data are used to understand the past and present industry position, but this has a limited predictive capability without the enrichment from qualitative studies. The advantage of this pragmatic approach is that it opens the research questions to the greatest possible number of worldviews. Critics of the mixed methods research strategy argue that quantitative and qualitative methods should not be mixed as their approaches are incompatible, although Onwuegbuzie & Leech (2005) argue for an integration of the skills of both methods, and Creswell & Plano Clark (2011) make the case for 'mixed methods' or a 'triangulation' approach as an established methodology within academic research. In the case of this thesis, I believe that findings and recommendations make coherent sense if all sources of data point to similar conclusions. I justify the choice of my approach in testing theory and adding to the development of the discipline. My belief is that a mixed methods study offers the best approach in to trying to answer complex research questions, particularly where quantitative historic data might offer understanding of the near past and offer pointers to the future, and where interview analysis might offer insights into industry management addressing industry transformation at a critical inflexion point.

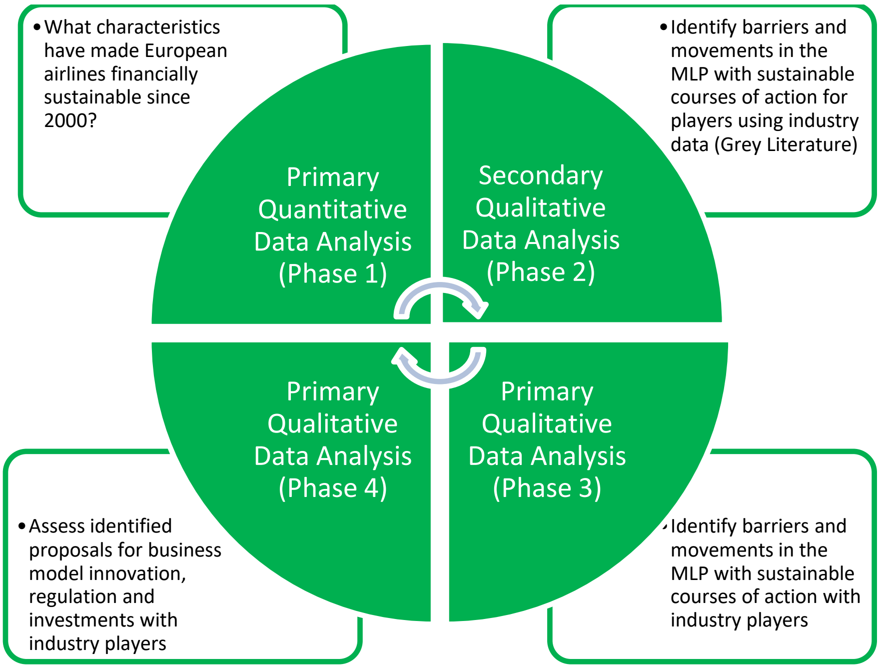


Figure 17: Four Cyclical Stages of Research for Sustainable Airline Business Models

3.3 Quantitative Study (Phase 1)

This section describes the rationale behind the study of industry performance in the European aviation sector from 2000 to 2019. These include the key metrics that monitor the performance of the current strategic business models of airlines for both network and low-cost carriers (Collins & Chan, 2011; Reichmuth, 2008; Mason & Morrison, 2008). Specifically, this section is concerned with examining the key factors shaping airlines' financial performance to understand their interrelationships with business models.

Although historic information is no firm guide to the future, it is considered useable for forecasting and planning. A baseline for planning is selected after data is adjusted for 'stress periods' such as those after September 11th 2001, the SARSCoV pandemic of 2002-2003, the Iraq War of 2003-2004, the financial crisis of 2007-2008 with oil price spike and crash, and the Eyjafjallajökull volcano eruption in 2010 (Sammonds et al., 2010). Outside these 'stress years' movements in airline financial performance traditionally follow the global GDP wave (Pierson & Sterman, 2013; Wang, 2013). The quantitative study is seen as important since some European airlines have survived these five crises since 2000. Which parameters might point towards success?

Quantitative mathematical, statistical correlation and regression techniques (Creswell & Plano Clark, 2011) were used to identify the variables that are critical to success. The goal here was to establish if there is a relationship between the management control of financial, operational, marketing and organisational critical success factors and company performance. The section finishes with a discussion of the limitations of the data pool.

The airlines and industry associations, the International Civil Aviation Organisation (ICAO), the Air Transport Action Group (ATAG), Airports Council International (ACI) and the International Air Transport Association (IATA) publish data on industry traffic and yield movements, unit cost developments and changes in global traffic flows that airlines use to support sensitivity analyses and make forecasts. The major aircraft manufacturers publish data on the demand from commercial airlines for new aircraft with projected deliveries and potential improvements in unit aircraft operating costs. Lee (2010) has used historic improvements in airline efficiency for use in financial modelling. Theoretical modelling tools and industry data have been applied to forecast the effect of the cost of fuel and emissions (DECC, 2013; DEFRA & DFT, 2008).

Once the collection and analysis of the quantitative study data was complete, and the key variables, issues and critical success factors identified from historic data - the themes and questions for interview were drawn up, including using the MLP and STOF frameworks and concepts drawn from the literature review.

3.3.1 Quantitative Study Data Sources

The analysis of secondary historic published accounting data from publicly listed companies and groups was used to assess the role of key organisational metrics in shaping financial performance outcomes. The sample data was obtained from the published financial reports and annual accounts of twenty European airlines from the years 2000 to 2019. The service quality index was obtained from Skytrax. I chose the largest publicly listed twenty airlines by passenger revenue in Europe in 2017, that publish financial and statistical information to International Accounting Standards (IAS) and that had a substantial trading history. The definition of Europe includes Iceland and Norway in the north, Russia and Turkey in the east, Spain and Greece in the south, and Portugal and Ireland in the west. This definition covers the majority of European air traffic and includes Turkish Airlines a major player in the European market.

For use in the modelling, ideally the parameters chosen for analysis should, i. have consistently been produced over a period of several years, ii. be produced in the same form for each airline in order to offer useful and comparable data, iii. capture the key aspects of airline financial performance and, iv. be subject to independent external audit and IAS. The final data pool used included over 30,000 data points for the trading years 2000 to 2019 from twenty airlines or airline groups. All accounting data was collected and converted from currency of reporting into Euro using World Bank rates (api.worldbank.org › indicator › PA.NUS.FCRF).

Publicly quoted airlines are useful and important as they provide a good source of financial and operational information that is consistently available over a substantial time period. Some large airlines are considered as part of groups for example the Lufthansa Group currently includes Lufthansa passenger airlines, Lufthansa Cityline, SWISS, Austrian Airlines, Brussels Airlines, and German/Eurowings, and IAG currently includes British Airways, Iberia, Aer Lingus and Vueling. In these specific cases networks are managed as a single group of airlines by eliminating sub-optimal routes and often supplying group feed traffic at hubs. These large groups are effectively a 'new' type of network or 'hub and spoke' carrier and as a result data is analysed at the 'Group' level and not at the individual level of the group members. Detailed information for the members of a large airline group is not publicly available and may contain suboptimal performance at the subsidiary level.

It is noted that both charter and cargo operations are included in the business operations of both network and LCCs. This is unfortunate for analysis but reflects the complexity of business models. Two further airline business models exist that are more specialised, the dedicated cargo carrier and the charter carrier. These are not discussed in this thesis, firstly as both types are small in relation to the overall size of the European airline industry, and secondly because in many large airlines such activities are already integrated into the passenger operations whether they be network based or low service, low-cost operators. For network carriers, cargo revenues usually account for 10% to 15% of total revenues, and for LCCs this is between 5% and 8%. For practical purposes in this study a cargo business is included in the available data. In the case of charter services some airlines simply adjust service frequency and destinations in the summer and winter schedules to accommodate the demand of seasonal traffic and thus are by default also included.

3.3.2 A Multiple Factor Regression Model of Airline Performance

The quantitative analysis was made using multiple factor regression analysis. A multiple factor regression model of consists of a dependent variable, several independent variables and an error constant (Creswell, 2009). A multiple regression model was developed that focuses on Operating Profit (Earnings Before Interest and Tax, EBIT) or Operating Cash Flow (OCF) as two variants of the dependent variable measuring airline financial performance, where b0 is the intercept.

EBIT = b0 + b1(Fuel Costs) +b2(Investment in Asset Base) + b3(airline ownership) + b4 (unit labour costs) + error

EBIT = b0 + b1 (Fuel Costs) +b2 (Fleet size) + b3 (Seat Load factor) + b4 (global alliance membership) + error

OCF = b0 + b1 (Yield) +b2 (Passenger Numbers) + b3 (Personnel Costs) + b4 (business model) + error

OCF = b0 + b1 (Unit Fuel Costs) +b2 (Yield) + b3 (Investment in Fixed Asset base) + b4 (Debt/Equity ratio) + error

3.3.3 The Modelling Approach - a Multiple Factor Linear Regression

To examine the key factors shaping airlines recent financial performance multiple factor linear regression was employed. As a tool of predictive analysis, multiple factor linear regression was used to explain the relationship between one continuous dependent variable and two or more independent variables. The independent variables can be continuous or categorical. There are three major uses for multiple factor linear regression analysis, i. it might be used to identify the strength of the effect that the independent variables have on a dependent variable, ii. it can be used to forecast effects or impacts of changes, and iii. multiple factor linear regression analysis can predict trends and future values. In this case, I use a multiple regression model to draw out from the data, the key independent variables for understanding and framing the interview stages of the study.

When selecting the model for the multiple linear regression analysis, an important consideration is the model fit (Kutner et al., 2004). Adding independent variables to a multiple linear regression model will always increase the amount of explained variance in the dependent variable (expressed as R-squared). However, adding too many independent variables without any theoretical justification may result in ‘overfit’ and an over complex model to no practical benefit (Frost, 2018). Overfitting a model is a condition where a statistical model tips into describing random error in the data rather than the real relationships between the variables. Overfitting can produce misleading R-squared values, regression coefficients and p values representing simply 'sample noise'. There is thus an optimum number of variables in any model. The independent variables are described in Chapter 4 in Table 34.

There are several assumptions inherent in this type of statistical analysis.

- Regression residuals must be normally distributed.
- A linear relationship is assumed between the dependent variable and the independent variables.
- The residuals are homoscedastic, i.e. share a common covariance.
- The absence of multi-collinearity is assumed in the model, meaning that the independent variables are not too highly correlated with one another.
- The goal of the multiple linear regression analysis is to fit a single line through a scatter plot. The simplest form has one dependent and two independent variables. The dependent variable is referred to as the outcome variable or regressand. The independent variables are referred to as the predictor variables or regressors.

3.3.4 The Principles for building a Multiple Regression Model for Airline Performance

General principles for building multivariate regression models were adopted (Kutner et al., 2004; Field & Miles, 2010; Hair et al., 2010). All statistical analysis were performed in JMP Pro v15 for SAS for Windows 10.

- The dependent variable will be operating profit (EBIT) or its close counterpart operating cash flow (OCF). OCF is EBIT plus accounting adjustments for non-cash charges such as depreciation and cost accruals.
- The model should account for most of the variance in the data – approximately 60% or more of the data variance should be explained for it to be a valuable tool.
- Independent variables will be cost related, investment related, operational parameters and those related to ownership, alliance membership, personnel and the business model.

- Control variables for all trading years and the country of main base operations and registration are included.
- Models with fewer independent variables accounting for the same variance as those using more independent variables are to be preferred - as they are simpler and thus less likely to suffer covariance problems.
- The Significance F value should be <0.05 for the model to be statistically significant.
- Single independent variables with P values <0.05 are not likely to be accounted for by chance and are most useful.
- Correlation is tested for to eliminate independent variables that are highly related with each other and thus move together in any model. For analytical purposes low correlation is regarded as being less than 30%.
- A variance inflation factor (VIF) between parameter sets of more than 10 indicates multi-collinearity and invalidates the model.

3.3.5 Limitations of the Data Pool

The data pool used for the multiple regression model includes twenty scheduled airlines. Given this limitation, small, privately owned, cargo and charter airlines are excluded and do not make up part of the modelling data set. Such exceptions might be expected to have different issues in viability.

An assumption is made that on converting accounting data from original currency to Euro, that accounting data is prepared under the same category definitions and also that the average exchange rate for the year is a fair conversion factor. In most cases the accounting year is the same as the calendar year with the exception some British carriers which historically adopted 31st March year end for tax year alignment, but later adopted the calendar year. The data set is partly self-selecting in that the airlines that provided the highest quality data (as detail and consistency) are those most represented in the data pool. This however was not exclusively the large airlines or groups, but the highest quality data was generally available from the airlines in Northern and Western Europe. The data is also self-selecting in that, only airlines that have survived the recent crises are included although two ceased trading during the data sample period

3.4 Qualitative Data Analysis of the European Airline Industry

This section explains the methodology of the qualitative research undertaken and the justification for the selection is explained. The insights from the literature review and the quantitative study were used to frame the qualitative analysis, which was completed in three successive phases. The purpose of the qualitative research is to identify the movements the Service, Technological, Organisational and Financial (STOF) forces in the MLP, barriers to change and sustainable courses of action for the players. The qualitative analysis took place in three phases – phase two from the grey literature (industry, consultancy, company and regulator) sources and phases three and four from primary interview sources. The section finishes with criticisms of the qualitative research methodology.

3.4.1 Methodology of a Grey Literature Review (Phase 2)

A grey literature review was made to summarise the most current knowledge of industry experts and practitioners and the current position level of industry regulation. It opens the study to the widest possible expertise and knowledge which might be limited by shorter but direct more questioning of an interview sample of industry experts. To review the literature for this thesis I employed a thematic approach (Braun and Clarke, 2012). This means that the methodology was driven by a desire to identify key documents and concepts of relevance to the broader debate while applying a replicable methodology. To that end, I followed the following steps: Firstly, I identified two key themes: i) Sustainable Airline Industry Transformation; and ii) Sustainable Airline Business (Figure 18). Based on these themes, I then listed twenty key search words in Table 17. I employed key word driven searches using the following search engines (Warwick) Library Search (filter: Trade, Magazines, Reports, Conferences), Classic Catalogue, Proquest, Google (Scholar), Aviation Management/Consultancy sources and the EC website. I further delimited the literature searches by setting a time frame for publication post 2000 to ensure the works reflect latest developments. This search revealed more than 140 relevant documents. I first read the summaries to determine whether papers related to the key themes and then organised them by placing documents under the business model canvas themes for analysis (Boote and Beile, 2005).

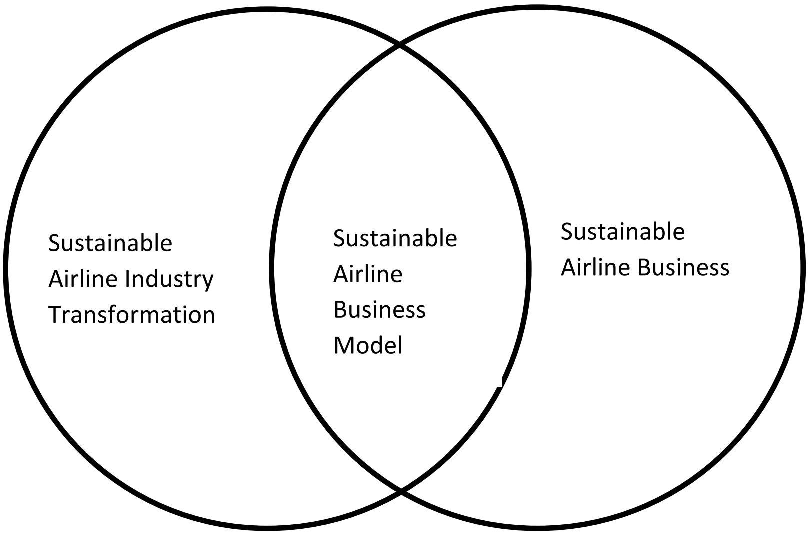


Figure 18: Venn Diagram of the Grey Literature Review

Table 17: Key Words used in Grey Literature Search

1. Airline mergers/consolidation/alliances (Europe)
2. Sustainable air transport/transformation
3. CORSIA
4. European Emissions Trading System
5. Sustainable Aviation Fuel
6. Sustainable Airline Business Models
7. Sustainable Airport Infrastructure
8. Airline Market / growth / competition
9. Road/rail/air competition
10. Airline financial sustainability
11. Airline investment
12. Airline Regulator/regulation (Europe)
13. Airline Hubs (Europe)
14. Airline State Aid (Europe)
15. Electric Hybrid Aircraft
16. Hydrogen powered Aircraft
17. European Transport Policy
18. Zero Emissions
19. Kerosene Taxes
20. Aircraft/Aircraft Engine technology

3.4.2 The Grey Literature Data Sample (Phase 2)

The second stage of data collection and analysis involved a review of the recent industry developments in airline industry competition, infrastructure, regulation, developments in technology and in airline business models. This stage differs from the literature review in that it focuses on data from four main sources, i. company reports and industry journals, ii. independent consultancy reports, iii. economic agencies, and iv. government publications. The advantage of using grey literature is that much important research is never published in academic journals or is delayed and positive research studies are often subject to publication bias, leaving out alternative viewpoints. This means that grey literature publications can be at the forefront of knowledge and best practise (von Elm et. al., 2003) It has been estimated that in medical research approximately two thirds of research abstracts are never published. Grey Literature includes expertise not found in the research departments of Universities that normally publish academic research (Pappas and Williams, 2011). The data sample consisted of more than 140 documents of which more than half were published in the last five years at the time of writing (2021) shown in Table 18.

Table 18: Grey Literature Review by Source and Date of Publication

Document Source /Type	**Pre 2000**	**2000-2005**	**2006-2010**	**2011-2015**	**2016-2021**	**Total**
Management Consultant	0	0	2	2	10	**14**
Economic Agency/ Think Tank	0	1	2	1	7	**11**
Industry Publication/ Conference	1	4	8	14	40	**67**
Regulator/Government	1	1	5	4	13	**24**
Other	1	3	3	6	12	**25**
Total	**3**	**9**	**20**	**27**	**82**	**141**

3.4.3 The Grey Literature Data Analysis (Phase 2)

The grey literature was analysed by theme and node allocating key phrases and points to one of the nine features of the Osterwalder & Pigneur (2009) Business Model Canvas in NVIVO v11 and Microsoft Excel. The nodes are shown in Table 19 and the presentation of the findings is in Chapter 5.

Table 19: Key Nodes for Grey Literature Review per Osterwalder & Pigneur Business Model Canvas (2009)

Business Model Feature	Service	Technology	Organisation /Operations	Finance	Total Nodes
Value Proposition	7	2	6	5	**20**
Key Activities	2	1	2	5	**10**
Key Resources	0	0	4	0	**4**
Key Partners	0	2	3	3	**8**
Customer Relationship	2	3	2	1	**8**
Customer Segment	3	3	0	3	**9**
Sales Channel	3	0	0	0	**3**
Revenue Structure	0	0	0	5	**5**
Cost Structure	0	0	0	12	**12**
Total	**17**	**11**	**17**	**34**	**79**

3.4.4 The Limitations of the Grey Literature Review

The main limitations of using grey literature are that it is not peer reviewed and could be subject to bias, patronage, opinion or produced by individuals with limited experience. It may not meet the high quality required of an academic journal, in particular statistical information may not meet the highest standards of an academic journal (Pappas & Williams, 2011). Grey Literature is also not indexed in major bibliographic sources and it be updated or produced in multiple versions, the new or revised information would not be found in the source document and is unlikely to be re-referenced. To minimise such issues, I have selected professional and reputable producers that reference their sources, and not included any statistical analysis.

3.5 Primary Qualitative Data and Sample (Phases 3 and 4)

Primary qualitative analysis enriches the quantitative analysis with the development of themes and the understanding of key player perception and intent. Linear predictions based on historic quantitative data are valuable but insufficient. The detailed questioning of industry experts in the disciplines of finance, service, technology and organisation adds significant value.

Primary qualitative data was collected in the form of interview questions which were written with an understanding of the current best practice in social science. This means the use of open ended, non-leading and bias free questions within a framework addressing the key issues (De Vaus, 2002; Creswell, 2009). Industry insider interviews were conducted with senior airline industry officials in Europe and with representatives of industry bodies. Expert opinion was also sought from an aviation lawyer in Switzerland, a regulator at the European Commission and with industry analysts, consultants and academics. Suppliers to the industry were involved in the interview process by including aircraft and engine manufacturers. The goal of the qualitative data collection was to understand if key figures in the industry concur with the findings identified from the quantitative study, and to capture how they envisage the industry developing as a response. A process of triangulation between the data sets adds confirmation to the understanding and validating the analysis and conclusions.

A list of over 80 contacts was established for in-depth interviews. This list was created from senior officials with whom I have had contact with or knew from industry conferences during my career in the airline industry, or by asking individuals through contacts I have made during my career in the airline industry or through higher education (i.e. snowballing per Boell & Cecez-Kecmanovic, 2010). Individuals were selected from four major groups, with different skills sets. In all interview arrangements I disclosed that I was a part time PhD student and that I worked for the Lufthansa Group. Interviewees were contacted by telephone or email and with the most senior officials through gatekeepers. I had no pre-existing relationship with any interviewee or developed close relationships with them during the data collection process (Aguinis & Solarino, 2019).

- Airline expertise: Senior Officials such as CEO, CFO, CMO, CTO, others
- Third Party Experts: University Academics, Industry Experts, Lobbyists, Management Consultants
- Airline Industry Suppliers: Boeing, Airbus, CFM-Safran, Rolls Royce, Bombardier, Embraer, Fuel (SkyNRG)
- Airline Industry Regulators and Administrators: those that represent the industry e.g. EC, IATA, ICAO, ATAG, National Regulatory Body

3.5.1 Data Collection and Data Analysis (Phases 3 and 4)

Interviews were conducted face to face or by Skype and generally lasted about one hour. A first round of interview questions with 24 interviewees (phase 3) was followed up by a second round of 15 interviews (phase 4) approximately one year after the first round was analysed. The second round presented the first-round results for comment, insight and potential revision. Only five of these individuals in the second round overlapped with the first-round group, with eleven new interviewees added for their judgement and expert opinion. I note that most of the forty interviewees do not have English as a first language, although all are competent with English the universal language of aviation.

3.5.2 Research Ethics

All interviewees completed the University's 'Consent Form' which detailed the title of the project and the project supervisors. Interviewees were informed before the start of each recording that the interview was of a voluntary nature and that they could withdraw at any time. Consent was requested for a recording. Interviewees were given the option to remain anonymous and to review the written transcript of their recording.

3.5.3 Linking Interview Questions to the STOF Model and the MLP

In Chapter 2 I made the link between the forces affecting the STOF Model for the restructuring of Business Models and the MLP to explain industry transformation (Figure 16). Exploring the role of business model innovation in supporting a sustainability transition in the European airline sector is the goal of the thesis - so that questions asked of the industry experts reflect the linking of the levels of transformation and forces generated on organisations.

Bouwman et al. (2008) identify the forces affecting business model transformation and Market, Non-Market and Technology affecting Organisation. Geels et al. (2010) identify the levels of industry transformation as Socio-Technical Landscape, Socio-Technical Regime and Technological Niche. Choosing four different expert groups maximises the goal of good information covering all perspectives of the MLP. A sample size of forty increases opportunity to capture and encompass different views, and access to senior staff increases the chances of high-quality information. I justify the interview question structure in terms that the interviewees would understand and by linking these two approaches. The interviewees were generally not aware of the Multi-Level Perspective, but reacted to terms such as 'market, regulator, technology, organisation or business model' shown in Table 20.

Table 20: Linking the Interview Questions in Business Model Transformation to the Multi-Level Perspective

STOF Model Forces affecting Business Model Transformation	**Multi-Level Perspective Model Tier affecting Industry Transformation**
Market	Socio-Technical Landscape
Non-Market / Regulation	Socio-Technical Regime
Technology	Technological Niche
Organisation / Business Model	Business Model in the Socio-Technical Landscape

3.5.4 Qualitative Analysis Structure (Phase 3)

Following the conclusions drawn from the quantitative study, a series of fifteen questions were written to add depth, interpretation and a future perspective to this first stage of data gathering. The questions were designed in four sections reflecting the four sections of the design framework introduced above that is: Market, Non-Market, Technology and Organisation and their impacts on the Business Model following the STOF modelling of Bouwman et al. (2006, 2008). All full list of interview questions is included in Appendix 12.3. The questions focussed on the market and the issues with current business models, the role and responsibilities of the regulator, the issues concerning moving to new technologies, and how restructured or new organisations meet these challenges.

Twenty-four interviews were deemed sufficient to gain information saturation for drawing reliable conclusions about the current state of industry thought around the subject matter. Interviews were recorded primarily in English with some in German if the English of the interviewee was not sufficient. Interviews were recorded as .wav files on a Tascam DR05 digital recorder. The interviews were transcribed to text by a grounded Flight Attendant who was available to translate the German sections, but mostly by a professional third-party transcription service (Val Turner Transcription Services, Hartford, Cheshire, UK). I made my own notes of key points during the interviews.

The Proprietary Computer Assisted Qualitative Data Analysis Software (CAQDAS) type software (QSR International) NVIVO v. 11 for Microsoft Windows was used for the analysis using a guide from Stanford University (2011). After collection primary interview data were collected and coded into themes, concepts, agents and ideas. Some themes emerged during the interview process but the questionnaire was designed based on insights from the quantitative study to prompt themes that are believed relevant to the study. Once coded, themes and linkages were established in order to draw out key issues and critical success factors that can be seen in context with phase 1. Themes common to both data sets were iteratively compared and matched to existing theory and relevant literature. A clear goal was to assess the qualitative data collected for an understanding of the forces shaping the industry and how the players will react to them. It is believed that bias was reduced by having a large sample size and interviewing a variety of interest groups. To improve the understanding of the responses from the various groups, the interview pool is summarised by interest group in Table 21 and Table 22. The experts who took part in the first and second rounds of interview are listed in Table 23. All transcribed interviews were transferred into NVIVO and analysed to nodes, sub nodes and text word searches illustrate the key points made. I have again linked the presentation of the interview findings to the MLP (Rip & Kemp, 1998; Kemp & Pontoglio, 2011; and Geels, 2011) and I present the findings in the same structure following the three MLP perspectives in Chapter 2.

Table 21: Interview Pool by Grouping Round One (Phase 3)

Category of Interviewee	**Number of Interviewees**	**Transcribed Pages of Interview Text**
Senior Airline Management	8	116
Management and Industry Consultants	5	101
Industry Suppliers	4	57
Industry Representative Officials	3	56
Industry Regulatory Officials	2	34
University Academics	2	46
Total	**24**	**410**

3.5.5 Qualitative Analysis Structure (Phase 4)

Following the conclusions drawn from phases 2 and 3, a series of ten questions were written to refine and add depth to the findings from the first set. All full list of interview questions is included in Appendix 12.4. These questions focused on the findings of the first set of questions, specifically business model fragmentation and the feedback on the proposals for industry solutions. Interviews were recorded, transcribed and presented as in phase 3. The findings were structured in distinct nodes shown in Table 27.

Table 22: Interview Pool by Grouping Round Two (Phase 4)

Category of Interviewee	Number of Interviews (persons)	Transcribed Pages of Interview Text
Senior Airline Management	6 (7)	110
Management and Industry Consultants	3	50
Industry Representative Officials	2	47
Industry Suppliers	2	49
Pressure Groups	1	14
Industry Regulatory Officials	1	19
Total	**15 (16)**	**289**

In total approximately 40 hours of interviews were transcribed to text from phases 3 and 4, delivering almost 700 pages of A4 text.

3.5.6 Data Analysis (Phase 3 and Phase 4)

The analysis of interviews was made in two stages reflecting the sources and questions. I have linked the presentation of the interview findings to the Multi-Level Perspective (Rip & Kemp, 1998; Kemp & Pontoglio, 2011; & Geels, 2011) in Chapters 6 and 7 and I present the findings in the same structure following the three MLP perspectives plus 'organisation' and 'other'.

In the analysis concerning the organisation, I examine the content of the interviews by using word searching over 400 pages of interview text for relevant content to contribute to design elements for new business models for the airline industry. Through the multiple levels of nodes used in NVIVO, I draw out relevant content. By using the text query function in NVIVO, I use the Osterwalder & Pigneur Business Model (2004, 2005, 2009, 2010) nine-factor matrix to draw out major features for a series of proposed airline business models in Europe. It was the phase 3 analysis that was presented to the second group of interviewees in phase 4 for their comments and to discuss proposals for industry transformation. This two-stage interview process was designed to increase the validity of the findings. Only five of the second-round interviewees had not been previously consulted for their opinion so this offers a fresh perspective on the findings from the first group.

Table 23: List of Experts interviewed by Round 1 and 2

No.	Source: Author	Position/Title	Organisation/Location	Round 1	Round 2	Interview methodology
1	Consultant	Senior Economic Adviser	PwC, London, UK	yes	no	recorded telephone/Skype call
-	Academic		Warwick Business School, Coventry, UK			
2	Industry Consultant	Independent Aviation Consultant	Independent Aviation Consultant, Tunbridge Wells, UK	yes	yes	recorded telephone/Skype call
3	Academic	Head of HSG Aviation Competence Centre	University of St Gallen, St Gallen, Switzerland	yes	no	recorded face to face in person
4	Airline Industry Body	Chief Economist	IATA, Geneva, Switzerland	yes	yes	recorded telephone/Skype call
5	Aero Engine Manufacturer	Business Development & Strategy - Civil Aerospace	Rolls Royce Aero Engines, Derby, UK	yes	no	recorded telephone/Skype call
6	Aero Engine Manufacturer	Environment Strategy Manager	Rolls Royce Aero Engines, Derby, UK	yes	no	recorded telephone/Skype call
7	Aero Engine Manufacturer	Senior Manager Business Development - Civil Aerospace	Rolls Royce Aero Engines, Derby, UK	yes	no	recorded telephone/Skype call
8	Aircraft Manufacturer	Vice President Sustainability and Alternative Fuels	The Boeing Company, Seattle, USA	yes		recorded telephone/Skype call
-	Aircraft Manufacturer	Head of Growth and Investment Sustainable Fuels	SkyNRG (KLM), Amsterdam, Netherlands		yes	
9	Airline Management	Chairman, Board Member Former, former Chief Executive Officer of two European airlines	Roche Group, Basel, Switzerland	yes	no	recorded face to face in person
10	Airline Management	Chairperson of the Performance Review Body PRB of the Single European Sky	European Commission, Brussels, Belgium	yes	yes	recorded face to face and telephone/Skype call
11	Airline Regulator	President	Aerosuisse, Zurich, Switzerland	yes	no	recorded face to face in person
12	Airline Management	Chief Financial Officer	Swiss International Air Lines AG, Zurich, Switzerland	yes	no	recorded face to face in person
13	Airline Management	Chief Executive Officer	Swiss International Air Lines AG, Zurich, Switzerland	yes	no	recorded face to face in person
14	Airline Management	Chief Commercial Officer	Swiss International Air Lines AG, Zurich, Switzerland	yes	no	recorded face to face in person
15	Airline Management	Vice President Environmental Issues	Lufthansa German Airlines Group, Frankfurt, Germany	yes	no	recorded telephone/Skype call
16	Management Consultant (Transportation)	Managing Director	Alix Partners, Zurich, Switzerland	yes	no	recorded face to face in person
17	Airline Industry Body	Head of Operational Cost Management	IATA, Montreal, Canada	yes	yes	recorded face to face in person
18	Airline Management	Head of Treasury, Fuel and Emissions Trading	Austrian Airlines, Vienna, Austria	yes	no	recorded face to face in person

Table 23 continued: List of Experts interviewed by Round 1 and 2

No.	Category	Position/Title	Organisation/Location	Round 1	Round 2	Interview methodology
19	Airline Industry Body	Assistant Director, Aviation Environment – Technology	IATA, Geneva, Switzerland	yes	no	recorded telephone/Skype call
20	Academic	Lecturer in Aviation Management	Dublin City University, Dublin, Ireland	yes	no	recorded telephone/Skype call
21	Industry Consultant	Global Managing Director - Airlines, Aerospace and MRO	ICF, London, UK	yes	no	recorded telephone/Skype call
22	Airline Management	Director Corporate Sustainability	Finnair PLC, Helsinki Finland	yes	no	recorded telephone/Skype call
23	Management Consultant (Transportation)	Principal Transportation Competence Center	Roland Berger, Hamburg, Germany	yes	no	recorded telephone/Skype call
24	Airline Management	Chief Executive Officers (2)	Lufthansa Group and Swiss International Air Lines	yes	no	recorded Q & A conference interview in person
25	Airline Management	Senior Director Network Management and prev. Senior Director Corporate Development	Swiss International Air Lines AG, Zurich, Switzerland	no	yes	recorded face to face in person
26	Airline Management	Chief Financial Officer and Member of Lufthansa Group Executive Board	Swiss International Air Lines AG, Zurich, Switzerland	no	yes	recorded face to face in person
27	Airline Management	Head of Sustainability and Human Resources	Swiss International Air Lines AG, Zurich, Switzerland	no	yes	recorded face to face in person
-	-	Senior Manager Carbon Compensation	Swiss International Air Lines AG, Zurich, Switzerland	no	yes	recorded face to face in person
28	Industry Consultant	Principal	ICF Aviation Consultants, London, UK and Amsterdam, Netherlands	no	yes	recorded telephone/Skype call
29	Airline Management	Head of Fleet Technical Services & Deputy Technical Director	Easyjet PLC, Luton, UK	no	yes	recorded face to face in person
-	Academic	Lecturer	Cranfield University, Bedfordshire, UK			
30	Industry Consultant	Senior Economic Consultant	ICF Aviation Consultants, London, UK and Amsterdam, Netherlands	no	yes	recorded telephone/Skype call
31	Aircraft Manufacturer	Head of Sustainability Initiatives and Environmental Affairs	Airbus Industrie SA, Toulouse, France	no	yes	recorded telephone/Skype call
32	Pressure Group and Climate Change Consultancy	Press Officer and Consultancy Spokesman	Myclimate AG, Zurich, Switzerland	no	yes	recorded telephone/Skype call
33	Airline Management	Senior Director Corporate Development	Swiss International Air Lines AG, Zurich, Switzerland	no	yes	recorded face to face in person
34	Airline Management	Head of Business Development	Eurowings AG, Cologne, Germany		yes	recorded telephone/Skype call
-	Airline Management	Chairman Maintenance Cost Task Group	IATA			
	Total			**24**	**16**	

By coding key points to nodes. I let the data 'speak for itself' by grouping points that came up on a regular basis to a dedicated nodes adding nodes as this became necessary. Counting key words and nodes (triggers) is established as a useful qualitative method´s analytical technique in NVIVO (Leech & Onwuegbuzie, 2011; Onwuegbuzie et al., 2012). The nodes arising from the phase 3 and phase 4 data analysis resulted as follows in Table 24 and Table 27.

Table 24: Round One Interview Nodes (Phase 3)

Primary Node	**Secondary Node**	**Tertiary Node**	**Number of References**
Socio-Technical Landscape: Market	The levels of regulation in the market	The market, monopolies and competition	107
		Environment	27
		Airline Finance: operating costs, cost of capital, profits	42
	Hub access	Hub access, competition	18
	Future market growth	Market growth	31
		Airline restructuring	24
Socio-Technical Regime: The Non-Market	Global and local regulation	Global and local regulation	27
		Fuel and emissions agreements	29
	Infrastructure	Infrastructure pressures, requirements	24
	Industry transformation	Role of the state	55
		Public Value	17
		Co-operation across MLP and lobbying	14
Technological Niche: Technology	Speed of technology transfer	Energy transformation	72
	The risk of new investment and change	Barriers to growth and change	31
	Developments in aircraft and engine technology	New industry technologies and innovation	47
		Investments: incentives and penalties	42
		New fuels	31
Organisation	Business Models	Business Model Types	41
		Organisational characteristics	39
		Differentiation	36
Total			**754**

After this first phase 3 exercise was completed, the data was then word searched using the following terms relating to the nine points of the Osterwalder & Pigneur Business Model matrix (2004, 2009, 2010). Using the text search function in NVIVO v11 for the words and phrases ‘characteristic’, ‘business model’, ‘low-cost carrier’, ‘very low cost’, ‘value carrier’, ‘long-haul’, ‘short-haul’, ‘network carrier’ and ‘differentiate’ enabled the coding of specific quotes to a different level of query from which I draw the following findings relating to a series of potential business models for the future airline market in Europe (Table 25 and Table 26).

Table 25: Search ‘text query’ Terms used to identify Airline Business Model Types and Characteristics (Phase 3)

Search Text (using AND, OR, NOT, + logic) in NVIVO	Sources	Number of References
Low-cost carrier OR LCC	23	1,052
very low cost	22	683
business model OR model	23	612
value carrier	19	224
network carrier	19	194
long-haul OR long-haul	21	121
short-haul OR short haul	16	64
differentiate OR differentiation	12	18
characteristic OR characteristics	4	5
Total	**159**	**1,921**

Table 26: Business Model Features ‘search text queries’ used for Data Analysis of Interviews (Phase 3)

Search Text (using AND, OR, NOT, + logic) in NVIVO	Number of References
(key) partner OR partners	31
(key) activity OR activities	15
(key) resources	24
value AND proposition	82
customer AND relationship	100
sales AND channel OR channels	18
customer AND segment	115
cost AND structure	385
revenue OR stream OR streams	27
Total	**797**

Table 27: Round Two Interview Nodes (Phase 4)

Primary Node	Secondary Node	Tertiary Node	Number of References
Socio-Technical Landscape	Short journeys and cheap fares	Kerosene and carbon taxes	20
		The end of cheap fares	9
		The problems of taxes	8
		Price equalisation of rail and flying	8
		Price sensitivity of low fares models	5
		Diverse minor themes	43
	The Four Business Models	'Four Business Models'	37
		Pressure on low fares models	16
		A 'three factor' simplification	6
		Airline branding	6
		Diverse minor themes	13
	Airline survival and differentiation	Falling air travel demand	11
		Industry consolidation and pressure on Business Models	10
		'Four Business Models'	9
		Raising funds and credit	5
		Diverse minor themes	17
	Connected transport systems	Integration of Transport Systems	19
		Passenger/yield/profit management	7
		Problems of long-haul flights	6
		Rising fares	4
		Diverse minor themes	14
Socio-Technical Regime	Emissions and Carbon Lock-in	Carbon Compensation and Offsetting	17
		Increasing pressure on airlines	12
		New taxes	7
		State investments	6
		Diverse minor themes	25
	Decarbonisation and regulation	State investment	14
		Sub-optimal and complexity of taxes	8
		Structural mergers	6
		Late decarbonisation	5
		A global carbon price	4
		Minor themes	7
	Infrastructure and Hubs	Paying for industry renewal	3
		Rationalising hub feed	3
		Building airport infrastructure	3
		Diverse minor themes	2
Technological Niche	New Aircraft Fuels	Biofuels and new fuels	31
		Sources of new fuels	29
		Decarbonising the Supply Chain	4
		Diverse minor themes	2
	Electric Aviation	Electric/hybrid short-haul services	17
		Cabin Batteries	9
		Focus on fuel (and not electric aircraft)	5
		Diverse minor themes	3
	Knowledge transfer and generation	Effective aircraft lifecycle shortening	10
		The knowledge environment	6
		International standards and incremental lock- in	5
		Diverse minor themes	10

	New Financing Models	State intervention and incentives	11
		Hypothecation of taxes	8
		Minor themes	4
Other	Recommendations	State intervention and leading	25
		Kerosene+ or renewable fuel escalator	21
		A 'three factor' simplification	10
		The use of optimum aircraft size	10
		Other recommendations (various)	67
	Total		**682**

3.5.7 Limitations and Criticisms of the Interview Sample

One issue encountered was that the gatekeepers to some interviewees were often obstructive, and on a few occasions a third party stepped in to support my request for interview access. More than 50% of the targeted contacts declined to be interviewed, including any senior management from IAG, Virgin Atlantic, CFM-Safran, ICAO and ATAG where I had good contacts. Never-the-less twenty-four interviewees consented to be recorded in the first round, and sixteen for a second round but resulting in 30% of the total interview pool being from the four airlines of the Lufthansa Group. It is likely that this proportion would have been lower if I had not been working for the Lufthansa Group and thus a competitor for some of the target interviewee group. On the positive side I was allowed access to Board level members within the group and many were generous with their time. It was particularly disappointing that proposed interviews with senior officials from the key regulator ICAO were declined due to the 'speculative and sensitive nature' of the subject matter and after several months of attempting to secure internal approval.

3.6 Summary

This chapter has outlined the overarching methodology for the empirical part of this thesis. It detailed the approaches; data sources, samples and methods used during the primary quantitative analysis in phase 1, and the secondary qualitative analysis of phase 2, and the primary qualitative analyses of phases 3 and 4. The next chapter presents the results from the quantitative study.

Chapter 4 Quantitative Study - An Analysis of the recent Performance of the European Airline Industry (Phase 1)

4.1 Introduction

This chapter presents the first empirical chapter of this thesis and is based on a summary of the literature of the measurement of airline performance and the results of the quantitative study (Phase 1 in Figure 17) on the data pool of airlines created; specifically, the preparation of a multiple regression analysis and the proposal for a best fit 'multiple regression model'. The goal of this chapter is to identify which factors support (have supported) and thus predict the financial viability of airlines in Europe and to turn raw data into insights. Phase 1 is seen as important since European airlines have survived five major crises since 2000: 9.11.2001, SARSCoV (2002-2003), the Iraq War (2003-2004), the financial crisis (2007-2008) with oil price peak and crash (2009) and the Eyjafjallajökull eruption (2010). In 2020 the most serious crisis ever to affect civil aviation joined this list when another Coronavirus (SARS CoV2) brought the global industry to a standstill.

Specifically, using a multiple regression model the aim is to test if some parameters might be used to direct industry change and airline investment policy. The value of this chapter is that a unique quantitative contribution is made in that so far there has been no comprehensive analysis of the variety of factors shaping airline's performance including financial and operational measures, service levels, business models and ownership of airlines during this period of industry volatility in Europe.

4.2 Measuring and Managing Airlines

The measurement of business performance within the airline industry has followed two main streams: quantitative financial performance that is published by publicly listed airlines; and non-financial performance indicators such as production data, service quality and efficiency, safety and human resource metrics that is generally not published, remaining for internal use. Financial and operational statistics are available in the annual report and accounts of listed companies that are normally required by financial regulation. Unlisted airlines do not publish large volume of high-quality information, retaining it for internal use.

Although non-financial metrics usually remain within airlines, external companies such as Skytrax publish their own assessments based on customer reports and an 'expert' evaluation and the audit process. Skytrax is an independent UK based consultancy company which runs an airline and airport review and ranking site. It conducts research for commercial airlines, as well as taking surveys from international travellers to rate cabin staff, airports, airlines, airline lounges, in-flight entertainment, on-board catering, and other elements of air travel, holding an annual World Airline and Airport awards and a ranking for airlines and airports.

It is noted that the financial, operational, service and safety performance of airlines are reflected in the ultimate financial results of airlines as the continuing willingness of customers to pay for services. Chen (2008) shows that the provision of high-quality service is a core competitive advantage for in reaching sustainable profitability.

Standard measures for assessing the performance of airlines within the industry are reported to the IATA Airline Cost Management Group (ACMG) for benchmarking studies and for the monitoring of industry trends. Benchmarking studies by ICAO (2016) use similar measures. Benchmarking studies are used by airlines to assess their own performance in line with best practice in a geographical segment such as Europe or worldwide. In addition to the standard statutory reports and accounts of airlines in local currency, the following measures (Table 28) are normally produced by these organisations for industry use. For reporting to IATA and ICAO all costs and unit costs are normally expressed in USD (IATA, 2015; ICAO, 2016). Standardisation of currency and performance measures is important for the production of industry statistics which are used to understand air transport economics over time, comparisons with other users of fossil fuels and for negotiations with the regulator.

Table 28: Common Industry Measures used by IATA and ICAO for assessing Airline Performance

Measure	Definition	Purpose of Measure
Revenue per ASK	All Revenues/ Available seat Kilometers	Unit Revenues per unit of seat capacity
Revenue per RPK (RRPK or passenger yield)	Passenger Revenues/ Revenue Passenger Kilometers	Passenger Yield per seat kilometer
Revenue per Available Tonne Kilometer (RATK)	Revenue / Total available capacity in tonnes x distance flown	Unit measure of passenger and cargo capacity
Revenue per Revenue Tonne Kilometer (RRTK)	Revenue / Total filled capacity in tonnes x distance flown	Unit measure of filled passenger and cargo capacity (total yield)
Operating Cost per ASK (CASK)	All Operating (but not financing costs)/ Available Seat Kilometers	Unit Cost of Operation
Non-Fuel Operating Cost per ASK (nonfuel CASK)	All Operating (but not financing or fuel costs)/ Available Seat Kilometers	Non-Fuel Unit Cost of Operation
Unit Cost per Aircraft Flight Hour	Direct Operating Costs/Aircraft Flight Hours	Unit Cost of Flight Operations
Unit Cost per Aircraft Block Hour	Direct Operating Costs/Aircraft Block Hours	Unit Cost of Flight Operations including Ground Operations
Cost of Labour / Employees	Cost of all employed staff	Cost or Unit Cost of all employed staff
Cost of Fuel	The cost of fuel including hedging costs	The cost and volume of energy consumed
Cost of Product & Services	The cost of all products and services consumed by the passenger	The cost of all services consumed by the passenger by class of travel
Cost of Distribution	Cost of sales channels including internet, agents and the cost of other corporate clients and commissions	The cost of selling a ticket is reduced by direct sales to passengers
Cost of Maintenance	The cost of aircraft, engine, component and vehicle maintenance	The cost of vehicle servicing often partly subcontracted to low labour countries
Seat Density adjustment	Adjustment for number of seats in an aircraft cabin	Comparability of aircraft types with different seat densities
Flight Costs	Flight Crew, Fuel, Flight Equipment, Navigation costs	The cost of all services related to aircraft operation, often operated by strong unions or monopolies
Ground Costs	Maintenance, Airport Charges, Ground Handling	The cost of Ground Services often subcontracted to low wage companies or is monopoly operated
System Costs	Cabin Crew, Passenger Services, Reservation Costs, Insurance, Ticketing, Marketing, IT, Communications and Administration	The cost of non-flight related services
Operational Statistics	ASK, RPK, ATK, RTK, CTK, AFH, ABH, SLF, overall load factor, Dispatch Reliability	Statistics used for calculating unit costs or revenues

In extant academic research, Feng & Wang (2000) have shown that the financial performance of airlines is dependent on two factors, profitability and liquidity. Doganis (2013) draws conclusions about predicting airline profitability from the interrelationships of unit costs, unit revenues and seat load factors. Financial measures normally include measures of sales, profits, liquidity, risk (shown as diversification from the core business) and gearing. Operational measures normally include airline strategy (indicated as business model), size, capacity growth and selected efficiency ratios (Doganis, 2013).

Jenatabadi & Ismail (2014) developed a 'successful' predictive and triangular 'Structural Equation Model' (SEM) for predicting airline financial performance. The model involves the linear regression of eleven factors from over 200 airlines. The three perspectives of their model are 'Internal, (macro) Economic and Airline Performance'. The authors conclude that both internal performance and economic factors are predictive of airline financial performance (Table 29).

Table 29: A Three Perspective Predictive Airline Business Model

Internal	**(macro) Economic**	**Airline Performance**
Number of departures	GDP	(Operating) Profit
Stage length	Inflation	Seat Load Factor
Advertising Expenditure	Human Development Index (United Nations)	Market share
ASKs (capacity)		RPKs (filled capacity)

Source: Jenatabadi & Ismail (2014:28)

Teker et al. (2016) developed a 'hormonic index' for predicting the airline financial performance of the world's largest twenty airlines by total assets. The 'hormonic index' consisted of financial, operating, liquidity and efficiency measures, and is presented in Table 30. The index is largely a financial model and all eleven measures are weighted equally. The highest score in an equation summing all the measures predicts the most profitable airline. However, Teker et al. (2016) maintain that the prediction of the future financial results based on the simple financial metrics of revenue and profitability alone is weak, because it displayed too much volatility from year to year, and that other operational indicators should be included to enhance the useful predictability of their model.

Table 30: A Four Perspective Predictive Airline Business Model

Financial Metrics	Operating Metrics	Liquidity Metrics	Efficiency Metrics
Return on Assets	Days Account Receivables	Quick ratio	Revenues per Employee
Return on Equity	Inventory Turnover	Debt ratio	Revenues per Aircraft
Net Profit	Days Account Payables	Interest coverage	

Source: Teker et al. (2016:607)

Researchers that have identified additional parameters of airline performance are summarised in a STOF and scorecard type format in Appendix 12.1.

4.3 Four Perspectives of Business Model Transformation

The Quantitative Analysis in this chapter includes a multiple regression of a selection of parameters that are recognised and used by all airlines and cover all four STOF perspectives core to business model transformation. There has been no industry performance study during this period of industry crises since 2000, in Europe, covering all four perspectives and differentiating ownership, alliance participation and business models. There has also been no study that examines reinvestment in the asset base, credit rating proxy, debt or the cost of energy. There is a gap in the literature which if filled by this study, offers understanding to assist the restructuring of the industry in Europe.

Using the Bouwman (2008) STOF model as a reference, the ‘Service, Technological, Organisational and Financial’ factors of business re-modelling, in the following I review the major points of research interest and the essence of the academic literature with regard to the four elements of the STOF model.

4.3.1 The Financial Perspective of Transformation (F)

Maximising the efficient use and cost of kerosene and emissions will be a critical success factor in future ongoing sustainability of airline business models (IATA, 2018), and during the transition phase. In an attempt to recover rising fuel costs and protect the operating result, airlines have traditionally added fuel surcharges to the fares, but it became clear that there is only a finite elasticity in this practise, with passengers eventually refusing to travel (Wadud, 2015). The collected data in the sample includes oil prices fluctuating between USD 50 and USD 150 per tonne of kerosene. The key parameter here might be the cost of fuel, the volume (tonnes) of fuel burned, or unit measures of fuel consumption such as the cost of fuel per unit of capacity (ASK). Other key financial perspectives include, liquidity, unit costs and debt and equity ratios. Cost measurement is most appropriately measured as the (fuel or non-fuel) cost per ASK or CASK. In a global study Barneto and Ouvrard (2015) could not identify a link between airline business model and financial performance alone.

The ownership and control of an airline may have an effect of profitability and the ability of an airline to raise sufficient funds for transformation. Firstly, airlines that are majority state owned have an implicit guarantee of state funds might they fail, or receive funds at preferential terms if they generate insufficient liquidity to maintain trading or for reinvestment. Additionally, some airlines are so closely linked to the state even if not majority owned, they might realistically count on government support. The management board members of such airlines operate between political and commercial realities. Such carriers are partly instruments of government policy in that they may have goals other than profitability – these include social connectivity, national status or maintaining direct ownership of export routes. Furthermore, majority state owned carriers may not act or lobby against government legislation that might adversely affect their commercial interests. The key parameter here might be ‘more than 50% state controlled’. As it is difficult to clearly and objectively measure this parameter another way this definition is used. Vogel (2016) notes that the (partial) privatisation of European airports improved their operating efficiency, but not investor returns due to increased gearing and changes in capital structure. Backx et al. (2002) conclude in a global airline study that privately owned carriers generally show improved performance over mixed or state-owned carriers, but that the evidence is not universal by measured parameter.

4.3.2 The Organisational or Operational Perspective of Transformation (O)

The size of an airline has an effect on its performance as there is a minimum efficient scale of operation (Doganis, 2013). Airline scale is a factor in leveraging the cost-effective volume purchase of operating third party services, of operating efficiency and in reducing unit overhead costs – since overhead costs can be spread over more units of capacity. Airline size can be best represented by the capacity offered as Available Seat Kilometer (ASKs), passenger numbers, employees, flights, destinations, or fleet size.

Yield management is a core airline skill to deliver the maximum revenue per perishable airline seat and from supplementary services. Large fleets offer greater operational flexibility in aircraft size, substitution and 'aircraft on ground' coverage that enable the maximum revenue to be generated from each seat. This parameter is best measured as Total Revenue per RPK (RRPK) or Revenue per ASK (RASK).

The efficient control of employee numbers and their related costs adds leverage to the delivery of an operating surplus once the high fixed and semi-fixed costs of flight operations are covered. Employee costs are the second largest cost block after fuel costs for airlines and are influenced by the level of in/outsourcing. This measure can be best represented by the employee numbers or the ratio of employees to aircraft or unit cost per employee.

The business model operated by an airline has an effect on operating efficiency and profitability. Taking the elements from the Table 6 in Chapter 2, I create a feature set of the main two airline business models (Table 31). In the case of allocating an airline to a business model group – offering a large number of global destinations close to major world cities currently dictates the operation of a network 'hub and spoke' type model with its associated complexity, operational inefficiencies, service tailoring and higher fares. Offering the lowest fares dictates an airline model using secondary airports, standardised fleets, offering minimal service and delivering the highest asset utilisation in a low-cost model (Gillen, 2006; Lange & Bier, 2019).

Table 31 shows that business model construction is a strategic decision and that the interrelationships between the various parts of the business model are more important than the individual elements. If designed and operated correctly, both business models have shown success. This measure is best represented by the parameter 'business model' with the definition coming from the airline groupings.

Table 31: Characteristics and Elements used in an Airline Business Model

Element of Business Model	**Low-Cost Carrier**	**Full-Service Network Carrier**
Value Proposition/Product Value Leadership	High Price/Value leadership	Medium Price/Value leadership, comfort, network reach
Revenue Streams	Payable extras, few revenue streams, single class product	Inclusive fares, greater importance of cargo, many streams, multi class product
Target Customer/Market Share	Low	Low
Distribution Channel Complexity	Simple, single channel, direct	Medium to high, many channels
Network Model	Point to Point (P2P)	Hub and spoke
Key Resources	Secondary airports	Major city airports
Customer Relationship	Customer highly involved/interactive in purchase decision	Customer less involved in purchase decision
Value configuration and degree of Business Model integration	High	Medium
Capabilities and spread	Low	Medium
Partnerships and Networks used	Few partners used in Business Model, stand alone	Many partners used in Business Model, complex arrangements, airline alliances important
Cost Structure	Low-cost due simplicity of point-to-point model. Low-cost leadership, single aircraft type with high utilisation	High(er) cost due complexity of hub model, multiple aircraft types with lower utilisation
Revenue Model	Few revenue streams, focussed	Many revenue streams, often diversified into related businesses

Source: adapted from Osterwalder (2004), Osterwalder & Pigneur (2009)

4.3.3 The Technological or Investment Perspective of Transformation (T)

Due to the lack of highly rated investment grade airlines in Europe and the likely difficulty or high expense of obtaining credit, self-generated funds for reinvestment in fleet, passenger services and organisational restructuring will be a critical success factor in undergoing any industry transition. Some investment grade airlines will be able to raise funds in capital markets, but their credit rating will still be dependent on multiples of interest coverage which is clearly linked to operating cash flow. Airlines which might be able to call upon state support, or those that can generate high levels of operating cash flow may have an advantage. Average fleet aircraft age is therefore proposed as a good proxy for Technology because the incremental improvements in aerodynamics, fuel efficiency, electronics and data are incorporated into each new generation of aircraft. In two studies, Erumban & Timmer (2012) and Boucekkine et al. (2009) support the idea of asset age as a proxy for technological status, although the studies were not in the airline industry.

4.3.4 The Service Perspective of Transformation (S)

Deepa & Jayaraman (2017) and others identified the quality of product and customer service as an important element of customer satisfaction and customer retention, and might be an important factor in generating superior performance in a competitive and over supplied market (Chang & Yeh, 2002; Chen & Hu, 2013 and Ford et al., 2015). As well as a service index, reinvestment in the capital base might be indicative of improved service as well as the size of the network and ancillary passenger or cargo services.

According to Tsafarakis et al. (2018) the service management of airlines involves the measurement of multiple criteria of service delivery. Chang & Yeh (2002), Chen & Hu (2013) and Ford et al. (2015), maintain that airline service quality is important to retain passengers, and that a service culture is key for passenger confidence and repeat business (Gronroos, 2007; Chen & Chang, 2005; Chen & Wang, 2016, and Gebauer et al., 2010). It is to be noted that competition on key routes in terms of a service/price trade-off is also important. Studies have been made that link passenger satisfaction to passenger loyalty of airline passengers in Western countries (Gursoy et al., 2005; Tieman et al., 2008). Customer satisfaction, trust and loyalty have been recognized in the literature as predictors of customer intention to repurchase (Hong & Cho, 2011; Hu & Di Paolo, 2009; Lin & Wang, 2006; Won & Mijeong, 2014; Gwinner et al., 2017).

Some researchers have developed scale measurements to evaluate service quality in an airline context (Babbar & Koufteros, 2008; Tieman et al., 2008). According to Wu & Cheng (2013), industry-specific dimensions of service quality need to be developed and there is a general consensus among researchers that service quality measures are multidimensional and industry specific (Baker, 2013). The major studies linking service quality to customer satisfaction, customer retention and loyalty are summarised in Table 32.

Table 32: Studies Linking Service Quality to Customer Retention and Satisfaction

Outcome Variable	Key success criteria	Authors
Passenger satisfaction, loyalty and intention for repeat purchase	Overall passenger satisfaction	Hong & Cho, 2011 Hu et al., 2009 Lin & Wang, 2006
	Value for money, airline image	Park et al., 2010
	Personal contact with staff	Chen & Chang, 2005
	Courtesy, safety, comfort, reliability	Liou & Tzeng, 2007
	Expectation/reality gap in price and service	Liou & Tzeng, 2007 Wen-Tai & Chen, 2011
	Display of empathy and personal contact	Suki, 2014
	Personal contact, education level of other passengers	Pakdil & Aydin, 2007
	Service level, noting that LCCs service can meet/exceed that of legacy carriers	Baker, 2013
	Service quality and service chain efficiency, loyalty	Choi & Choi, 2014 Chen & Chang, 2005 Chen & Wang, 2016
	Tailored passenger service	Shahin & Zairi, 2009

The measurement of 'Service Delivery' by airlines has been accomplished using four main approaches: i. quantitative (using ordinal multiple regression techniques), ii. qualitative measures, iii. consumer behaviour motivation theory, and iv. measuring the effectiveness of loyalty schemes (Tsafarakis et al., 2018) in Figure 19.

high **Performance** Low ↑	Transfer resources elsewhere in company	Leverage competitive advantage
	The Status Quo	Take remedial action
	low **Importance** →	

Figure 19: Matrix to Analyse Airline Service Performance

Source: Tsafarakis et al. (2018:5)

A commonly used structure for airline service management is to measure customer feedback at a series of service delivery or 'touch' points. In the case of comparing service quality between airlines, the most widely accepted measure within the industry is the Skytrax five-point ordinal scale with '5' being the highest level of service and '1' the lowest. Although a measure of pooled factors, the index is a well-accepted summary of service quality and is prominently featured in the industry press each year. I note here that the Skytrax index excludes a measure of safety although it might do indirectly through satisfaction and loyalty. Reviewing recent scores, the index shows that LCCs can reach the service levels of legacy network carriers that are traditionally differentiated by their higher level of service.

4.4 Statistical Approach

The quantitative analysis was made using multiple factor regression analysis. The purpose of this modelling approach is to identify the most statistically relevant parameters to airline financial performance, their direction and size. To do this the approach examines combinations of 50 independent variables to establish the most important. This differs to a multiple regression approach of the hypotheses testing of individual parameters and evaluating their statistical significance. The analysis included critical variables that have defined strong financial performance in the past (e.g. unit costs, scale, operational and financial ratios, service indices) and aims to understand the leverage to be applied to achieve success (Antoniou, 1992; Mason & Morrison, 2008; Tsikriktsis, 2007; Kawasaki & Lin, 2013; Vasigh, 2013; Windle, 1991).

4.4.1 Methodology of the Multiple Regression Model

The details of the variables employed in the multiple regression analysis are covered in Chapter 3 and the modelling approach is in this section. The procedure followed to build a multiple regression model followed the methodology demonstrated by Dr Julian Parris (for JMP Pro and the University of California, San Diego) and is termed 'backward selection' or 'backward elimination'. Moreover, backward elimination allows the selection of the most relevant covariants when some are very likely to be correlated with one another (Derksen & Keselman, 1992; Mansfield et al., 1997; Sauerbrei, 1993 & 1999; Vu et al., 2015; Sanchez-Pinto et al., 2018).

The multivariate regression model was constructed by placing all parameters in JMP Pro for SAS. In a first stage, parameters that had low correlation with the dependent variable were removed and variables annotated by the model as 'with bias' were also removed. In an iterative process the largest independent variable t value in turn was removed which had only a marginal effect on the model R squared value, that is those with probabilities of t >0.05 (5%), but that still ensured more than 60% of the sample variation was explained by the model. After testing the model residuals for a normal distribution. The final model F ratio was the checked to ensure that the model was better than simply using sample means and that multicollinearity was low.

4.4.2 The Dependent Variable

As discussed above airline financial performance can be measured in a variety of ways - I have chosen ***operating profit*** and ***operating cash flow*** because they are measures used by all organisations and calculated the same way (Feng & Wang, 2000; Jenatabadi & Ismail, 2014; Teker et al. 2016). They are also vital to financial sustainability, specifically in terms of paying creditors and reinvestment in the asset base. Return on assets as a measure is problematic as it depends on the valuation of the asset base and also the methodology of aircraft financing (Teker et al., 2016). The performance of share prices is also not applicable to those airlines that are partly state owned because they have implicit state guarantees. This approach is termed 'accounting based' versus 'market-based' measures of performance.

Operating profit (as EBIT) eliminates the individual company decision of financing, interest payable and receivable and the home country policy of taxation. ***Operating cash flow (OCF)*** has the same benefits whilst additionally eliminating the company specific policy of asset depreciation which is closely related to fleet age. Using operating profit or operating cash flow as the dependent variable is the key to funding sustainable industry transformation and enables airlines in normal trading conditions to function without seeking external financial support. These two key measures were selected from the published reports and accounts of the largest twenty quoted airlines in Europe.

4.4.3 The Independent Variables were chosen to capture various drivers of airline financial performance identified in the literature review and that were uniformly available from the airlines in the data pool. Consistent with the STOF model these explanatory variables fall under the categories of:

- service (customer index, reinvestment, alliance),
- technology (reinvestment),
- operational parameters (capacity, passengers and business model) and
- finance (both profit and loss and balance sheet).

The independent variables are explained in Table 34.

Operational costs (excluding fuel) are often grouped differently by airlines making analysis inconsistent and problematic. The following common measures were selected because of their availability in the published accounts of European airlines and their common clarity of definition. The name of the carrier and the currency of reporting are noted in order to allocate a carrier to a business model group and to convert all financial reporting information in currencies to Euro at prevailing World Bank rates for each year of trading (api.worldbank.org › indicator › PA.NUS.FCRF).

Network carrier models in Europe are mature and thus have offered more stable individual capacity in the period under study. A total capacity cut-off of approximately 50 billion ASK's per annum was identified with an airline flying less than this considered small, and an airline flying more than this considered large. The size parameter is not considered applicable to the low-cost carrier group as most of these airlines have grown so rapidly, they have not offered a stable baseline. This segmentation resulted in three different groups of: i. four large network carrier airlines or mixed model airlines, ii. ten non-aligned smaller network carriers and, iii. six low-cost carriers. These are shown in Table 33.

Table 33: Grouping of Twenty European Airlines for Statistical Analysis

Large Network Carrier or mixed business model Group (>50 Bio ASK p.a. flown annually)	**Small Network Carrier Group (<50 Bio ASK flown annually)**	**Low-Cost Carrier Group**
Air France / KLM Group	Aegean Airlines	Easyjet
International Airlines Group (IAG formed January 2011) (incl. British Airways, Iberia, Aer Lingus, Vueling)	Aer Lingus (joined IAG in September 2015)	Flybe (ceased operations in March 2020)
Lufthansa Group (incl. Swiss International Air Lines, Austrian Airlines, German/Eurowings, Brussels Air Lines	Aeroflot Airlines	Ryanair
British Airways (pre IAG)	Czech Airlines	Norwegian Air Shuttle
	Finnair	Croatia Airlines from 2015 trading as Smartwings
	Iberia (pre IAG)	Air Berlin (ceased operations in October 2017)
	Icelandair	
	SAS Scandinavian Air Lines	
	TAP Portugal	
	Turkish Airlines	

Table 34: Independent Variables used in a Multiple Regression Analysis Model

No.	Parameter (Type)	Data Type	STOF Perspective	Data Availability (High, Med)	Description, Definition
1	Sales	continuous	Finance	H	The total revenue generated by the company is used for calculating the yield (RRPK) and sales per employee.
2	Sales per employee	continuous	Finance	H	Indicates the efficiency of an organisation in generating revenues from the staff.
3	Sales per ASK (RASK)	continuous	Finance	H	Indicates the efficiency of an organisation in generating revenues from the unit capacity offered. This ratio is analogous to yield which uses the filled capacity rather than total capacity.
4	Sales per aircraft	continuous	Finance	H	Similar to 3 above but shows the revenue generated from an aircraft not a unit of capacity.
5	Operating Expenditure	continuous	Finance	H	Reflects the cost base used for calculating non fuel operating costs and the unit cost of operation CASK.
6	Cost per ASK (CASK)	continuous	Finance	H	The standard measure of airline unit costs. The cost of operations divided by the standard measure of capacity.
7	Non-Fuel Costs	continuous	Finance	H	Includes all operating costs except fuel. I use this measure due to the lack of comparability of many operating costs between carriers
8	Revenue per Revenue Passenger Kilometer (RRPK) or yield	continuous	Finance	H	Reflects the revenue generated per filled passenger seat and thus combines the revenues and seat load factor. The measure I have used also includes non-passenger (cargo, ancillary revenues) revenues but this is generally in line with the fleet size and is treated the same way for all airlines.
9	Free cash flow	continuous	Finance	H	Is a measure of freshly generated liquidity and is the difference between operating and investing cash-flow. This is in effect the surplus cash generated each year that can be used to ride out difficult trading periods, pay down debt, pay for non-capital investments or survive the pressure arising from delays in in receiving cash from sales.
10	Cost of Fuel per ASK	continuous	Finance/ Technology	H	This ratio can be used as a measure of fuel efficiency where the cost is divided by the capacity offered (ASK). It includes the variability in the fuel price and hedging policy. Longer sectors maximise time in the air and minimise unit fuel costs.
11	Non-Fuel Cost per ASK	continuous	Finance	H	This ratio can be used as a measure of operational efficiency excluding fuel – these costs are generally more controllable.
12	Investing Cash Flow	continuous	Finance/ Technology/ Service	H	Reflects the investment cash outflow in the year. Since investments cannot be made before earnings are achieved. I have used a one-year lag (t-1). For example: the investing cash flow from 2015 is assumed to be made from 2014 earnings.
13	Cost of Fuel	continuous	Finance	H	The cost of fuel is essential for testing the importance of energy costs to the business model. It will include the effects of hedging fuel purchases, insurance and loading and the effect of location and currency of purchase. Airline fuel is priced in USD.
14	Cost of Fuel per RPK	continuous	Finance /Technology	H	The ratio of cost of fuel to the filled capacity is used for assessing unit energy efficiency, also a proxy for aircraft age since new aircraft are more fuel efficient.
15	Debt/Equity ratio	continuous	Finance	H	Indicates how the airline is financed, dependent of ownership, tax legislation and risk appetite
16	Operating Costs without Fuel and Labour	continuous	Finance	H	Operating costs excluding labour and fuel, mainly ATC, airport charges and aircraft costs
17	Liquidity/Revenue ratio	continuous	Finance	H	A measure of liquidity, airlines sometimes target 20% of sales as cash to ride out seasonality and weak trading
18	Net Debt	continuous	Finance	H	Indicates the carrying debt net of cash balances and an indicator of liquidity and prior claim on profits, also the basis of credit ratings
19	EBITDA/Net Debt	continuous	Finance	H	Indicates the carrying debt net of cash balances and an indicator of liquidity and prior claim on profits, also the basis of third-party credit ratings
20	Labour Costs	continuous	Finance	H	Total labour cost, traditionally the second highest expense after fuel
21	Unit Labour Costs per employee	continuous	Finance/ Organisation	H	Labour cost per employee
22	Fleet size year end	continuous	Organisation	H	The fleet size is a measure of operational scale. Larger fleets are operationally easier to plan than small fleets as they offer advantages in planning essential down time. Routine maintenance or operational fallout can be covered more easily if there are aircraft of varying size that can be substituted.
23	Passenger Numbers	continuous	Organisation	H	Reflects airline scale and the success in attracting customers. This measure is also used to calculate efficiency ratio of staff/passengers.
24	Available Seat Kilometres (ASK)	continuous	Organisation	H	Reflects the offered capacity if an airline. The metric is calculated by multiplying the number of seats on offer by the distance. Thus, ASK reflects both the maximum potential passenger numbers and the size of the network.
25	Revenue Passenger Kilometer (RPK)	continuous	Organisation	H	Reflects the filled capacity of an airline and is essential for calculating the key measure of yield (RRPK). The metric is calculated by multiplying the number of occupied seats by the distance travelled.
26	Seat Load Factor (SLF)	continuous	Organisation	H	The ratio RPK/ASK is termed seat load factor and indicates if an airline can fill its seats over the operated network. Of course, seats can be filled by adjusting the price, but SLF is still a key measure of whether a network is the correct size for the (home) market.

Table 34 continued: Independent Variables used in a Multiple Regression Analysis Model

No.	Parameter (Type)	Data Type	STOF Perspective	Data Availability (High, Med)	Description, Definition
27	Journey length	continuous	Organisation	M	The average length of a passenger trip which could be multi segment. Longer trips usually have higher yields
28	Average Number of Employees	continuous	Organisation	H	Reflects the size of an airline and thus a proxy for the size of the largely fixed cost of staff employed. It is also used for calculating organisational efficiency ratios.
29	Number of Employees as a ratio to the size of the Aircraft Fleet	continuous	Organisation	H	A ratio often used by airlines is the ratio of the number of employees to aircraft fleet size, which shows the relative personnel efficiency of an airline. Normally Flight and Cabin Crew account for approximately 50% of the staff with the rest being administrative and operational ground staff. Some airlines separate flight and cabin crew from employee costs placing them in costs of operation, or use temporary staff to cover short term peaks that may or may not be included in personnel costs.
30	Passengers as a ratio to the number of employees	continuous	Organisation	H	Shows the ratio of customers to employees and both in terms of cost efficiency and customer service.
31	Log10 Employees	continuous	Organisation	H	The log10 of employees has the effect of a lower volatility in calculations than employee numbers.
32	Tonnes of Fuel consumed	continuous	Organisation/ Finance	H	The fuel consumption reflects both fuel efficiency and airline scale. Most fuel is burned during take-off and landing and excess fuel can be dumped before landing for safety reasons. Long-haul or long sector flying is generally more efficient than short haul flying as there are fewer take-offs and landings per day and aircraft are flying at higher altitude. Lower altitude flying generally consumes more fuel. This parameter excludes the effect of fuel hedging since it refers to the raw material consumed.
33	Tonnes of C02 emitted	continuous	Organisation /Finance	H	Shows the efficiency of the fuel burn and is indicative of future carbon charges in any sensitivity analysis on the operating profit. A sensitivity analysis can be introduced into the model by incorporating a cost of carbon into fuel costs as the number of tonnes of CO2 emitted is known. The forecast cost of carbon is will come from the industry regulator ICAO (using IEA), or consulting companies e.g. EC, Synapse Energy Consulting, Point Carbon.
34	More than 50% owned by state	nominal	Organisation	H	Indicates state control of an airline and perhaps an implicit guarantee of state support if the airline should fail or perform poorly. The variable may indicate goals other than maximising shareholder profit or cash flow.
35	Large Network Carrier	nominal	Organisation	H	Indicates a major network carrier business model using a 'hub and spoke' business model flying more 50 Bio ASK per year. Such groups may include a low-cost carrier within the group but the majority of the capacity flown is through a hub and spoke model. Service is normally multi class and organisations and complex fleets enjoy coordinated flight operations.
36	Small Network Carrier	nominal	Organisation	H	Indicates a small network carrier flying less than 50 Bio ASK per year. Such network carriers do not have the benefits of economies of scale but still operate a hub and spoke model.
37	Low-Cost Carrier	nominal	Organisation	H	Indicates an airline that operates a 'point to point' airline business model with high aircraft utilisation involving short-haul flights normally under four hours. Service is normally of a single class and fares are price sensitive. Fleets, offered services and management structures are simple.
38	Average aircraft age	continuous	Technology	M	Aircraft age is linked to high technology fleet, improved fuel consumption, greater operational data and lower maintenance costs
39	Fixed Asset Base	continuous	Technology/ Service	H	The fixed asset base reflects the assets used in generating operating cash flow and thus the operating profit. Aircraft normally have useful operational lives of twenty to twenty-five years but cabin interiors are refreshed approximately after every five years. Aircraft also undergo constant modification to meet the latest safety and operational standards and legislation.
40	Investing Cash Flow as % Fixed Asset Base	continuous	Technology/ Service	H	The investment ratio is expressed at Investing Cash Flow (t-1) as a proportion of the Tangible Fixed Asset base. This ratio removes the scale effects of airline size.
41	Number of Flights	continuous	Organisation/ Service	M	Number of flights annually
42	Destinations	continuous	Organisation/ Service	M	Number of airports flown to indicating the size of the network and connectivity
43	Flights/destinations	continuous	Organisation /Service	M	Number of flights divided by number of destinations, an indicator network density and connectivity
44	Ancillary Revenues	continuous	Service/Finance	M	Passenger revenues not from tickets
45	Ancillary Revenues/Pax	continuous	Service/Finance	M	Passenger revenues not from tickets per passenger
46	Pax per Flight	continuous	Service/Organisation	M	Indicates the average number of passengers on each flight and average aircraft size
47	Member of Global Alliance	ordinal	Organisation/Service	H	Membership of one of the 3 global airline alliances Oneworld, STAR and Skyteam. Membership enables better connectivity, higher yields and operational cost savings.
48	Tonnes of Cargo transported	continuous	Service/Finance /Organisation	M	Indicates size of the cargo operation and potential contribution. Some carriers aggregate this with passenger revenues in traffic revenues
49	Tonnes of Cargo carried per aircraft	continuous	Service/Finance /Organisation	M	Indicates the size of the annual cargo operation and potential contribution per aircraft. Some carriers aggregate this with passenger revenues in traffic revenues
50	Skytrax score	ordinal	Service	H	Indicates an external perception of the service quality an airline offers. The score is on an ordinal scale of one to five. Five is the highest level of service and one the lowest level of service.

From the analysis of data sets it is evident that since that since 2000 several airlines have greatly improved the quality and depth of their reporting, and especially since 2009. The larger airlines in western Europe generally produce the best data. Nevertheless, gaps do exist for some parameters in some trading years. In cases where this occurs the data row has been left blank, which means that not all airlines are represented in each year and that overall, the sample is weighted towards more recent years. Some 320 sets of airline annual report and accounts were used in the data collection and 50 independent variables were analysed for their effect. I note that published data presentation is not consistent from year to year and even from the same carrier (indicating the possibility of concealment) and that some financial and non-financial data must be hand-picked using a search function from annual reports and accounts and from the STATISTA database. I have attempted to deliver the highest comparability between independent variables over the 2000-2019 window but acknowledge the possibility of variation due to data aggregation, lack of consistent presentation and change in reporting periods over time.

4.4.4 The Control Variables

The following parameters were used as control variables to eliminate the effect of adverse trading events in any single year and the home country of registration for possible local political or economic effects. Each is represented by a binary dummy variable.

***Trading year*:** may have an effect on the trading result of the company by stressing the existing business model. For example, the trading years 2001 to 2003 were subject the influence of 9.11.2001, the Gulf War and SARS depressing global airline traffic (Flouris & Walker, 2005). Similarly, the years 2008 and 2009 suffered a downturn due to the global financial crisis, oil price collapse and in high yield business traffic. In the trading year 2010 intra-European air traffic was severely affected by the eruption of the Icelandic volcano Eyjafjallajökul which closed much of the European airspace for six weeks resulting in the largest air traffic shut down since World War 2 (Sammonds et al., 2010). The year 2019 was excluded as a binary dummy variable.

Country of registration or incorporation: the country of registration shows which national company law the airline is subject to, although most European countries are additionally subject to EU aviation and competition law. This control variable might become important for the UK post Brexit, as it withdrew from EASA on 31st December 2020. There are only one or two airlines per country in the analysis.

4.5 Results of Multiple Regression Analysis - Collected Data Tables

The characteristics of the sample data, the testing of the control variables and the Pearson Correlation Coefficients are shown in Table 35 to Table 41. It is clear from the data that the country control variables correspond closely to airlines with only one or two airlines per country used in the analysis. As a result, the country was eliminated as a control variable.

Table 35: Sample Descriptive Statistics for all Airlines data pool

Analysis Column	N	Mean	Std Dev	Min	Max	Median	Variance	Std Err	CV
2000	242	0,012396694	0,11087749	0	1	0	0,012293817	0,00712747	894,4117271
2001	242	0,012396694	0,11087749	0	1	0	0,012293817	0,00712747	894,4117271
2002	242	0,024793388	0,15581721	0	1	0	0,024279003	0,01001631	628,462745
2003	242	0,033057851	0,17915821	0	1	0	0,032097665	0,01151673	541,9535893
2004	242	0,033057851	0,17915821	0	1	0	0,032097665	0,01151673	541,9535893
2005	242	0,041322314	0,19944713	0	1	0	0,039779157	0,01282095	482,6620511
2006	242	0,049586777	0,21753961	0	1	0	0,04732348	0,01398398	438,7048712
2007	242	0,053719008	0,22592964	0	1	0	0,051044203	0,01452331	420,5767171
2008	242	0,061983471	0,24162527	0	1	0	0,058382772	0,01553226	389,8221036
2009	242	0,066115703	0,24899923	0	1	0	0,062000617	0,01600628	376,6113376
2010	242	0,066115703	0,24899923	0	1	0	0,062000617	0,01600628	376,6113376
2011	242	0,061983471	0,24162527	0	1	0	0,058382772	0,01553226	389,8221036
2012	242	0,061983471	0,24162527	0	1	0	0,058382772	0,01553226	389,8221036
2013	242	0,061983471	0,24162527	0	1	0	0,058382772	0,01553226	389,8221036
2014	242	0,061983471	0,24162527	0	1	0	0,058382772	0,01553226	389,8221036
2015	242	0,061983471	0,24162527	0	1	0	0,058382772	0,01553226	389,8221036
2016	242	0,061983471	0,24162527	0	1	0	0,058382772	0,01553226	389,8221036
2017	242	0,05785124	0,23394579	0	1	0	0,054730633	0,01503861	404,3920111
2018	242	0,05785124	0,23394579	0	1	0	0,054730633	0,01503861	404,3920111
Operating cashflow	242	721,4168279	1026,18405	-798	5368	297,1482068	1053053,708	65,9656093	142,2456494
Sales	242	7301,629495	8547,35364	193,071	36424	3796,676661	73057254,25	549,444702	117,060906
OPEX	242	6928,941947	8216,13669	192,039	34735	3622,847487	67504902,04	528,15327	118,5770749
Investing Cash Flow t-1	242	-452,931126	898,707243	-3805	2692	-219,204704	807674,7087	57,7710896	-198,420288
Cost of Fuel	242	1586,325681	1817,90949	26,979	7392	805,05	3304794,9	116,859648	114,5987554
Non Fuel OPEX	242	5351,84853	6528,44198	165,06	28020	2527,330085	42620554,66	419,664145	121,9848047
Fixed Asset Base	242	5792,646811	6954,9791	83,088	31374	2360,753004	48371734,34	447,08299	120,065651
Fleet Size year end	242	216,2260579	186,191076	12	763	149,5	34667,1168	11,9688157	86,10945317
Pax Mio	242	37,86970507	33,171142	1,296	145,19	29,0045	1100,32466	2,13232177	87,59281837
ASK Mio	242	91531,09174	89470,0687	1967	359567	54570	8004893197	5751,35385	97,74828096
RPK Mio	242	73930,08032	74295,4296	1371	296511	42082,5	5519810863	4775,8911	100,4941822
ave.Employees Mio	242	27633,95455	34361,1128	925	137784	10939,5	1180686074	2208,81599	124,3438132
Free Cash Flow	242	229,4503646	695,97775	-1752	4934	72,89447833	484385,0281	44,7391442	303,3238805
>50% State owned	242	0,314049587	0,46509818	0	1	0	0,216316313	0,02989764	148,0970506
Listed	242	0,67768595	0,46833112	0	1	1	0,219334042	0,03010546	69,10739762
Private	242	0,008264463	0,09072029	0	1	0	0,00823017	0,00583172	1097,71547
LCC	242	0,252066116	0,43509892	0	1	0	0,189311066	0,02796922	172,6130123
Network	242	0,747933884	0,43509892	0	1	1	0,189311066	0,02796922	58,17344614
LargeNet/Mixed	242	0,371900826	0,4843138	0	1	0	0,234559857	0,03113287	130,2265997
Small Network	242	0,376033058	0,48539239	0	1	0	0,235605775	0,0312022	129,0823726
RASK	242	0,075332989	0,02216814	0,022643697	0,15500091	0,072108475	0,000491426	0,00142502	29,42686361
CASK	242	0,071912148	0,0235113	0,020328109	0,14775949	0,072080255	0,000552781	0,00151136	32,6944715
log employees	242	4,123858702	0,54143387	2,954242509	5,13919879	4,038996979	0,293150639	0,03480469	13,12930225
SLF	242	0,786786061	0,06387749	0,543	0,9554263	0,789677772	0,004080333	0,0041062	8,118787238
Fuel CASK	242	0,016350418	0,00458911	0,004690415	0,0284123	0,016118143	2,10599E-05	0,000295	28,06721584
Non Fuel CASK	242	0,055741021	0,02234878	0,013878464	0,13568602	0,051504288	0,000499468	0,00143663	40,09394986
RRPK yield	242	0,097161183	0,03222154	0,029062244	0,23945759	0,092614715	0,001038228	0,00207128	33,16297844
Pax/Employees	242	0,014307907	0,08988445	0,00033322	0,72718778	0,001525872	0,008079214	0,00577799	628,2152228
Employees/Fleet	242	106,2421106	53,6717267	28,70068027	273,81686	98,72217195	2880,654242	3,45014926	50,5183174
Invest/Assetbase	242	-0,09817468	0,17056546	-0,74152358	0,49204581	-0,09786916	0,029092576	0,01096436	-173,736719
Sales/Employees	242	0,319521159	0,12574195	0,087265949	0,67055154	0,285301882	0,015811039	0,008083	39,35324788
Sales/aircraft	242	28,7359142	10,0603354	11,60273642	53,4266667	27,32629312	101,2103482	0,64670285	35,00962358
Skytrax	242	3,652892562	0,49412723	3	5	4	0,244161723	0,0317637	13,5270125
Total Liabs Mio	242	6517,121846	7896,87206	0,344879461	32403	2866,979504	62360588,26	507,630162	121,1711587
Equity Mio	242	1904,406584	2265,09292	-1470,194	10614	951,956	5130645,954	145,605688	118,9395659
Labour Costs Mio	242	1720,980801	2323,45713	0,10858851	9121	575,3675	5398453,02	149,357481	135,0077308
Ancill. Pax Revenue Mio	242	426,5610492	851,233644	0,029252617	6851,63996	155,7235	724598,717	54,7193711	199,5572839
Cash&Liq y/e	242	1211,951259	1438,82616	0,011113847	6676	568,3668344	2070220,723	92,4912487	118,7198042
Interest bearing Debt Mio	242	2723,537713	3222,34872	0,14973483	14254	1174,888556	10383531,3	207,140421	118,3148193
EBITDA	242	722,1821842	3872,34797	-51757	23987,3668	333,7170863	14995078,77	248,923955	536,2009823
Debt/Equity	242	4,919966426	31,5230552	-37,7563291	477,624615	2,291321862	993,7030095	2,02637874	640,7168764
Flights number	242	312417,7123	270438,35	9418,604651	1177315	231358	73136901113	17384,4356	86,56306581
Unit Labour costs/Employee	242	0,059241031	0,01990148	4,97656E-05	0,09678718	0,060859526	0,000396069	0,00127932	33,59408433
OPEX less Labour and Fuel	242	3630,867728	4252,11103	130,938	19022	1820,129013	18080448,19	273,336049	117,1100504
Pax/Flight	242	123,8908361	26,1633221	54,96247524	180,38237	126,9115499	684,5194215	1,68184204	21,11804464
Ancill. Rev per Pax	242	10,64150291	13,6290039	0,019738608	99,8781336	8,920473976	185,749748	0,87610555	128,0740516
Network Airports	242	162,2479339	100,770787	29	510	134	10154,75155	6,47779154	62,10913432
Global Alliance	242	0,661157025	0,47429737	0	1	1	0,224957992	0,03048899	71,73747668
Liquidity/Sales	242	0,18420367	0,16258043	2,35661E-05	0,95768732	0,148836452	0,026432398	0,01045107	88,26123503
Net Debt Mio	242	1511,586455	2322,91269	-1676,185	10192	721,2221188	5395923,356	149,322483	153,6738227
NetDebt/EBITDA	242	0,701473795	15,364569	-202,805556	32,319933	1,340358957	236,0699812	0,9876719	2190,326871
Journey length	242	1933,872658	745,789646	725,2	3603,35706	1951,058626	556202,1964	47,9411742	38,56456851
AC Age	242	8,44231405	3,51702233	2	20,6	7,935	12,36944608	0,22608276	41,65945865
Flights/Destinations	242	1766,890344	1054,93212	269,10299	5005,3913	1532,554597	1112881,773	67,8136049	59,70557942

Table 36: Sample Descriptive Statistics for Network Airlines data pool

Analysis Column	N	Mean	Std Dev	Min	Max	Median	Variance	Std Err	CV
2000	187	0,021390374	0,14507022	0	1	0	0,021045368	0,010608585	678,2032715
2001	187	0,021390374	0,14507022	0	1	0	0,021045368	0,010608585	678,2032715
2002	187	0,032085562	0,17670044	0	1	0	0,031223046	0,012921616	550,7163793
2003	187	0,037433155	0,19033033	0	1	0	0,036225634	0,013918332	508,4538776
2004	187	0,037433155	0,19033033	0	1	0	0,036225634	0,013918332	508,4538776
2005	187	0,042780749	0,20290569	0	1	0	0,041170721	0,014837934	474,2920588
2006	187	0,048128342	0,21461199	0	1	0	0,046058306	0,015693983	445,9160226
2007	187	0,048128342	0,21461199	0	1	0	0,046058306	0,015693983	445,9160226
2008	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
2009	187	0,080213904	0,27235326	0	1	0	0,074176298	0,019916443	339,5337305
2010	187	0,064171123	0,2457154	0	1	0	0,060376057	0,017968489	382,9064945
2011	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
2012	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
2013	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
2014	187	0,064171123	0,2457154	0	1	0	0,060376057	0,017968489	382,9064945
2015	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
2016	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
2017	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
2018	187	0,058823529	0,23592578	0	1	0	0,055660974	0,017252602	401,0738274
Operating Cashflow	187	794,3834334	1111,84299	-798	5368	274,5	1236194,844	81,30601217	139,9630138
Sales Mio	187	8399,888159	9398,63027	471,6032176	36424	4069,50626	88334250,92	687,295914	111,8899453
OPEX Mio	187	8046,652955	9012,70956	462,8959924	34735	3997,942328	81228933,61	659,0745968	112,0056949
Investing Cash Flow t-1	187	-467,12821	965,958192	-3805	2692	-192,004645	933075,2284	70,63785886	-206,786525
Cost of Fuel Mio	187	1762,0889	2011,84654	72,42	7392	779,1076867	4047526,511	147,1207898	114,1739525
Non Fuel OPEX Mio	187	6296,51169	7136,36118	344,6924938	28020	3137,552374	50927650,89	521,8624139	113,3383297
Fixed Asset Base Mio	187	6571,336849	7645,19319	62,19761637	31374	2315,573	58448978,94	559,0718958	116,3415203
Fleet Size year end	187	227,3406738	203,497976	26	763	145	41411,42623	14,88124582	89,51234841
Pax Mio	187	34,5837734	33,095685	1,296	145,19	25,31	1095,324366	2,42019618	95,69714855
ASK Mio	187	97818,6886	98627,1939	3776,921053	359567	46343	9727323373	7212,334716	100,8265346
RPK Mio	187	77672,55542	81687,9655	2530,537105	296511	34714	6672923701	5973,615652	105,1696639
Ave. Employees	187	33686,8877	36930,7846	1216	137784	17706	1363882854	2700,646441	109,6295537
Tonnes Fuel Mio	187	3,09558786	3,28615644	0,102492505	11,91	1,30067359	10,79882414	0,240307558	106,1561353
CO2 Tonnes Fuel Mio	187	9,752263228	10,3580605	0,322851392	37,5165	4,097121808	107,2894182	0,757456404	106,2118639
Free Cash Flow	187	279,1258159	736,732612	-1752	4934	114,781	542774,9411	53,87522429	263,9428421
>50% State owned	187	0,411764706	0,49347418	0	1	0	0,243516762	0,036086406	119,8437283
Listed	187	0,582887701	0,49440548	0	1	1	0,244436778	0,036154509	84,82002254
Private	187	0,005347594	0,07312724	0	1	0	0,005347594	0,005347594	1367,479433
Network	187	1	0	1	1	1	0	0	0
LargeNet/Mixed	187	0,481283423	0,50099091	0	1	0	0,250991892	0,036636084	104,0947781
Small Network	187	0,518716578	0,50099091	0	1	1	0,250991892	0,036636084	96,58278377
RASK	187	0,082915594	0,02374969	0,022643697	0,17429085	0,078907737	0,000564048	0,001736749	28,64320832
CASK	187	0,080036705	0,02436285	0,020328109	0,17228369	0,076442632	0,000593548	0,001781588	30,4395921
Log employees	187	4,233952878	0,54741625	3,084933575	5,13919879	4,24812046	0,29966455	0,040031041	12,92920032
SLF	187	0,745653575	0,1246667	0,111981692	0,92085537	0,771653543	0,015541786	0,009116532	16,71911793
Fuel CASK	187	0,017314884	0,00556813	0,004690415	0,04593552	0,017187701	3,10041E-05	0,000407182	32,158046
Non Fuel CASK	187	0,062953844	0,02264103	0,013878464	0,13788033	0,059161224	0,000512616	0,001655676	35,96449782
RRPK Yield	187	0,108732133	0,0337605	0,029062244	0,23945759	0,100468814	0,001139771	0,002468812	31,04923955
Pax/Employees	187	0,00147313	0,00101693	0,00033322	0,00512722	0,001072036	1,03E-06	7,43654E-05	69,03206425
Employees/Fleet	187	124,1344599	47,5324653	32,86486487	273,81686	118,3333333	2259,335259	3,475918113	38,29111219
Invest/Assetbase	187	-0,08706189	0,14846097	-0,62204604	0,49204581	-0,0913459	0,02204066	0,010856541	-170,52348
Sales/Employees	187	0,272293258	0,09324978	0,087265949	0,48506904	0,254107914	0,008695521	0,006819099	34,2460843
Sales/Aircraft	187	31,23375437	9,92031232	11,60273642	53,4266667	31,138	98,4125965	0,725445084	31,76151096
Skytrax	187	3,695187166	0,48430012	3	5	4	0,234546605	0,035415532	13,10624054
Total Liabs Mio	187	7447,174678	8687,14166	0,344879461	32403	2911,5	75466430,23	635,2667141	116,6501665
Equity Mio	187	2001,158492	2430,49592	-833,031022	10614	872,0014151	5907310,42	177,7354644	121,4544441
Labour Costs Mio	187	2096,463796	2520,7783	0,10858851	9121	896,3389252	6354323,24	184,3375658	120,2395341
Ancill. Pax Revenue	187	262,1956568	405,291928	0,029252617	1921	108,725	164261,547	29,63788108	154,576141
Cash&Liq y/e	187	1311,317381	1588,45255	0,011113847	6676	529,7131892	2523181,5	116,1591546	121,1341032
Interest bearing Debt	187	3019,926803	3539,72863	0,14973483	14254	1231,43384	12529678,74	258,8505932	117,2123981
EBITDA	187	790,3566965	4394,37488	-51757	23987,3668	338,2939846	19310530,6	321,3485172	555,9989435
Debt/Equity	187	5,501975692	35,7472097	-37,7563291	477,624615	2,461679951	1277,863004	2,614094872	649,715879
Flights Number	187	311598,2331	291066,327	17187,5	1177315	181277,1931	84719606763	21284,87786	93,41077585
Unit Labour costs/Employee	187	0,058096536	0,02116216	4,97656E-05	0,09578212	0,0608181	0,000447837	0,001547531	36,42585851
OPEX less labour and fuel	187	4200,047894	4665,00676	330,2976866	19022	2000,665993	21762288,04	341,13908	111,0703229
Pax per flight	187	115,7470059	26,8726065	19,26085104	162,824432	119,8115942	722,1369826	1,965119613	23,21667532
Ancill. Rev per Pax	187	8,837859841	9,26958633	0,019738608	46,3845224	6,961342304	85,92523074	0,677859287	104,8849665
Network airports	187	169,9946524	111,755277	30	510	130	12489,24191	8,172355222	65,74046612
Global Alliance	187	0,834224599	0,37287724	0	1	1	0,139037433	0,027267484	44,69746355
Tonnesk Cargo	187	492,4509499	605,240479	6,730005083	2120	158,14	366316,0374	44,25956723	122,9037083
Liquidity/Sales	187	0,163472463	0,15185023	2,35661E-05	0,95768732	0,139138303	0,023058492	0,011104389	92,89040273
Net Debt Mio	187	1708,609422	2523,83326	-1676,185	10192	746,8680816	6369734,341	184,5609669	147,712709
NetDebt/EBITDA	187	0,477758277	17,3671313	-202,805556	32,319933	1,431041998	301,6172506	1,270010423	3635,129343
Journey length	187	2143,310773	702,057484	725,2	3603,35706	2186,609929	492884,7105	51,3395278	32,75574837
AC Age	187	9,380855615	3,1991009	2	20,6	9	10,23424658	0,233941427	34,1024426
Tonnes per aircraft	187	1,690038138	0,98174308	0,181892029	4,72383721	1,391746667	0,963819477	0,071792164	58,08999567
Flights/Destinations	187	1630,667972	971,947604	450,744898	5005,3913	1354,132911	944682,1452	71,07584806	59,60426161

Table 37: Sample Descriptive Statistics for Low-Cost Airlines data pool

Analysis Column	N	Mean	Std Dev	Min	Max	Median	Variance	Std Err	CV
2000	66	0	0	0	0	0	0	0	.
2001	66	0	0	0	0	0	0	0	.
2002	66	0,015151515	0,12309149	0	1	0	0,015151515	0,01515152	812,4038405
2003	66	0,03030303	0,17273341	0	1	0	0,02983683	0,02126201	570,0202426
2004	66	0,03030303	0,17273341	0	1	0	0,02983683	0,02126201	570,0202426
2005	66	0,045454546	0,20989508	0	1	0	0,044055944	0,0258363	461,7691731
2006	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2007	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2008	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2009	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2010	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2011	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2012	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2013	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2014	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2015	66	0,075757576	0,26663753	0	1	0	0,071095571	0,03282081	351,9615364
2016	66	0,075757576	0,26663753	0	1	0	0,071095571	0,03282081	351,9615364
2017	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
2018	66	0,060606061	0,24043473	0	1	0	0,057808858	0,02959547	396,7172991
Operating Cashflow Mio	66	400,4091739	572,216487	-472,05	2233,2	251,0871224	327431,7081	70,4349806	142,9079363
Sales Mio	66	3075,383837	2027,55731	51,43643152	7697,4	2989,314577	4110988,646	249,575052	65,92859356
OPEX Mio	66	2708,791555	1724,56638	61,25652285	6680,6	2605,212427	2974129,185	212,279447	63,66552543
Investing Cash Flow t-1	66	-343,276453	584,636566	-2888,2	868,01054	-273,807806	341799,9139	71,9637865	-170,310711
Cost of Fuel Mio	66	839,3829104	627,55384	4,107653196	2427,3	786,578909	393823,8219	77,2465378	74,76371416
Non Fuel OPEX Mio	66	1869,408644	1185,78523	57,14886965	4253,3	1846,001469	1406086,614	145,960072	63,43103392
Fixed Asset Base Mio	66	2659,708513	2374,76889	13,72940124	9446,7	1857,020182	5639527,286	292,313844	89,28681018
Fleet Size year end	66	153,6212121	107,939266	7	468	142	11650,88508	13,2864052	70,26325611
Pax Mio	66	41,42889394	33,2234592	0,301	142,1	33,05	1103,798242	4,08952513	80,19393242
ASK Mio	66	59444,51933	43960,1054	248	185917,394	56865	1932490869	5411,11492	73,95148606
RPK Mio	66	51707,98419	40676,1486	128,96	176988,776	46985	1654549067	5006,88778	78,66512157
Ave. Employees	66	6345,393939	4046,73087	198	16840	6682,5	16376030,7	498,118136	63,77430472
Tonnes Fuel Mio	66	497,7830355	1042,75526	0,006876847	3933,08391	1,319090909	1087338,541	128,3543	209,4798717
CO2 Tonnes Fuel Mio	66	1568,064166	3284,65605	0,021662067	12389,2143	4,157272727	10788965,36	404,31321	209,4720433
Free Cash Flow	66	59,49214383	463,073039	-1198,8	1562,7	-1,3294863	214436,6394	57,0003508	778,3767893
>50% State owned	66	0,075757576	0,26663753	0	1	0	0,071095571	0,03282081	351,9615364
Listed	66	0,878787879	0,32887461	0	1	1	0,108158508	0,04048167	37,42366235
Private	66	0,045454546	0,20989508	0	1	0	0,044055944	0,0258363	461,7691731
LCC	66	1	0	1	1	1	0	0	0
RASK	66	0,06165872	0,02489519	0,028087003	0,20740497	0,060363156	0,00061977	0,00306439	40,37577606
CASK	66	0,057907534	0,03090528	0,026944197	0,24700211	0,051485256	0,000955136	0,00380418	53,37004566
log Employees	66	3,638431801	0,43192124	2,29666519	4,22634209	3,771940424	0,186555954	0,05316583	11,87108236
SLF	66	0,826966382	0,07940863	0,52	0,9554263	0,838711438	0,006305731	0,00977453	9,602401778
Fuel CASK	66	0,014340554	0,00318789	0,006165092	0,02106154	0,014210709	1,01627E-05	0,0003924	22,22990873
Non Fuel CASK	66	0,04356698	0,03015317	0,018559951	0,23043899	0,037663649	0,000909214	0,0037116	69,2110695
Fuel tonnes/RPK	66	4926,609175	10634,0821	0,022222222	33281,0382	28,63532845	113083702,3	1308,96502	215,849923
RRPK yield	66	0,078162724	0,04787564	0,03683423	0,3988557	0,072028115	0,002292077	0,00589308	61,25123877
Pax/Employees	66	0,048736157	0,16822085	0,001520202	0,72718778	0,00658071	0,028298256	0,02070656	345,1664299
Employees/Fleet	66	45,14272509	13,6490839	28,28571429	80,0833333	40,04744526	186,2974919	1,68008609	30,23540093
Invest/Assetbase	66	-0,18149516	0,31538757	-1,45505887	0,43352965	-0,15266197	0,099469317	0,03882153	-173,77189
Sales/Employee	66	0,458637799	0,10090385	0,204091966	0,67055154	0,464783979	0,010181588	0,01242041	22,00077167
Sales/Aircraft	66	19,86459365	4,65848323	7,348061646	29,62	18,8417571	21,70146601	0,57341965	23,45118815
Skytrax	66	3,53030303	0,50290531	3	4	4	0,252913753	0,06190336	14,24538652
Total Liabs Mio	66	2833,658176	2389,69537	19,85988401	8244,32065	2280,083588	5710643,946	294,151166	84,33252067
Equity Mio	66	1335,890774	1516,8758	-1470,194	5214,9	549,752	2300912,189	186,714504	113,5478909
Labour Costs Mio	66	388,6779224	259,44806	14,35468093	1076,33933	383,872632	67313,2959	31,9358486	66,75142713
Ancill. Pax Revenue	66	825,1498707	1416,02491	0,27524019	6851,63996	321,1429762	2005126,54	174,300617	171,6082082
Cash&Liq y/e	66	731,6666608	658,483268	2,782	2708,3	422,2552798	433600,2147	81,0536873	89,99771394
Interest bearing Debt	66	1438,878135	1386,77878	0	6192,87112	1030,3305	1923155,385	170,700668	96,37916834
EBITDA	66	415,1841371	556,860281	-581,146	2228,3	189,5440809	310093,3724	68,5447622	134,123689
Debt/Equity	66	3,232461129	5,73743842	-11,1335293	31,8474536	1,78789583	32,91819963	0,70622985	177,4944289
Flights number	66	269553,8912	198552,135	1041,132291	787771	228192	39422950265	24440,0783	73,65953205
Unit Labour costs	66	0,061086872	0,01483236	0,036008649	0,09678718	0,058894588	0,000219999	0,00182574	24,28076564
OPEX less labour and fuel	66	1480,730722	957,16245	42,79418872	3269,3	1367,863797	916159,9553	117,818553	64,64122313
Pax per Flight	66	142,8687072	24,8133629	71,7240846	180,38237	147,4569381	615,7029765	3,05431383	17,36794806
Ancill. Rev per Pax	66	14,76090522	20,6159687	0,713536571	99,8781336	10,10950811	425,0181651	2,53765032	139,666019
Network Airports	66	119,4090909	50,7988423	4	219	131	2580,522378	6,25290524	42,54185498
Global Alliance	66	0,151515152	0,36129784	0	1	0	0,130536131	0,04447269	238,4565756
Liquidity/Sales	66	0,22671091	0,17925667	0,012876351	0,85022157	0,188391508	0,032132953	0,02206497	79,068391
Net Debt	66	707,2114744	1175,03976	-657,009105	5878,6409	371,9964708	1380718,447	144,637397	166,151117
NetDebt/EBITDA	66	0,827811521	4,90279136	-22,2720567	14,511914	1,04026411	24,03736312	0,6034919	592,2593776
Journey Length	66	1192,430954	357,475592	428,4385382	2392,70718	1123,321747	127788,799	44,0022036	29,97872464
AC Age	66	5,624545455	2,70851545	2,3	15,63	5,2	7,336055944	0,33339521	48,15527712
Flights/Destinations	66	2051,059581	1205,08776	235,6063535	4380,5	1676,057487	1452236,506	148,336049	58,7544004

Table 38: Pearson Correlation Coefficients All Airlines Page 1 of 2

All Airlines	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	EBIT mio	OCF	Sales	OPEX	Invest. Cashflow t-1	Cost Fuel	Non Fuel OPEX	Fixed Asset Base	Fleet Size y/e	Pax Mio	ASK Mio	RPK Mio	ave.Ees Mio	Free Cash Flow	>50% State owned
2000	1,000	-0,013	-0,018	-0,021	-0,021	-0,023	-0,026	-0,027	-0,029	-0,030	-0,030	-0,029	-0,029	-0,029	-0,029	-0,029	-0,029	-0,028	-0,028	-0,015	-0,004	-0,000	0,002	-0,042	-0,054	0,017	0,029	0,006	-0,041	-0,012	-0,028	0,031	-0,047	0,085
2001	-0,013	1,000	-0,018	-0,021	-0,021	-0,023	-0,026	-0,027	-0,029	-0,030	-0,030	-0,029	-0,029	-0,029	-0,029	-0,029	-0,029	-0,028	-0,028	-0,016	-0,022	0,001	0,003	0,013	-0,044	0,016	0,033	0,028	-0,043	-0,014	-0,028	0,029	-0,080	0,085
2002	-0,018	-0,018	1,000	-0,030	-0,030	-0,033	-0,036	-0,038	-0,041	-0,042	-0,042	-0,041	-0,041	-0,041	-0,041	-0,041	-0,041	-0,040	-0,040	0,003	-0,000	-0,003	-0,003	0,041	-0,077	0,018	0,014	-0,007	-0,065	-0,046	-0,059	0,049	0,034	0,064
2003	-0,021	-0,021	-0,030	1,000	-0,034	-0,038	-0,042	-0,044	-0,048	-0,049	-0,049	-0,048	-0,048	-0,048	-0,048	-0,048	-0,048	-0,046	-0,046	-0,065	-0,043	-0,039	-0,035	0,009	-0,105	-0,015	-0,034	-0,044	-0,079	-0,069	-0,080	0,018	0,012	0,024
2004	-0,021	-0,021	-0,030	-0,034	1,000	-0,038	-0,042	-0,044	-0,048	-0,049	-0,049	-0,048	-0,048	-0,048	-0,048	-0,048	-0,048	-0,046	-0,046	-0,018	-0,036	-0,034	-0,034	0,021	-0,090	-0,017	-0,035	-0,045	-0,069	-0,058	-0,060	0,014	-0,024	0,024
2005	-0,023	-0,023	-0,033	-0,038	-0,038	1,000	-0,047	-0,050	-0,053	-0,055	-0,055	-0,053	-0,053	-0,053	-0,053	-0,053	-0,053	-0,051	-0,051	-0,034	-0,051	-0,054	-0,053	-0,013	-0,089	-0,042	-0,059	-0,067	-0,086	-0,079	-0,086	-0,020	-0,007	0,038
2006	-0,026	-0,026	-0,036	-0,042	-0,042	-0,047	1,000	-0,054	-0,059	-0,061	-0,061	-0,059	-0,059	-0,059	-0,059	-0,059	-0,059	-0,057	-0,057	0,005	0,012	-0,023	-0,024	0,010	-0,045	-0,018	-0,028	-0,024	-0,053	-0,042	-0,049	0,011	-0,006	-0,032
2007	-0,027	-0,027	-0,038	-0,044	-0,044	-0,050	-0,054	1,000	-0,061	-0,063	-0,063	-0,061	-0,061	-0,061	-0,061	-0,061	-0,061	-0,059	-0,059	0,045	0,010	-0,018	-0,022	0,074	-0,036	-0,018	-0,036	-0,028	-0,057	-0,047	-0,050	0,003	0,073	-0,043
2008	-0,029	-0,029	-0,041	-0,048	-0,048	-0,053	-0,059	-0,061	1,000	-0,068	-0,068	-0,066	-0,066	-0,066	-0,066	-0,066	-0,066	-0,064	-0,064	-0,083	-0,054	-0,033	-0,028	0,068	-0,019	-0,030	-0,049	-0,047	-0,070	-0,056	-0,059	-0,013	0,051	-0,026
2009	-0,030	-0,030	-0,042	-0,049	-0,049	-0,055	-0,061	-0,063	-0,068	1,000	-0,071	-0,068	-0,068	-0,068	-0,068	-0,068	-0,068	-0,066	-0,066	-0,210	-0,125	-0,058	-0,044	0,022	-0,047	-0,043	-0,054	-0,042	-0,081	-0,066	-0,072	-0,028	-0,075	-0,037
2010	-0,030	-0,030	-0,042	-0,049	-0,049	-0,055	-0,061	-0,063	-0,068	-0,071	1,000	-0,068	-0,068	-0,068	-0,068	-0,068	-0,068	-0,066	-0,066	-0,117	-0,097	-0,051	-0,043	0,022	-0,047	-0,042	-0,045	-0,038	-0,063	-0,057	-0,058	-0,031	-0,100	-0,037
2011	-0,029	-0,029	-0,041	-0,048	-0,048	-0,053	-0,059	-0,061	-0,066	-0,068	-0,068	1,000	-0,066	-0,066	-0,066	-0,066	-0,066	-0,064	-0,064	-0,063	-0,072	-0,015	-0,011	0,069	0,023	-0,021	-0,019	-0,007	-0,025	-0,019	-0,022	-0,012	-0,033	-0,026
2012	-0,029	-0,029	-0,041	-0,048	-0,048	-0,053	-0,059	-0,061	-0,066	-0,068	-0,068	-0,066	1,000	-0,066	-0,066	-0,066	-0,066	-0,064	-0,064	-0,059	-0,053	0,007	0,012	-0,046	0,083	-0,009	-0,013	-0,007	-0,009	-0,004	-0,004	-0,013	0,050	-0,026
2013	-0,029	-0,029	-0,041	-0,048	-0,048	-0,053	-0,059	-0,061	-0,066	-0,068	-0,068	-0,066	-0,066	1,000	-0,066	-0,066	-0,066	-0,064	-0,064	-0,019	-0,002	0,016	0,018	-0,031	0,083	-0,001	-0,017	0,004	0,013	0,010	0,011	-0,013	-0,032	-0,026
2014	-0,029	-0,029	-0,041	-0,048	-0,048	-0,053	-0,059	-0,061	-0,066	-0,068	-0,068	-0,066	-0,066	-0,066	1,000	-0,066	-0,066	-0,064	-0,064	-0,016	-0,040	0,021	0,023	-0,051	0,083	0,006	-0,009	0,010	0,030	0,026	0,028	-0,010	-0,067	-0,026
2015	-0,029	-0,029	-0,041	-0,048	-0,048	-0,053	-0,059	-0,061	-0,066	-0,068	-0,068	-0,066	-0,066	-0,066	-0,066	1,000	-0,066	-0,064	-0,064	0,092	0,023	0,022	0,016	-0,015	0,031	0,011	0,019	0,015	0,052	0,040	0,046	-0,013	-0,006	0,011
2016	-0,029	-0,029	-0,041	-0,048	-0,048	-0,053	-0,059	-0,061	-0,066	-0,068	-0,068	-0,066	-0,066	-0,066	-0,066	-0,066	1,000	-0,064	-0,064	0,083	0,033	0,030	0,025	0,043	0,009	0,030	0,017	0,035	0,077	0,061	0,067	-0,006	0,052	0,011
2017	-0,028	-0,028	-0,040	-0,046	-0,046	-0,051	-0,057	-0,059	-0,064	-0,066	-0,066	-0,064	-0,064	-0,064	-0,064	-0,064	-0,064	1,000	-0,061	0,143	0,169	0,058	0,051	-0,128	0,026	0,058	0,054	0,068	0,123	0,096	0,109	0,012	0,168	0,023
2018	-0,028	-0,028	-0,040	-0,046	-0,046	-0,051	-0,057	-0,059	-0,064	-0,066	-0,066	-0,064	-0,064	-0,064	-0,064	-0,064	-0,064	-0,061	1,000	0,203	0,148	0,068	0,052	-0,141	0,069	0,048	0,096	0,083	0,157	0,124	0,140	0,022	-0,018	0,023
EBIT mio	-0,015	-0,016	0,003	-0,065	-0,018	-0,034	0,005	0,045	-0,083	-0,210	-0,117	-0,063	-0,059	-0,019	-0,016	0,092	0,083	0,143	0,203	1,000	0,766	0,552	0,492	-0,467	0,494	0,481	0,546	0,545	0,650	0,595	0,602	0,436	0,290	-0,213
Operating cashflow	-0,004	-0,022	-0,000	-0,043	-0,036	-0,051	0,012	0,010	-0,054	-0,125	-0,097	-0,072	-0,053	-0,002	-0,040	0,023	0,033	0,169	0,148	0,766	1,000	0,855	0,827	-0,565	0,768	0,826	0,854	0,839	0,822	0,859	0,860	0,786	0,524	-0,315
Sales	-0,000	0,001	-0,003	-0,039	-0,034	-0,054	-0,023	-0,018	-0,033	-0,058	-0,051	-0,015	0,007	0,016	0,021	0,022	0,030	0,058	0,068	0,552	0,855	1,000	0,997	-0,567	0,944	0,992	0,955	0,950	0,802	0,947	0,933	0,964	0,435	-0,308
OPEX	0,002	0,003	-0,003	-0,035	-0,034	-0,053	-0,024	-0,022	-0,028	-0,044	-0,043	-0,011	0,012	0,018	0,023	0,016	0,025	0,051	0,052	0,492	0,827	0,997	1,000	-0,552	0,943	0,996	0,950	0,944	0,780	0,937	0,921	0,970	0,430	-0,303
Investing Cash Flow t-1	-0,042	0,013	0,041	0,009	0,021	-0,013	0,010	0,074	0,068	0,022	0,022	0,069	-0,046	-0,031	-0,051	-0,015	0,043	-0,128	-0,141	-0,467	-0,565	-0,567	-0,552	1,000	-0,519	-0,550	-0,525	-0,555	-0,541	-0,502	-0,495	-0,538	-0,137	0,196
Cost of Fuel	-0,054	-0,044	-0,077	-0,105	-0,090	-0,089	-0,045	-0,036	-0,019	-0,047	-0,047	0,023	0,083	0,083	0,083	0,031	0,009	0,026	0,069	0,494	0,768	0,944	0,943	-0,519	1,000	0,907	0,908	0,916	0,807	0,944	0,937	0,872	0,403	-0,323
Non Fuel OPEX	0,017	0,016	0,018	-0,015	-0,017	-0,042	-0,018	-0,018	-0,030	-0,043	-0,042	-0,021	-0,009	-0,001	0,006	0,011	0,030	0,058	0,048	0,481	0,826	0,992	0,996	-0,550	0,907	1,000	0,942	0,932	0,756	0,916	0,898	0,977	0,429	-0,290
Fixed Asset Base	0,029	0,033	0,014	-0,034	-0,035	-0,059	-0,028	-0,036	-0,049	-0,054	-0,045	-0,019	-0,013	-0,017	-0,009	0,019	0,017	0,054	0,096	0,546	0,854	0,955	0,950	-0,525	0,908	0,942	1,000	0,939	0,821	0,958	0,943	0,912	0,446	-0,355
Fleet Size year end	0,006	0,028	-0,007	-0,044	-0,045	-0,067	-0,024	-0,028	-0,047	-0,042	-0,038	-0,007	-0,007	0,004	0,010	0,015	0,035	0,068	0,083	0,545	0,839	0,950	0,944	-0,555	0,916	0,932	0,939	1,000	0,895	0,956	0,948	0,918	0,416	-0,300
Pax Mio	-0,041	-0,043	-0,065	-0,079	-0,069	-0,086	-0,053	-0,057	-0,070	-0,081	-0,063	-0,025	-0,009	0,013	0,030	0,052	0,077	0,123	0,157	0,650	0,822	0,802	0,780	-0,541	0,807	0,756	0,821	0,895	1,000	0,884	0,899	0,694	0,373	-0,396
ASK Mio	-0,012	-0,014	-0,046	-0,069	-0,058	-0,079	-0,042	-0,047	-0,056	-0,066	-0,057	-0,019	-0,004	0,010	0,026	0,040	0,061	0,096	0,124	0,595	0,859	0,947	0,937	-0,502	0,944	0,916	0,958	0,956	0,884	1,000	0,997	0,871	0,453	-0,343
RPK Mio	-0,028	-0,028	-0,059	-0,080	-0,060	-0,086	-0,049	-0,050	-0,059	-0,072	-0,058	-0,022	-0,004	0,011	0,028	0,046	0,067	0,109	0,140	0,602	0,860	0,933	0,921	-0,495	0,937	0,898	0,943	0,948	0,899	0,997	1,000	0,846	0,446	-0,353
ave.Employees Mio	0,031	0,029	0,049	0,018	0,014	-0,020	0,011	0,003	-0,013	-0,028	-0,031	-0,012	-0,013	-0,013	-0,010	-0,013	-0,006	0,012	0,022	0,436	0,786	0,964	0,970	-0,538	0,872	0,977	0,912	0,918	0,694	0,871	0,846	1,000	0,402	-0,235
Free Cash Flow	-0,047	-0,080	0,034	0,012	-0,024	-0,007	-0,006	0,073	0,051	-0,075	-0,100	-0,033	0,050	-0,032	-0,067	-0,006	0,052	0,168	-0,018	0,290	0,524	0,435	0,430	-0,137	0,403	0,429	0,446	0,416	0,373	0,453	0,446	0,402	1,000	-0,212
>50% State owned	0,085	0,085	0,064	0,024	0,024	0,038	-0,032	-0,043	-0,026	-0,037	-0,037	-0,026	-0,026	-0,026	-0,026	0,011	0,011	0,023	0,023	-0,213	-0,315	-0,308	-0,303	0,196	-0,323	-0,290	-0,355	-0,300	-0,396	-0,343	-0,353	-0,235	-0,212	1,000
Listed	-0,083	-0,083	-0,118	-0,021	-0,021	-0,079	0,035	0,047	0,031	0,041	0,041	0,031	0,031	0,031	0,031	-0,006	-0,006	-0,019	-0,019	0,217	0,320	0,318	0,313	-0,207	0,334	0,299	0,364	0,312	0,406	0,354	0,363	0,244	0,209	-0,981
Private	-0,010	-0,010	0,279	-0,017	-0,017	0,210	-0,021	-0,022	-0,024	-0,024	-0,024	-0,024	-0,024	-0,024	-0,024	-0,024	-0,024	-0,023	-0,023	-0,027	-0,038	-0,061	-0,060	0,061	-0,067	-0,057	-0,058	-0,071	-0,066	-0,066	-0,067	-0,055	0,010	-0,062
LCC	-0,065	-0,065	-0,093	-0,054	-0,054	-0,025	-0,001	0,031	0,009	-0,001	-0,001	0,009	0,009	0,009	0,009	0,048	0,048	0,019	0,019	-0,061	-0,164	-0,272	-0,284	0,054	-0,218	-0,298	-0,244	-0,159	0,119	-0,178	-0,142	-0,352	-0,138	-0,290
Network	0,065	0,065	0,093	0,054	0,054	0,025	0,001	-0,031	-0,009	0,001	0,001	-0,009	-0,009	-0,009	-0,009	-0,048	-0,048	-0,019	-0,019	0,061	0,164	0,272	0,284	-0,054	0,218	0,298	0,244	0,159	-0,119	0,178	0,142	0,352	0,138	0,290
LargeNet/Mixed	0,068	0,068	0,097	0,049	0,049	0,012	0,021	0,006	-0,021	-0,033	-0,033	-0,021	-0,021	-0,021	-0,021	-0,021	-0,021	-0,008	-0,008	0,393	0,596	0,666	0,662	-0,337	0,652	0,651	0,691	0,655	0,429	0,680	0,649	0,704	0,376	-0,152
Small Network	-0,010	-0,010	-0,014	-0,000	-0,000	0,010	-0,020	-0,034	0,013	0,034	0,034	0,013	0,013	0,013	0,013	-0,023	-0,023	-0,010	-0,010	-0,337	-0,448	-0,421	-0,406	0,288	-0,455	-0,383	-0,471	-0,510	-0,534	-0,519	-0,520	-0,386	-0,252	0,412
RASK	0,113	0,110	0,184	0,073	0,033	-0,003	-0,015	0,038	0,020	-0,049	-0,027	-0,023	0,030	0,025	-0,016	-0,021	-0,062	-0,052	-0,076	0,095	0,260	0,453	0,468	-0,297	0,300	0,506	0,332	0,326	0,076	0,206	0,175	0,538	0,076	0,130
CASK	0,099	0,113	0,157	0,074	0,027	-0,010	-0,029	0,005	0,027	0,001	-0,010	-0,009	0,031	0,016	-0,013	-0,037	-0,062	-0,028	-0,088	-0,034	0,173	0,408	0,436	-0,230	0,267	0,474	0,290	0,277	0,009	0,166	0,133	0,502	0,046	0,155
log employees	0,077	0,076	0,092	0,060	0,061	0,006	0,018	0,005	-0,014	-0,037	-0,041	-0,032	-0,032	-0,022	-0,017	-0,031	-0,022	-0,006	0,001	0,424	0,682	0,839	0,839	-0,433	0,783	0,837	0,819	0,858	0,667	0,821	0,795	0,868	0,362	-0,065
SLF	-0,278	-0,212	-0,209	-0,189	-0,091	-0,110	-0,064	-0,025	-0,088	-0,105	-0,024	-0,020	0,041	0,073	0,093	0,111	0,120	0,183	0,187	0,262	0,292	0,204	0,183	-0,138	0,288	0,149	0,223	0,283	0,522	0,335	0,389	0,062	0,133	-0,425
Fuel CASK	-0,124	-0,108	-0,203	-0,284	-0,224	-0,163	-0,038	0,004	0,211	0,009	0,014	0,152	0,316	0,266	0,203	0,007	-0,159	-0,156	-0,066	0,018	0,119	0,311	0,324	-0,188	0,451	0,281	0,215	0,222	0,120	0,220	0,214	0,276	0,063	-0,055
Non Fuel CASK	0,129	0,141	0,206	0,134	0,073	0,021	-0,024	0,002	-0,017	-0,003	-0,016	-0,043	-0,035	-0,040	-0,057	-0,042	-0,027	0,007	-0,073	-0,042	0,155	0,363	0,389	-0,203	0,185	0,440	0,257	0,243	-0,017	0,126	0,092	0,467	0,033	0,187
RRPK yield	0,196	0,176	0,227	0,116	0,052	0,021	-0,003	0,033	0,036	-0,025	-0,025	-0,022	0,008	-0,004	-0,046	-0,050	-0,082	-0,084	-0,101	0,021	0,152	0,335	0,352	-0,233	0,176	0,394	0,229	0,219	-0,046	0,090	0,051	0,444	0,014	0,227
Pax/Employees	-0,017	-0,017	-0,024	-0,027	-0,026	-0,028	-0,029	-0,031	-0,033	-0,035	-0,035	-0,033	-0,033	-0,032	-0,032	-0,032	0,092	0,110	0,112	-0,064	-0,093	-0,117	-0,116	0,064	-0,117	-0,113	-0,113	-0,147	-0,135	-0,135	-0,130	-0,113	-0,046	0,181
Employees/Fleet	0,104	0,057	0,204	0,183	0,163	0,092	0,049	0,035	0,041	-0,003	-0,016	-0,046	-0,058	-0,065	-0,071	-0,076	-0,090	-0,082	-0,079	0,169	0,402	0,587	0,602	-0,248	0,470	0,626	0,526	0,468	0,168	0,452	0,412	0,710	0,255	0,138
Invest/Assetbase	-0,040	0,044	0,048	-0,032	-0,002	-0,125	0,011	-0,005	-0,012	0,026	0,031	0,047	0,002	-0,022	-0,027	-0,008	0,040	-0,032	-0,048	-0,049	0,008	0,094	0,103	0,402	0,096	0,101	0,098	0,087	0,046	0,128	0,124	0,091	0,045	-0,050
Sales/Employees	-0,134	-0,127	-0,184	-0,184	-0,168	-0,113	-0,059	-0,034	-0,036	-0,086	-0,034	0,032	0,115	0,133	0,143	0,105	0,093	0,075	0,069	0,074	-0,059	-0,190	-0,210	0,004	-0,101	-0,236	-0,162	-0,132	0,176	-0,090	-0,051	-0,355	-0,063	0,399
Sales/aircraft	-0,016	-0,042	0,031	-0,025	-0,015	-0,031	-0,025	0,016	0,027	-0,090	-0,048	-0,024	0,045	0,060	0,050	0,006	-0,017	0,008	0,020	0,354	0,572	0,753	0,758	-0,340	0,696	0,760	0,692	0,583	0,412	0,661	0,638	0,726	0,353	-0,150
Skytrax	0,003	0,003	0,058	0,083	0,083	0,062	0,045	0,056	0,007	-0,015	-0,015	-0,028	-0,028	-0,028	0,007	-0,062	-0,062	-0,041	-0,041	0,228	0,347	0,386	0,379	-0,170	0,378	0,369	0,407	0,340	0,229	0,390	0,378	0,399	0,214	-0,192
Total Liabs Mio	0,010	0,015	0,005	-0,037	-0,035	-0,060	-0,029	-0,042	-0,057	-0,042	-0,046	-0,029	-0,013	-0,009	0,015	0,031	0,030	0,056	0,090	0,527	0,851	0,971	0,969	-0,532	0,929	0,960	0,985	0,942	0,813	0,968	0,956	0,924	0,437	-0,335
Equity Mio	0,032	0,026	-0,009	-0,040	-0,017	-0,039	0,028	0,054	0,025	-0,039	-0,007	0,018	-0,025	-0,031	-0,085	-0,037	-0,012	0,046	0,050	0,561	0,775	0,796	0,783	-0,476	0,734	0,781	0,844	0,837	0,787	0,785	0,770	0,774	0,484	-0,402
Labour Costs Mio	0,014	0,013	0,019	-0,011	-0,009	-0,031	-0,006	-0,007	-0,021	-0,037	-0,033	-0,016	-0,001	0,002	0,001	0,009	0,008	0,031	0,034	0,418	0,780	0,976	0,984	-0,505	0,901	0,987	0,928	0,912	0,717	0,900	0,884	0,969	0,397	-0,275
Ancill. Pax Revenue Mio	0,017	0,015	-0,026	-0,046	-0,046	-0,076	-0,058	-0,059	-0,055	-0,064	-0,061	-0,026	0,073	0,078	0,097	0,111	-0,004	0,011	0,036	0,277	0,232	0,199	0,174	-0,100	0,250	0,149	0,237	0,282	0,439	0,292	0,321	0,094	0,157	-0,270
Cash&Liq y/e	-0,017	-0,022	-0,003	-0,021	-0,014	-0,032	0,002	0,029	-0,028	-0,041	-0,019	-0,018	0,001	0,000	-0,005	-0,003	0,028	0,069	0,037	0,577	0,792	0,880	0,870	-0,542	0,842	0,860	0,857	0,864	0,769	0,869	0,860	0,819	0,487	-0,417
Interest bearing Debt Mio	0,064	0,076	0,045	-0,028	-0,037	-0,065	-0,040	-0,062	-0,075	-0,057	-0,036	-0,017	-0,010	-0,012	-0,004	0,023	0,031	0,047	0,050	0,408	0,717	0,819	0,822	-0,351	0,802	0,810	0,912	0,837	0,726	0,886	0,875	0,765	0,404	-0,331
EBITDA	-0,002	-0,002	-	-0,007	-0,008	-0,009	0,003	0,010	-0,233	-0,027	-0,020	-0,015	-0,006	0,101	-0,002	0,021	0,023	0,051	0,058	0,277	0,324	0,291	0,280	-0,180	0,271	0,276	0,287	0,299	0,289	0,310	0,311	0,261	0,186	-0,140
Debt/Equity	0,006	0,004	-0,007	-0,013	-0,015	-0,015	-0,020	-0,022	-0,029	-0,026	-0,028	-0,023	-0,015	-0,025	-0,056	0,016	-0,014	-0,009	0,003	0,068	0,114	0,055	0,043	0,003	0,074	0,034	0,092	0,080	0,075	0,113	0,115	0,055	-0,001	0,066
Flights number	0,017	0,010	-0,011	-0,042	-0,028	-0,051	-0,041	-0,044	-0,058	-0,068	-0,054	-0,014	-0,007	0,012	0,016	0,030	0,044	0,073	0,095	0,600	0,831	0,889	0,875	-0,616	0,839	0,868	0,874	0,945	0,938	0,884	0,880	0,834	0,342	-0,310
Unit Labour costs/Employee	-0,090	-0,076	-0,108	-0,115	-0,107	-0,064	-0,059	-0,031	-0,032	-0,076	-0,036	-0,026	0,086	0,079	0,074	0,069	0,067	0,070	0,068	0,038	0,122	0,231	0,236	-0,086	0,227	0,236	0,224	0,169	0,229	0,216	0,229	0,123	0,024	-0,192
OPEX less Labour and Fuel	0,018	0,018	0,017	-0,017	-0,022	-0,048	-0,024	-0,024	-0,035	-0,045	-0,046	-0,023	-0,012	-0,003	0,008	0,012	0,041	0,071	0,055	0,510	0,843	0,990	0,991	-0,569	0,900	0,996	0,940	0,933	0,769	0,914	0,895	0,971	0,442	-0,294
Pax/Flight	-0,205	-0,192	-0,177	-0,119	-0,104	-0,073	0,002	0,031	-0,001	-0,016	0,001	-0,022	0,021	0,017	0,055	0,044	0,060	0,112	0,110	0,088	-0,006	-0,163	-0,180	0,124	-0,035	-0,218	-0,105	-0,110	0,149	0,012	0,055	-0,290	0,061	-0,353
Ancill. Rev per Pax	0,027	0,028	-0,014	-0,039	-0,042	-0,086	-0,074	-0,070	-0,005	-0,021	-0,017	0,010	0,124	0,107	0,103	0,083	-0,041	-0,036	-0,033	0,017	-0,054	-0,055	-0,068	0,077	-0,022	-0,080	-0,021	-0,046	0,052	-0,018	0,001	-0,120	0,028	-0,129
Network Airports	-0,003	0,007	-0,003	-0,050	-0,044	-0,037	-0,024	-0,066	-0,058	-0,058	-0,048	-0,059	-0,029	0,025	0,058	0,070	0,050	0,069	0,095	0,500	0,718	0,752	0,741	-0,459	0,718	0,732	0,762	0,808	0,698	0,793	0,778	0,746	0,315	-0,229
Global Alliance	0,001	0,001	0,002	-0,014	-0,014	-0,027	0,003	0,016	-0,033	-0,056	-0,020	-0,033	0,003	0,003	0,003	0,039	0,039	0,028	0,028	0,098	0,232	0,387	0,400	-0,108	0,342	0,410	0,349	0,307	0,088	0,323	0,293	0,427	0,165	0,372
Liquidity/Sales	-0,049	-0,049	-0,068	0,005	-0,014	0,045	0,150	0,105	0,029	0,032	0,041	0,018	0,008	-0,010	-0,010	-0,064	-0,072	-0,041	-0,062	0,053	-0,015	-0,096	-0,106	0,058	-0,086	-0,109	-0,061	-0,070	0,063	-0,066	-0,056	0,136	0,007	-0,419
Net Debt Mio	0,099	0,119	0,065	-0,026	-0,043	-0,071	-0,056	-0,104	-0,087	-0,053	-0,039	-0,013	-0,015	-0,017	-0,002	0,034	0,026	0,022	0,047	0,208	0,504	0,591	0,602	-0,151	0,591	0,592	0,734	0,625	0,530	0,691	0,681	0,555	0,259	-0,200
NetDebt/EBITDA	0,023	0,064	0,028	0,047	0,011	0,013	-0,001	-0,008	0,008	-0,222	-0,031	0,029	-0,000	0,005	0,019	-0,006	0,031	0,013	0,031	0,009	0,049	0,081	0,083	-0,055	0,077	0,083	0,098	0,115	0,085	0,095	0,090	0,088	-0,013	0,136
Journey length	0,027	0,054	0,020	-0,028	0,009	-0,037	-0,016	-0,024	-0,019	0,006	0,020	0,011	0,006	0,000	0,008	-0,019	-0,009	0,001	0,010	0,081	0,231	0,348	0,358	-0,009	0,370	0,346	0,362	0,272	0,028	0,371	0,354	0,383	0,258	0,118
AC Age	0,001	-0,027	-0,036	-0,063	-0,031	-0,077	-0,080	-0,068	-0,060	-0,070	-0,051	-0,046	-0,027	0,008	0,038	0,056	0,089	0,105	0,139	0,093	0,151	0,238	0,246	-0,107	0,212	0,251	0,190	0,122	-0,021	0,141	0,133	0,242	0,086	0,189
Flights/Destinations	0,079	0,023	-0,005	0,049	0,048	0,003	-0,001	0,005	-0,030	-0,060	-0,059	0,011	-0,005	-0,009	-0,034	-0,022	0,006	0,015	0,023	0,344	0,431	0,481	0,467	-0,393	0,455	0,462	0,468	0,577	0,697	0,481	0,489	0,416	0,113	-0,186

Table 38: Pearson Correlation Coefficients All Airlines Page 2 of 2

All Airlines	Listed	Private	LCC	Network	LargeNet/Mixed	Small Network	RASK	CASK	log Ees	SLF	Fuel CASK	NonFuel CASK	RRPK yield	Pax/Employees	Employees/Fleet	Invest/Assetbase	Sales/Employees	Sales/aircraft	Skytrax	Total Liabs Mio	Equity Mio	Labour Costs Mio	Ancill. Pax Rev. Mio	Cash&Liq y/e	Int.bear. Debt Mio	EBITDA	Debt/Equity	Flights number	Unit Labour/Eee	OPEX less Labour&Fuel	Pax/Flight	Ancill. Rev per Pax	Network Airports	Global Alliance	Liquidity/Sales	Net Debt Mio	NetDebt/EBITDA	Journey length	AC Age	Flights/Dest.
2000	-0,083	-0,010	-0,065	0,065	0,068	-0,010	0,113	0,099	0,077	-0,278	-0,124	0,129	0,196	-0,017	0,104	-0,040	-0,134	-0,016	0,003	0,010	0,032	0,014	0,017	-0,017	0,064	-0,002	0,006	0,017	-0,090	0,018	-0,205	0,027	-0,003	0,001	-0,049	0,099	0,023	0,027	0,001	0,079
2001	-0,083	-0,010	-0,065	0,065	0,068	-0,010	0,110	0,113	0,076	-0,212	-0,108	0,141	0,176	-0,017	0,057	0,044	-0,127	-0,042	0,003	0,015	0,026	0,013	0,015	-0,022	0,076	-0,002	0,004	0,010	-0,076	0,018	-0,192	0,028	0,007	0,001	-0,049	0,119	0,064	0,054	-0,027	0,023
2002	-0,118	0,279	-0,093	0,093	0,097	-0,014	0,184	0,157	0,092	-0,209	-0,203	0,206	0,227	-0,024	0,204	0,048	-0,184	0,031	0,058	0,005	-0,009	0,019	-0,026	-0,003	0,045	-	-0,007	-0,011	-0,108	0,017	-0,177	-0,014	-0,003	0,002	-0,068	0,065	0,028	0,020	-0,036	-0,005
2003	-0,021	-0,017	-0,054	0,054	0,049	-0,000	0,073	0,074	0,060	-0,189	-0,284	0,134	0,116	-0,027	0,183	-0,032	-0,184	-0,025	0,083	-0,037	-0,040	-0,011	-0,046	-0,021	-0,028	-0,007	-0,013	-0,042	-0,115	-0,017	-0,119	-0,039	-0,050	-0,014	0,005	-0,026	0,047	-0,028	-0,063	0,049
2004	-0,021	-0,017	-0,054	0,054	0,049	-0,000	0,033	0,027	0,061	-0,091	-0,224	0,073	0,052	-0,026	0,163	-0,002	-0,168	-0,015	0,083	-0,035	-0,017	-0,009	-0,046	-0,014	-0,037	-0,008	-0,015	-0,028	-0,107	-0,022	-0,104	-0,042	-0,044	-0,014	-0,014	-0,043	0,011	0,009	-0,031	0,048
2005	-0,079	0,210	-0,025	0,025	0,012	0,010	-0,003	-0,010	0,006	-0,110	-0,163	0,021	0,021	-0,028	0,092	-0,125	-0,113	-0,031	0,062	-0,060	-0,039	-0,031	-0,076	-0,032	-0,065	-0,009	-0,015	-0,051	-0,064	-0,048	-0,073	-0,086	-0,037	-0,027	0,045	-0,071	0,013	-0,037	-0,077	0,003
2006	0,035	-0,021	-0,001	0,001	0,021	-0,020	-0,015	-0,029	0,018	-0,064	-0,038	-0,024	-0,003	-0,029	0,049	0,011	-0,059	-0,025	0,045	-0,029	0,028	-0,006	-0,058	0,002	-0,040	0,003	-0,020	-0,041	-0,059	-0,024	0,002	-0,074	-0,024	0,003	0,150	-0,056	-0,001	-0,016	-0,080	-0,001
2007	0,047	-0,022	0,031	-0,031	0,006	-0,034	0,038	0,005	0,005	-0,025	0,004	0,002	0,033	-0,031	0,035	-0,005	-0,034	0,016	0,056	-0,042	0,054	-0,007	-0,059	0,029	-0,062	0,010	-0,022	-0,044	-0,031	-0,024	0,031	-0,070	-0,066	0,016	0,105	-0,104	-0,008	-0,024	-0,068	0,005
2008	0,031	-0,024	0,009	-0,009	-0,021	0,013	0,020	0,027	-0,014	-0,088	0,211	-0,017	0,036	-0,033	0,041	-0,012	-0,036	0,027	0,007	-0,057	-0,025	-0,021	-0,055	-0,028	-0,075	-0,233	-0,029	-0,058	-0,032	-0,035	-0,001	-0,005	-0,058	-0,033	0,029	-0,087	0,008	-0,019	-0,060	-0,030
2009	0,041	-0,024	-0,001	0,001	-0,033	0,034	-0,049	0,001	-0,037	-0,105	0,009	-0,003	-0,025	-0,035	-0,003	0,026	-0,086	-0,090	-0,015	-0,042	-0,039	-0,037	-0,064	-0,041	-0,057	-0,027	-0,026	-0,068	-0,076	-0,045	-0,016	-0,021	-0,058	-0,056	0,032	-0,053	-0,222	0,006	-0,070	-0,060
2010	0,041	-0,024	-0,001	0,001	-0,033	0,034	-0,027	-0,010	-0,041	-0,024	0,014	-0,016	-0,025	-0,035	-0,016	0,031	-0,034	-0,048	-0,015	-0,046	-0,007	-0,033	-0,061	-0,019	-0,036	-0,020	-0,028	-0,054	-0,036	-0,046	0,001	-0,017	-0,048	-0,020	0,041	-0,039	-0,031	0,020	-0,051	-0,059
2011	0,031	-0,024	0,009	-0,009	-0,021	0,013	-0,023	-0,009	-0,032	-0,020	0,152	-0,043	-0,022	-0,033	-0,046	0,047	0,032	-0,024	-0,028	-0,029	-0,018	-0,016	-0,026	-0,018	-0,017	-0,015	-0,023	-0,014	-0,026	-0,023	-0,022	0,010	-0,059	-0,033	0,018	-0,013	0,029	0,011	-0,046	0,011
2012	0,031	-0,024	0,009	-0,009	-0,021	0,013	0,030	0,031	-0,032	0,041	0,316	-0,035	0,008	-0,033	-0,058	0,002	0,115	0,045	-0,028	-0,013	-0,025	-0,001	0,073	0,001	-0,010	-0,006	-0,015	-0,007	0,086	-0,012	0,021	0,124	-0,029	0,003	0,008	-0,015	-0,000	0,006	-0,027	-0,005
2013	0,031	-0,024	0,009	-0,009	-0,021	0,013	0,025	0,016	-0,022	0,073	0,266	-0,040	-0,004	-0,032	-0,065	-0,022	0,133	0,060	-0,028	-0,009	-0,031	0,002	0,078	0,000	-0,012	0,101	-0,025	0,012	0,079	-0,003	0,017	0,107	0,025	0,003	-0,010	-0,017	0,005	0,000	0,008	-0,009
2014	0,031	-0,024	0,009	-0,009	-0,021	0,013	-0,016	-0,013	-0,017	0,093	0,203	-0,057	-0,046	-0,032	-0,071	-0,027	0,143	0,050	0,007	0,015	-0,085	0,001	0,097	-0,005	-0,004	-0,002	-0,056	0,016	0,074	0,008	0,055	0,103	0,058	0,003	-0,010	-0,002	0,019	0,008	0,038	-0,034
2015	-0,006	-0,024	0,048	-0,048	-0,021	-0,023	-0,021	-0,037	-0,031	0,111	0,007	-0,042	-0,050	-0,032	-0,076	-0,008	0,105	0,006	-0,062	0,031	-0,037	0,009	0,111	-0,003	0,023	0,021	0,016	0,030	0,069	0,012	0,044	0,083	0,070	0,039	-0,064	0,034	-0,006	-0,019	0,056	-0,022
2016	-0,006	-0,024	0,048	-0,048	-0,021	-0,023	-0,062	-0,062	-0,022	0,120	-0,159	-0,027	-0,082	0,092	-0,090	0,040	0,093	-0,017	-0,062	0,030	-0,012	0,008	-0,004	0,028	0,031	0,023	-0,014	0,044	0,067	0,041	0,060	-0,041	0,050	0,039	-0,072	0,026	0,031	-0,009	0,089	0,006
2017	-0,019	-0,023	0,019	-0,019	-0,008	-0,010	-0,052	-0,028	-0,006	0,183	-0,156	0,007	-0,084	0,110	-0,082	-0,032	0,075	0,008	-0,041	0,056	0,046	0,031	0,011	0,069	0,047	0,051	-0,009	0,073	0,070	0,071	0,112	-0,036	0,069	0,028	-0,041	0,022	0,013	0,001	0,105	0,015
2018	-0,019	-0,023	0,019	-0,019	-0,008	-0,010	-0,076	-0,088	0,001	0,187	-0,066	-0,073	-0,101	0,112	-0,079	-0,048	0,069	0,020	-0,041	0,090	0,050	0,034	0,036	0,037	0,050	0,058	0,003	0,095	0,068	0,055	0,110	-0,033	0,095	0,028	-0,062	0,047	0,031	0,010	0,139	0,023
EBIT mio	0,217	-0,027	-0,061	0,061	0,393	-0,337	0,095	-0,034	0,424	0,262	0,018	-0,042	0,021	-0,064	0,169	-0,049	0,074	0,354	0,228	0,527	0,561	0,418	0,277	0,577	0,408	0,277	0,068	0,600	0,038	0,510	0,088	0,017	0,500	0,098	0,053	0,208	0,009	0,081	0,093	0,344
Operating cashflow	0,320	-0,038	-0,164	0,164	0,596	-0,448	0,260	0,173	0,682	0,292	0,119	0,155	0,152	-0,093	0,402	0,008	-0,059	0,572	0,347	0,851	0,775	0,780	0,232	0,792	0,717	0,324	0,114	0,831	0,122	0,843	-0,006	-0,054	0,718	0,232	-0,015	0,504	0,049	0,231	0,151	0,431
Sales	0,318	-0,061	-0,272	0,272	0,666	-0,421	0,453	0,408	0,839	0,204	0,311	0,363	0,335	-0,117	0,587	0,094	-0,190	0,753	0,386	0,971	0,796	0,976	0,199	0,880	0,819	0,291	0,055	0,889	0,231	0,990	-0,163	-0,055	0,752	0,387	-0,096	0,591	0,081	0,348	0,238	0,481
OPEX	0,313	-0,060	-0,284	0,284	0,662	-0,406	0,468	0,436	0,839	0,183	0,324	0,389	0,352	-0,116	0,602	0,103	-0,210	0,758	0,379	0,969	0,783	0,984	0,174	0,870	0,822	0,280	0,043	0,875	0,236	0,991	-0,180	-0,068	0,741	0,400	-0,106	0,602	0,083	0,358	0,246	0,467
Investing Cash Flow t-1	-0,207	0,061	0,054	-0,054	-0,337	0,288	-0,297	-0,230	-0,433	-0,138	-0,188	-0,203	-0,233	0,064	-0,248	0,402	0,004	-0,340	-0,170	-0,532	-0,476	-0,505	-0,100	-0,542	-0,351	-0,180	0,003	-0,616	-0,086	-0,569	0,124	0,077	-0,459	-0,108	-0,058	-0,151	-0,055	-0,009	-0,107	-0,393
Cost of Fuel	0,334	-0,067	-0,218	0,218	0,652	-0,455	0,300	0,267	0,783	0,288	0,451	0,185	0,176	-0,117	0,470	0,096	-0,101	0,696	0,378	0,929	0,734	0,901	0,250	0,842	0,802	0,271	0,074	0,839	0,227	0,900	-0,035	-0,022	0,718	0,342	-0,086	0,591	0,077	0,370	0,212	0,455
Non Fuel OPEX	0,299	-0,057	-0,298	0,298	0,651	-0,383	0,506	0,474	0,837	0,149	0,281	0,440	0,394	-0,113	0,626	0,101	-0,236	0,760	0,369	0,960	0,781	0,987	0,149	0,860	0,810	0,276	0,034	0,868	0,236	0,996	-0,218	-0,080	0,732	0,410	-0,109	0,592	0,083	0,346	0,251	0,462
Fixed Asset Base	0,364	-0,058	-0,244	0,244	0,691	-0,471	0,332	0,290	0,819	0,223	0,215	0,257	0,229	-0,113	0,526	0,098	-0,162	0,692	0,407	0,985	0,844	0,928	0,237	0,857	0,912	0,287	0,092	0,874	0,224	0,940	-0,105	-0,021	0,762	0,349	-0,061	0,734	0,098	0,362	0,190	0,468
Fleet Size year end	0,312	-0,071	-0,159	0,159	0,655	-0,510	0,326	0,277	0,858	0,283	0,222	0,243	0,219	-0,147	0,468	0,087	-0,132	0,583	0,340	0,942	0,837	0,912	0,282	0,864	0,837	0,299	0,080	0,945	0,169	0,933	-0,110	-0,046	0,808	0,307	-0,070	0,625	0,115	0,272	0,122	0,577
Pax Mio	0,406	-0,066	0,119	-0,119	0,429	-0,534	0,076	0,009	0,667	0,522	0,120	-0,017	-0,046	0,135	0,168	0,046	0,176	0,412	0,229	0,813	0,787	0,717	0,439	0,769	0,726	0,289	0,075	0,938	0,222	0,769	0,149	0,052	0,698	0,088	-0,063	0,530	0,085	0,028	-0,021	0,697
ASK Mio	0,354	-0,066	-0,178	0,178	0,680	-0,519	0,206	0,166	0,821	0,335	0,220	0,126	0,090	-0,135	0,452	0,128	-0,090	0,661	0,390	0,968	0,785	0,900	0,292	0,869	0,886	0,310	0,113	0,884	0,216	0,914	0,012	-0,018	0,793	0,323	-0,066	0,691	0,095	0,371	0,141	0,481
RPK Mio	0,363	-0,067	-0,142	0,142	0,649	-0,520	0,175	0,133	0,795	0,389	0,214	0,092	0,051	-0,130	0,412	0,124	-0,051	0,638	0,378	0,956	0,770	0,884	0,321	0,860	0,875	0,311	0,115	0,880	0,229	0,895	0,055	0,001	0,778	0,293	-0,056	0,681	0,090	0,354	0,133	0,489
ave.Employees Mio	0,244	-0,055	-0,352	0,352	0,704	-0,386	0,538	0,502	0,868	0,062	0,276	0,467	0,444	-0,113	0,710	0,091	-0,355	0,726	0,399	0,924	0,774	0,969	0,094	0,819	0,765	0,261	0,055	0,834	0,123	0,971	-0,290	-0,120	0,746	0,427	-0,136	0,555	0,088	0,383	0,242	0,416
Free Cash Flow	0,209	0,010	-0,138	0,138	0,376	-0,252	0,076	0,046	0,362	0,133	0,063	0,033	0,014	-0,046	0,255	0,045	-0,063	0,353	0,214	0,437	0,484	0,397	0,157	0,487	0,404	0,186	-0,001	0,342	0,024	0,442	0,061	0,028	0,315	0,165	0,007	0,259	-0,013	0,258	0,086	0,113
>50% State owned	-0,981	-0,062	-0,290	0,290	-0,152	0,412	0,130	0,155	-0,065	-0,425	-0,055	0,187	0,227	0,181	0,138	-0,050	-0,399	-0,150	-0,192	-0,335	-0,402	-0,275	-0,270	-0,417	-0,331	-0,140	0,066	-0,310	-0,192	-0,294	-0,353	-0,129	-0,229	0,372	-0,419	-0,200	0,136	0,118	0,189	-0,186
Listed	1,000	-0,132	0,278	-0,278	0,147	-0,396	-0,120	-0,144	0,077	0,440	0,081	-0,180	-0,222	-0,178	-0,135	0,018	0,397	0,158	0,196	0,344	0,411	0,284	0,276	0,426	0,338	0,141	-0,065	0,320	0,210	0,303	0,360	0,139	0,239	-0,344	0,420	0,204	-0,139	-0,105	-0,174	0,194
Private	-0,132	1,000	0,052	-0,052	0,024	-0,071	-0,048	-0,053	-0,065	-0,094	-0,136	-0,029	-0,021	-0,011	-0,011	0,164	-0,003	-0,048	-0,028	-0,059	-0,063	-0,058	-0,041	-0,062	-0,048	-0,011	-0,002	-0,063	-0,098	-0,056	-0,049	-0,054	-0,057	-0,128	-0,021	-0,028	0,020	-0,061	-0,069	-0,044
LCC	0,278	0,052	1,000	-1,000	-0,447	-0,451	-0,447	-0,459	-0,434	0,479	-0,254	-0,436	-0,475	0,246	-0,657	-0,142	0,684	-0,486	-0,190	-0,255	-0,118	-0,326	0,318	-0,171	-0,211	-0,041	-0,030	-0,046	0,047	-0,279	0,383	0,223	-0,207	-0,610	0,168	-0,186	0,033	-0,545	-0,456	0,238
Network	-0,278	-0,052	-1,000	1,000	0,447	0,451	0,447	0,459	0,434	-0,479	0,254	0,436	0,475	-0,246	0,657	0,142	-0,684	0,486	0,190	0,255	0,118	0,326	-0,318	0,171	0,211	0,041	0,030	0,046	-0,047	0,279	-0,383	-0,223	0,207	0,610	-0,168	0,186	-0,033	0,545	0,456	-0,238
LargeNet/Mixed	0,147	0,024	-0,447	0,447	1,000	-0,597	0,161	0,120	0,752	-0,161	0,160	0,087	0,150	-0,113	0,619	0,066	-0,485	0,468	0,559	0,680	0,532	0,633	-0,006	0,567	0,657	0,264	0,102	0,513	-0,240	0,653	-0,298	-0,231	0,695	0,352	-0,211	0,561	0,088	0,546	0,103	0,064
Small Network	-0,396	-0,071	-0,451	0,451	-0,597	1,000	0,240	0,292	-0,361	-0,268	0,068	0,303	0,276	-0,108	-0,028	0,062	-0,129	-0,031	-0,388	-0,450	-0,425	-0,340	-0,279	-0,413	-0,467	-0,227	-0,075	-0,470	0,197	-0,402	-0,046	0,030	-0,508	0,195	0,060	-0,392	-0,118	-0,056	0,307	-0,277
RASK	-0,120	-0,048	-0,447	0,447	0,161	0,240	1,000	0,964	0,401	-0,321	0,377	0,940	0,970	0,096	0,589	-0,022	-0,438	0,509	-0,032	0,349	0,286	0,522	-0,110	0,349	0,180	0,062	-0,071	0,342	0,172	0,491	-0,632	-0,086	0,185	0,459	-0,218	0,034	0,078	0,065	0,501	0,238
CASK	-0,144	-0,053	-0,459	0,459	0,120	0,292	0,964	1,000	0,362	-0,367	0,370	0,979	0,946	0,115	0,585	0,037	-0,471	0,495	-0,091	0,314	0,218	0,495	-0,196	0,289	0,168	0,015	-0,086	0,275	0,181	0,458	-0,632	-0,132	0,148	0,499	-0,255	0,055	0,062	0,080	0,507	0,157
log employees	0,077	-0,065	-0,434	0,434	0,752	-0,361	0,401	0,362	1,000	0,020	0,184	0,342	0,343	-0,287	0,753	0,177	-0,432	0,700	0,416	0,824	0,689	0,829	0,147	0,732	0,742	0,233	0,077	0,783	0,085	0,833	-0,261	-0,093	0,761	0,488	-0,206	0,576	0,159	0,488	0,169	0,454
SLF	0,440	-0,094	0,479	-0,479	-0,161	-0,268	-0,321	-0,367	0,020	1,000	0,061	-0,402	-0,517	-0,101	-0,377	-0,030	0,640	0,058	0,064	0,229	0,235	0,135	0,495	0,258	0,204	0,183	0,052	0,324	0,358	0,156	0,642	0,330	0,208	-0,251	0,195	0,123	0,028	-0,043	-0,089	0,322
Fuel CASK	0,081	-0,136	-0,254	0,254	0,160	0,068	0,377	0,370	0,184	0,061	1,000	0,183	0,285	-0,010	0,174	-0,004	-0,020	0,380	0,035	0,237	0,160	0,297	0,058	0,220	0,110	-0,018	-0,041	0,181	0,133	0,270	-0,083	0,066	0,126	0,223	-0,177	0,017	-0,013	0,222	0,378	0,011
Non Fuel CASK	-0,180	-0,029	-0,436	0,436	0,087	0,303	0,940	0,979	0,342	-0,402	0,183	1,000	0,941	0,122	0,574	0,035	-0,485	0,442	-0,113	0,278	0,192	0,457	-0,222	0,257	0,150	0,019	-0,082	0,252	0,175	0,425	-0,655	-0,158	0,127	0,484	-0,231	0,049	0,068	0,032	0,460	0,168
RRPK yield	-0,222	-0,021	-0,475	0,475	0,150	0,276	0,970	0,946	0,343	-0,517	0,285	0,941	1,000	0,114	0,591	-0,022	-0,526	0,408	-0,068	0,241	0,195	0,412	-0,196	0,238	0,105	0,005	-0,074	0,235	0,068	0,380	-0,718	-0,144	0,107	0,447	-0,231	-0,002	0,074	0,028	0,440	0,174
Pax/Employees	-0,178	-0,011	0,246	-0,246	-0,113	-0,108	0,096	0,115	-0,287	-0,101	-0,010	0,122	0,114	1,000	-0,093	-0,052	-0,082	-0,170	-0,178	-0,113	-0,108	-0,105	-0,053	-0,113	-0,114	-0,024	-0,012	-0,137	-0,138	-0,116	-0,224	-0,035	-0,166	0,076	-0,117	-0,088	0,024	-0,222	0,196	-0,118
Employees/Fleet	-0,135	-0,011	-0,657	0,657	0,619	-0,028	0,589	0,585	0,753	-0,377	0,174	0,574	0,591	-0,093	1,000	0,161	-0,775	0,725	0,387	0,545	0,386	0,644	-0,149	0,450	0,426	0,077	0,013	0,358	-0,087	0,609	-0,438	-0,146	0,421	0,563	-0,281	0,312	0,074	0,581	0,346	0,039
Invest/Assetbase	0,018	0,164	-0,142	0,142	0,066	0,062	-0,022	0,037	0,177	-0,030	-0,004	0,035	-0,022	-0,052	0,161	1,000	-0,142	0,204	-0,066	0,104	0,032	0,099	0,023	0,033	0,138	-0,012	0,037	0,042	-0,068	0,102	-0,027	0,029	0,121	0,187	-0,115	0,171	-0,088	0,194	-0,020	-0,035
Sales/Employees	0,397	-0,003	0,684	-0,684	-0,485	-0,129	-0,438	-0,471	-0,432	0,640	-0,020	-0,485	-0,526	-0,082	-0,775	-0,142	1,000	-0,233	-0,156	-0,169	-0,053	-0,269	0,409	-0,057	-0,125	0,010	-0,031	-0,007	0,414	-0,215	0,566	0,350	-0,134	-0,451	0,356	-0,138	-0,047	-0,479	-0,386	0,198
Sales/aircraft	0,158	-0,048	-0,486	0,486	0,468	-0,031	0,509	0,495	0,700	0,058	0,380	0,442	0,408	-0,170	0,725	0,204	-0,233	1,000	0,401	0,721	0,505	0,760	0,070	0,656	0,592	0,156	0,015	0,523	0,412	0,751	-0,109	0,057	0,511	0,564	-0,102	0,415	0,038	0,504	0,324	0,181
Skytrax	0,196	-0,028	-0,190	0,190	0,559	-0,388	-0,032	-0,091	0,416	0,064	0,035	-0,113	-0,068	-0,178	0,387	-0,066	-0,156	0,401	1,000	0,388	0,364	0,363	0,132	0,340	0,338	0,202	0,068	0,224	0,049	0,369	0,185	0,122	0,342	0,080	0,016	0,258	-0,028	0,364	-0,216	-0,005
Total Liabs Mio	0,344	-0,059	-0,255	0,255	0,680	-0,450	0,349	0,314	0,824	0,229	0,237	0,278	0,241	-0,113	0,545	0,104	-0,169	0,721	0,388	1,000	0,780	0,952	0,216	0,879	0,903	0,283	0,093	0,868	0,243	0,954	-0,105	-0,044	0,766	0,371	-0,064	0,708	0,094	0,381	0,205	0,452
Equity Mio	0,411	-0,063	-0,118	0,118	0,532	-0,425	0,286	0,218	0,689	0,235	0,160	0,192	0,195	-0,108	0,386	0,032	-0,053	0,505	0,364	0,780	1,000	0,743	0,293	0,792	0,713	0,275	-0,040	0,812	0,153	0,792	-0,019	-0,040	0,614	0,201	0,092	0,498	0,061	0,156	0,076	0,540
Labour Costs Mio	0,284	-0,058	-0,326	0,326	0,633	-0,340	0,522	0,495	0,829	0,135	0,297	0,457	0,412	-0,105	0,644	0,099	-0,269	0,760	0,363	0,952	0,743	1,000	0,150	0,848	0,815	0,261	0,033	0,832	0,279	0,969	-0,234	-0,067	0,690	0,419	-0,099	0,606	0,086	0,367	0,278	0,451
Ancill. Pax Revenue Mio	0,276	-0,041	0,318	-0,318	-0,006	-0,279	-0,110	-0,196	0,147	0,495	0,058	-0,222	-0,196	-0,053	-0,149	0,023	0,409	0,070	0,132	0,216	0,293	0,150	1,000	0,301	0,236	0,087	-0,021	0,315	0,230	0,146	0,278	0,826	0,151	-0,205	0,107	0,141	0,016	-0,058	-0,132	0,370
Cash&Liq y/e	0,426	-0,062	-0,171	0,171	0,567	-0,413	0,349	0,289	0,732	0,258	0,220	0,257	0,238	-0,113	0,450	0,033	-0,057	0,656	0,340	0,879	0,792	0,848	0,301	1,000	0,761	0,267	-0,012	0,815	0,287	0,857	-0,073	0,028	0,686	0,260	0,195	0,436	0,030	0,254	0,154	0,494
Interest bearing Debt Mio	0,338	-0,048	-0,211	0,211	0,657	-0,467	0,180	0,168	0,742	0,204	0,110	0,150	0,105	-0,114	0,426	0,138	-0,125	0,592	0,338	0,903	0,713	0,815	0,236	0,761	1,000	0,246	0,035	0,745	0,237	0,799	-0,069	-0,006	0,692	0,330	-0,052	0,916	0,134	0,388	0,108	0,388
EBITDA	0,141	-0,011	-0,041	0,041	0,264	-0,227	0,062	0,015	0,233	0,183	-0,018	0,019	0,005	-0,024	0,077	-0,012	0,010	0,156	0,202	0,283	0,275	0,261	0,087	0,267	0,246	1,000	0,065	0,286	0,062	0,282	-0,038	-0,045	0,305	0,058	-0,009	0,175	0,017	0,070	-0,008	0,120
Debt/Equity	-0,065	-0,002	-0,030	0,030	0,102	-0,075	-0,071	-0,086	0,077	0,052	-0,041	-0,082	-0,074	-0,012	0,013	0,037	-0,031	0,015	0,068	0,093	-0,040	0,033	-0,021	-0,012	0,035	0,065	1,000	0,063	-0,042	0,034	-0,033	-0,055	0,179	0,034	-0,076	0,056	0,015	0,072	-0,029	-0,026
Flights number	0,320	-0,063	-0,046	0,046	0,513	-0,470	0,342	0,275	0,783	0,324	0,181	0,252	0,235	-0,137	0,358	0,042	-0,007	0,523	0,224	0,868	0,812	0,832	0,315	0,815	0,745	0,286	0,063	1,000	0,223	0,878	-0,145	-0,038	0,760	0,237	0,008	0,530	0,107	0,047	0,074	0,733
Unit Labour costs/Employee	0,210	-0,098	0,047	-0,047	-0,240	0,197	0,172	0,181	0,085	0,358	0,133	0,175	0,068	-0,138	-0,087	-0,068	0,414	0,412	0,049	0,243	0,153	0,279	0,230	0,287	0,237	0,062	-0,042	0,223	1,000	0,211	0,175	0,277	0,046	0,074	0,235	0,152	-0,016	-0,090	0,155	0,278
OPEX less Labour and Fuel	0,303	-0,056	-0,279	0,279	0,653	-0,402	0,491	0,458	0,833	0,156	0,270	0,425	0,380	-0,116	0,609	0,102	-0,215	0,751	0,369	0,954	0,792	0,969	0,146	0,857	0,799	0,282	0,034	0,878	0,211	1,000	-0,207	-0,087	0,746	0,400	-0,113	0,577	0,081	0,331	0,234	0,464
Pax/Flight	0,360	-0,049	0,383	-0,383	-0,298	-0,046	-0,632	-0,632	-0,261	0,642	-0,083	-0,655	-0,718	-0,224	-0,438	-0,027	0,566	-0,109	0,185	-0,105	-0,019	-0,234	0,278	-0,073	-0,069	-0,038	-0,033	-0,145	0,175	-0,207	1,000	0,309	-0,133	-0,407	0,207	-0,050	-0,081	0,049	-0,260	-0,131
Ancill. Rev per Pax	0,139	-0,054	0,223	-0,223	-0,231	0,030	-0,086	-0,132	-0,093	0,330	0,066	-0,158	-0,144	-0,035	-0,146	0,029	0,350	0,057	0,122	-0,044	-0,040	-0,067	0,826	0,028	-0,006	-0,045	-0,055	-0,038	0,277	-0,087	0,309	1,000	-0,129	-0,204	0,085	-0,025	-0,038	0,039	-0,087	0,065
Network Airports	0,239	-0,057	-0,207	0,207	0,695	-0,508	0,185	0,148	0,761	0,208	0,126	0,127	0,107	-0,166	0,421	0,121	-0,134	0,511	0,342	0,766	0,614	0,690	0,151	0,686	0,692	0,305	0,179	0,760	0,046	0,746	-0,133	-0,129	1,000	0,356	-0,085	0,536	0,081	0,266	0,000	0,243
Global Alliance	-0,344	-0,128	-0,610	0,610	0,352	0,195	0,459	0,499	0,488	-0,251	0,223	0,484	0,447	0,076	0,563	0,187	-0,451	0,564	0,080	0,371	0,201	0,419	-0,205	0,260	0,330	0,058	0,034	0,237	0,074	0,400	-0,407	-0,204	0,356	1,000	-0,331	0,297	0,103	0,308	0,283	-0,003
Liquidity/Sales	0,420	-0,021	0,168	-0,168	-0,211	0,060	-0,218	-0,255	-0,206	0,195	-0,177	-0,231	-0,231	-0,117	-0,281	-0,115	0,356	-0,102	0,016	-0,064	0,092	-0,099	0,107	0,195	-0,052	-0,009	-0,076	0,008	0,235	-0,113	0,207	0,085	-0,085	-0,331	1,000	-0,193	-0,280	-0,364	-0,358	0,179
Net Debt Mio	0,204	-0,028	-0,186	0,186	0,561	-0,392	0,034	0,055	0,576	0,123	0,017	0,049	-0,002	-0,088	0,312	0,171	-0,138	0,415	0,258	0,708	0,498	0,606	0,141	0,436	0,916	0,175	0,056	0,530	0,152	0,577	-0,050	-0,025	0,536	0,297	-0,193	1,000	0,167	0,381	0,055	0,232
NetDebt/EBITDA	-0,139	0,020	0,033	-0,033	0,088	-0,118	0,078	0,062	0,159	0,028	-0,013	0,068	0,074	0,024	0,074	-0,088	-0,047	0,038	-0,028	0,094	0,061	0,086	0,016	0,030	0,134	0,017	0,015	0,107	-0,016	0,081	-0,081	-0,038	0,081	0,103	-0,280	0,167	1,000	0,095	0,106	0,114
Journey length	-0,105	-0,061	-0,545	0,545	0,546	-0,056	0,065	0,080	0,488	-0,043	0,222	0,032	0,028	-0,222	0,581	0,194	-0,479	0,504	0,364	0,381	0,156	0,367	-0,058	0,254	0,388	0,070	0,072	0,047	-0,090	0,331	0,049	0,039	0,266	0,308	-0,364	0,381	0,095	1,000	0,405	-0,316
AC Age	-0,174	-0,069	-0,456	0,456	0,103	0,307	0,501	0,507	0,169	-0,089	0,378	0,460	0,440	0,196	0,346	-0,020	-0,386	0,324	-0,216	0,205	0,076	0,278	-0,132	0,154	0,108	-0,008	-0,029	0,074	0,155	0,234	-0,260	-0,087	0,000	0,283	-0,358	0,055	0,106	0,405	1,000	-0,103
Flights/Destinations	0,194	-0,044	0,238	-0,238	0,064	-0,277	0,238	0,157	0,454	0,322	0,011	0,168	0,174	-0,118	0,039	-0,035	0,198	0,181	-0,005	0,452	0,540	0,451	0,370	0,494	0,388	0,120	-0,026	0,733	0,278	0,464	-0,131	0,065	0,243	-0,003	0,179	0,232	0,114	-0,316	-0,103	1,000

Table 39: Pearson Correlation Coefficients Network Airlines Page 1 of 2

Network Carrier Airlines	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	EBIT Mio	Op.Cashflow	Sales Mio	OPEX Mio	Invest.Cash Flow t-1	Cost of Fuel Mio	Non Fuel OPEX Mio	Fixed Asset Base Mio	Fleet Size year end	Pax Mio	ASK Mio	RPK Mio	Ave. Employees	Tonnes Fuel Mio	CO2 Tonnes Fuel Mio	Free Cash Flow	>50% State owned	Listed	Private
2000	1,000	-0,022	-0,027	-0,029	-0,029	-0,031	-0,033	-0,033	-0,037	-0,044	-0,039	-0,037	-0,037	-0,037	-0,039	-0,037	-0,037	-0,037	-0,037	-0,031	-0,030	-0,040	-0,039	-0,027	-0,088	-0,025	-0,012	-0,032	-0,060	-0,048	-0,060	-0,012	-0,044	-0,044	-0,052	0,102	-0,100	-0,011
2001	-0,022	1,000	-0,027	-0,029	-0,029	-0,031	-0,033	-0,033	-0,037	-0,044	-0,039	-0,037	-0,037	-0,037	-0,039	-0,037	-0,037	-0,037	-0,037	-0,034	-0,050	-0,038	-0,037	0,032	-0,078	-0,025	-0,009	-0,012	-0,062	-0,050	-0,060	-0,014	-0,044	-0,044	-0,077	0,102	-0,100	-0,011
2002	-0,027	-0,027	1,000	-0,036	-0,036	-0,038	-0,041	-0,041	-0,046	-0,054	-0,048	-0,046	-0,046	-0,046	-0,048	-0,046	-0,046	-0,046	-0,046	-0,001	-0,012	-0,025	-0,025	0,046	-0,096	-0,005	-0,004	-0,017	-0,057	-0,060	-0,069	0,022	-0,040	-0,040	0,024	0,033	-0,092	0,403
2003	-0,029	-0,029	-0,036	1,000	-0,039	-0,042	-0,044	-0,044	-0,049	-0,058	-0,052	-0,049	-0,049	-0,049	-0,052	-0,049	-0,049	-0,049	-0,049	-0,067	-0,045	-0,049	-0,045	0,002	-0,113	-0,025	-0,039	-0,041	-0,062	-0,069	-0,078	0,007	-0,047	-0,047	0,015	0,007	-0,005	-0,014
2004	-0,029	-0,029	-0,036	-0,039	1,000	-0,042	-0,044	-0,044	-0,049	-0,058	-0,052	-0,049	-0,049	-0,049	-0,052	-0,049	-0,049	-0,049	-0,049	-0,014	-0,041	-0,044	-0,044	0,018	-0,097	-0,029	-0,041	-0,044	-0,054	-0,058	-0,058	0,002	-0,035	-0,035	-0,037	0,007	-0,005	-0,014
2005	-0,031	-0,031	-0,038	-0,042	-0,042	1,000	-0,048	-0,048	-0,053	-0,062	-0,055	-0,053	-0,053	-0,053	-0,055	-0,053	-0,053	-0,053	-0,053	-0,023	-0,047	-0,055	-0,055	-0,030	-0,088	-0,046	-0,056	-0,058	-0,066	-0,072	-0,077	-0,023	-0,051	-0,051	-0,016	0,038	-0,036	-0,016
2006	-0,033	-0,033	-0,041	-0,044	-0,044	-0,048	1,000	-0,051	-0,056	-0,066	-0,059	-0,056	-0,056	-0,056	-0,059	-0,056	-0,056	-0,056	-0,056	0,015	0,024	-0,010	-0,012	0,015	-0,031	-0,006	-0,017	-0,003	-0,031	-0,029	-0,034	0,025	-0,002	-0,002	-0,014	-0,036	0,038	-0,016
2007	-0,033	-0,033	-0,041	-0,044	-0,044	-0,048	-0,051	1,000	-0,056	-0,066	-0,059	-0,056	-0,056	-0,056	-0,059	-0,056	-0,056	-0,056	-0,056	0,072	0,030	0,006	0,001	0,077	-0,010	0,004	-0,015	0,006	-0,028	-0,020	-0,022	0,029	0,002	0,004	0,108	-0,036	0,038	-0,016
2008	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	1,000	-0,074	-0,065	-0,063	-0,063	-0,063	-0,065	-0,063	-0,063	-0,063	-0,063	-0,085	-0,045	-0,022	-0,016	0,065	-0,004	-0,019	-0,039	-0,029	-0,054	-0,042	-0,044	-0,003	-0,024	-0,025	0,075	-0,024	0,027	-0,018
2009	-0,044	-0,044	-0,054	-0,058	-0,058	-0,062	-0,066	-0,066	-0,074	1,000	-0,077	-0,074	-0,074	-0,074	-0,077	0,010	0,010	0,010	0,010	-0,235	-0,158	-0,100	-0,085	0,056	-0,087	-0,084	-0,094	-0,084	-0,124	-0,109	-0,110	-0,074	-0,100	-0,102	-0,097	0,033	-0,030	-0,022
2010	-0,039	-0,039	-0,048	-0,052	-0,052	-0,055	-0,059	-0,059	-0,065	-0,077	1,000	-0,065	-0,065	-0,065	-0,069	-0,065	-0,065	-0,065	-0,065	-0,127	-0,105	-0,049	-0,041	0,021	-0,040	-0,041	-0,041	-0,038	-0,064	-0,053	-0,053	-0,030	-0,041	-0,041	-0,099	-0,042	0,044	-0,019
2011	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	-0,063	-0,074	-0,065	1,000	-0,063	-0,063	-0,065	-0,063	-0,063	-0,063	-0,063	-0,060	-0,069	-0,009	-0,004	0,066	0,035	-0,016	-0,010	-0,005	-0,026	-0,013	-0,016	-0,005	-0,008	-0,008	-0,024	-0,024	0,027	-0,018
2012	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	-0,063	-0,074	-0,065	-0,063	1,000	-0,063	-0,065	-0,063	-0,063	-0,063	-0,063	-0,075	-0,050	0,014	0,021	-0,039	0,097	-0,002	-0,006	-0,007	-0,011	0,000	0,001	-0,007	0,001	0,001	0,058	-0,024	0,027	-0,018
2013	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	-0,063	-0,074	-0,065	-0,063	-0,063	1,000	-0,065	-0,063	-0,063	-0,063	-0,063	-0,025	0,002	0,022	0,025	-0,058	0,095	0,005	-0,010	0,004	0,014	0,015	0,018	-0,007	0,005	0,005	-0,012	-0,024	0,027	-0,018
2014	-0,039	-0,039	-0,048	-0,052	-0,052	-0,055	-0,059	-0,059	-0,065	-0,077	-0,069	-0,065	-0,065	-0,065	1,000	-0,065	-0,065	-0,065	-0,065	-0,022	-0,046	0,006	0,009	-0,005	0,069	-0,009	-0,022	-0,012	0,007	0,006	0,010	-0,024	-0,005	-0,006	-0,092	0,003	0,000	-0,019
2015	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	-0,063	0,010	-0,065	-0,063	-0,063	-0,063	-0,065	1,000	0,034	-0,063	-0,063	0,098	0,018	0,024	0,018	-0,026	0,030	0,014	0,021	0,015	0,051	0,044	0,048	-0,008	0,021	0,020	0,037	0,022	-0,019	-0,018
2016	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	-0,063	0,010	-0,065	-0,063	-0,063	-0,063	-0,065	0,034	1,000	-0,063	-0,063	0,090	0,038	0,034	0,026	0,079	0,009	0,032	0,018	0,033	0,069	0,064	0,067	-0,002	0,032	0,033	0,033	0,022	-0,019	-0,018
2017	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	-0,063	0,010	-0,065	-0,063	-0,063	-0,063	-0,065	-0,063	-0,063	1,000	-0,063	0,141	0,167	0,055	0,048	-0,126	0,019	0,056	0,043	0,052	0,102	0,084	0,094	0,004	0,059	0,059	0,184	0,022	-0,019	-0,018
2018	-0,037	-0,037	-0,046	-0,049	-0,049	-0,053	-0,056	-0,056	-0,063	0,010	-0,065	-0,063	-0,063	-0,063	-0,065	-0,063	-0,063	-0,063	1,000	0,209	0,134	0,064	0,048	-0,173	0,061	0,045	0,083	0,063	0,129	0,105	0,117	0,013	0,081	0,081	-0,077	0,022	-0,019	-0,018
EBIT Mio	-0,031	-0,034	-0,001	-0,067	-0,014	-0,023	0,015	0,072	-0,085	-0,235	-0,127	-0,060	-0,075	-0,025	-0,022	0,098	0,090	0,141	0,209	1,000	0,752	0,573	0,518	-0,464	0,494	0,515	0,547	0,524	0,641	0,590	0,591	0,467	0,562	0,562	0,265	-0,261	0,262	-0,007
Operating Cashflow	-0,030	-0,050	-0,012	-0,045	-0,041	-0,047	0,024	0,030	-0,045	-0,158	-0,105	-0,069	-0,050	0,002	-0,046	0,018	0,038	0,167	0,134	0,752	1,000	0,876	0,853	-0,573	0,771	0,859	0,859	0,837	0,881	0,861	0,861	0,817	0,864	0,864	0,523	-0,414	0,416	-0,018
Sales Mio	-0,040	-0,038	-0,025	-0,049	-0,044	-0,055	-0,010	0,006	-0,022	-0,100	-0,049	-0,009	0,014	0,022	0,006	0,024	0,034	0,055	0,064	0,573	0,876	1,000	0,998	-0,606	0,944	0,993	0,957	0,970	0,952	0,958	0,952	0,967	0,975	0,975	0,435	-0,443	0,449	-0,049
OPEX Mio	-0,039	-0,037	-0,025	-0,045	-0,044	-0,055	-0,012	0,001	-0,016	-0,085	-0,041	-0,004	0,021	0,025	0,009	0,018	0,026	0,048	0,048	0,518	0,853	0,998	1,000	-0,595	0,945	0,996	0,954	0,969	0,942	0,952	0,945	0,971	0,972	0,972	0,432	-0,444	0,451	-0,051
Investing Cash Flow t-1	-0,027	0,032	0,046	0,002	0,018	-0,030	0,015	0,077	0,065	0,056	0,021	0,066	-0,039	-0,058	-0,005	-0,026	0,079	-0,126	-0,173	-0,464	-0,573	-0,606	-0,595	1,000	-0,540	-0,599	-0,547	-0,573	-0,582	-0,519	-0,510	-0,589	-0,564	-0,563	-0,089	0,238	-0,242	0,033
Cost of Fuel Mio	-0,088	-0,078	-0,096	-0,113	-0,097	-0,088	-0,031	-0,010	-0,004	-0,087	-0,040	0,035	0,097	0,095	0,069	0,030	0,009	0,019	0,061	0,494	0,771	0,944	0,945	-0,540	1,000	0,911	0,906	0,921	0,915	0,946	0,944	0,878	0,941	0,941	0,399	-0,435	0,442	-0,055
Non Fuel OPEX Mio	-0,025	-0,025	-0,005	-0,025	-0,029	-0,046	-0,006	0,004	-0,019	-0,084	-0,041	-0,016	-0,002	0,005	-0,009	0,014	0,032	0,056	0,045	0,515	0,859	0,993	0,996	-0,599	0,911	1,000	0,949	0,964	0,932	0,934	0,926	0,978	0,961	0,962	0,433	-0,436	0,443	-0,049
Fixed Asset Base Mio	-0,012	-0,009	-0,004	-0,039	-0,041	-0,056	-0,017	-0,015	-0,039	-0,094	-0,041	-0,010	-0,006	-0,010	-0,022	0,021	0,018	0,043	0,083	0,547	0,859	0,957	0,954	-0,547	0,906	0,949	1,000	0,950	0,940	0,962	0,952	0,919	0,969	0,970	0,446	-0,486	0,491	-0,044
Fleet Size year end	-0,032	-0,012	-0,017	-0,041	-0,044	-0,058	-0,003	0,006	-0,029	-0,084	-0,038	-0,005	-0,007	0,004	-0,012	0,015	0,033	0,052	0,063	0,524	0,837	0,970	0,969	-0,573	0,921	0,964	0,950	1,000	0,954	0,956	0,946	0,959	0,963	0,963	0,406	-0,382	0,390	-0,058
Pax Mio	-0,060	-0,062	-0,057	-0,062	-0,054	-0,066	-0,031	-0,028	-0,054	-0,124	-0,064	-0,026	-0,011	0,014	0,007	0,051	0,069	0,102	0,129	0,641	0,881	0,952	0,942	-0,582	0,915	0,932	0,940	0,954	1,000	0,964	0,961	0,885	0,946	0,946	0,401	-0,409	0,416	-0,054
ASK Mio	-0,048	-0,050	-0,060	-0,069	-0,058	-0,072	-0,029	-0,020	-0,042	-0,109	-0,053	-0,013	0,000	0,015	0,006	0,044	0,064	0,084	0,105	0,590	0,861	0,958	0,952	-0,519	0,946	0,934	0,962	0,956	0,964	1,000	0,998	0,894	0,984	0,984	0,447	-0,439	0,446	-0,055
RPK Mio	-0,060	-0,060	-0,069	-0,078	-0,058	-0,077	-0,034	-0,022	-0,044	-0,110	-0,053	-0,016	0,001	0,018	0,010	0,048	0,067	0,094	0,117	0,591	0,861	0,952	0,945	-0,510	0,944	0,926	0,952	0,946	0,961	0,998	1,000	0,881	0,980	0,980	0,440	-0,436	0,443	-0,055
Ave. Employees	-0,012	-0,014	0,022	0,007	0,002	-0,023	0,025	0,029	-0,003	-0,074	-0,030	-0,005	-0,007	-0,007	-0,024	-0,008	-0,002	0,004	0,013	0,467	0,817	0,967	0,971	-0,589	0,878	0,978	0,919	0,959	0,885	0,894	0,881	1,000	0,933	0,933	0,403	-0,405	0,411	-0,045
Tonnes Fuel Mio	-0,044	-0,044	-0,040	-0,047	-0,035	-0,051	-0,002	0,002	-0,024	-0,100	-0,041	-0,008	0,001	0,005	-0,005	0,021	0,032	0,059	0,081	0,562	0,864	0,975	0,972	-0,564	0,941	0,961	0,969	0,963	0,946	0,984	0,980	0,933	1,000	1,000	0,434	-0,474	0,481	-0,054
CO2 Tonnes Fuel Mio	-0,044	-0,044	-0,040	-0,047	-0,035	-0,051	-0,002	0,004	-0,025	-0,102	-0,041	-0,008	0,001	0,005	-0,006	0,020	0,033	0,059	0,081	0,562	0,864	0,975	0,972	-0,563	0,941	0,962	0,970	0,963	0,946	0,984	0,980	0,933	1,000	1,000	0,435	-0,474	0,481	-0,054
Free Cash Flow	-0,052	-0,077	0,024	0,015	-0,037	-0,016	-0,014	0,108	0,075	-0,097	-0,099	-0,024	0,058	-0,012	-0,092	0,037	0,033	0,184	-0,077	0,265	0,523	0,435	0,432	-0,089	0,399	0,433	0,446	0,406	0,401	0,447	0,440	0,403	0,434	0,435	1,000	-0,296	0,293	0,015
>50% State owned	0,102	0,102	0,033	0,007	0,007	0,038	-0,036	-0,036	-0,024	0,033	-0,042	-0,024	-0,024	-0,024	0,003	0,022	0,022	0,022	0,022	-0,261	-0,414	-0,443	-0,444	0,238	-0,435	-0,436	-0,486	-0,382	-0,409	-0,439	-0,436	-0,405	-0,474	-0,474	-0,296	1,000	-0,989	-0,061
Listed	-0,100	-0,100	-0,092	-0,005	-0,005	-0,036	0,038	0,038	0,027	-0,030	0,044	0,027	0,027	0,027	0,000	-0,019	-0,019	-0,019	-0,019	0,262	0,416	0,449	0,451	-0,242	0,442	0,443	0,491	0,390	0,416	0,446	0,443	0,411	0,481	0,481	0,293	-0,989	1,000	-0,087
Private	-0,011	-0,011	0,403	-0,014	-0,014	-0,016	-0,016	-0,016	-0,018	-0,022	-0,019	-0,018	-0,018	-0,018	-0,019	-0,018	-0,018	-0,018	-0,018	-0,007	-0,018	-0,049	-0,051	0,033	-0,055	-0,049	-0,044	-0,058	-0,054	-0,055	-0,055	-0,045	-0,054	-0,054	0,015	-0,061	-0,087	1,000
Network	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LargeNet/Mixed	0,006	0,006	0,068	0,036	0,036	0,008	0,033	0,033	-0,013	-0,087	-0,034	-0,013	-0,013	-0,013	-0,034	-0,013	-0,013	-0,013	-0,013	0,442	0,625	0,645	0,637	-0,378	0,653	0,618	0,690	0,698	0,635	0,712	0,694	0,662	0,708	0,708	0,380	-0,371	0,359	0,076
Small Network	-0,006	-0,006	-0,068	-0,036	-0,036	-0,008	-0,033	-0,033	0,013	0,087	0,034	0,013	0,013	0,013	0,034	0,013	0,013	0,013	0,013	-0,442	-0,625	-0,645	-0,637	0,378	-0,653	-0,618	-0,690	-0,698	-0,635	-0,712	-0,694	-0,662	-0,708	-0,708	-0,380	0,371	-0,359	-0,076
RASK	0,076	0,078	0,138	0,034	-0,011	-0,017	0,006	0,054	0,023	0,140	-0,033	-0,034	0,014	0,012	0,034	0,001	-0,024	0,000	-0,008	0,093	0,214	0,318	0,327	-0,320	0,190	0,359	0,221	0,273	0,200	0,124	0,114	0,371	0,215	0,216	0,011	0,005	-0,007	0,011
CASK	0,065	0,087	0,113	0,040	-0,014	-0,025	-0,002	0,020	0,034	0,194	-0,014	-0,018	0,025	0,006	0,034	-0,021	-0,042	0,026	-0,034	-0,021	0,142	0,283	0,301	-0,272	0,167	0,333	0,189	0,242	0,163	0,091	0,082	0,340	0,183	0,183	-0,020	0,020	-0,017	-0,015
Log employees	0,040	0,040	0,067	0,064	0,062	0,024	0,053	0,056	0,008	-0,145	-0,045	-0,036	-0,042	-0,033	-0,076	-0,045	-0,038	-0,028	-0,022	0,439	0,706	0,843	0,843	-0,480	0,787	0,842	0,830	0,885	0,817	0,841	0,822	0,875	0,859	0,859	0,352	-0,214	0,217	-0,026
SLF	-0,119	-0,087	-0,062	-0,066	-0,005	-0,009	0,013	0,032	0,002	-0,361	-0,070	-0,095	0,074	0,093	0,007	0,004	0,001	0,037	0,038	0,204	0,301	0,330	0,327	-0,148	0,351	0,314	0,322	0,330	0,367	0,379	0,385	0,291	0,356	0,356	0,172	-0,175	0,179	-0,033
Fuel CASK	-0,201	-0,153	-0,222	-0,279	-0,219	-0,147	-0,010	0,019	0,191	0,145	0,024	0,136	0,277	0,230	0,279	0,040	-0,082	-0,100	-0,001	-0,021	0,049	0,186	0,197	-0,144	0,330	0,156	0,109	0,131	0,118	0,125	0,132	0,135	0,145	0,145	0,019	-0,084	0,096	-0,084
Non Fuel CASK	0,118	0,130	0,174	0,109	0,037	0,007	-0,003	0,014	-0,014	0,170	-0,024	-0,055	-0,044	-0,052	-0,035	-0,035	-0,018	0,058	-0,029	-0,019	0,136	0,254	0,271	-0,257	0,094	0,316	0,171	0,224	0,145	0,062	0,051	0,326	0,156	0,156	-0,029	0,054	-0,055	0,004
RRPK Yield	0,166	0,153	0,185	0,085	0,011	0,006	0,014	0,047	0,039	0,145	-0,038	-0,031	-0,009	-0,018	0,016	-0,027	-0,043	-0,043	-0,060	0,018	0,096	0,190	0,199	-0,257	0,055	0,236	0,107	0,163	0,081	-0,003	-0,018	0,263	0,089	0,089	-0,064	0,098	-0,104	0,036
Pax/Employees	-0,121	-0,121	-0,139	-0,137	-0,123	-0,082	-0,075	-0,078	-0,051	-0,043	-0,035	0,007	0,046	0,072	0,107	0,095	0,102	0,122	0,137	-0,073	-0,214	-0,312	-0,318	0,170	-0,261	-0,326	-0,284	-0,323	-0,181	-0,270	-0,256	-0,403	-0,310	-0,310	-0,111	-0,151	0,157	-0,038
Employees/Fleet	0,029	-0,023	0,194	0,215	0,189	0,132	0,103	0,097	0,086	-0,090	0,001	-0,037	-0,058	-0,071	-0,120	-0,109	-0,135	-0,141	-0,144	0,233	0,462	0,593	0,600	-0,343	0,487	0,618	0,543	0,560	0,459	0,511	0,490	0,697	0,579	0,578	0,248	-0,173	0,164	0,063
Invest/Assetbase	-0,085	0,067	0,050	-0,060	-0,005	-0,212	0,030	0,007	0,045	-0,000	0,093	0,070	0,011	-0,037	0,029	-0,100	0,054	-0,035	-0,193	-0,030	0,026	0,062	0,066	0,372	0,078	0,060	0,093	0,066	0,077	0,114	0,115	0,055	0,089	0,089	-0,070	-0,143	0,138	0,034
Sales/Employees	-0,174	-0,164	-0,191	-0,232	-0,212	-0,173	-0,130	-0,087	-0,081	-0,023	-0,061	0,009	0,118	0,152	0,204	0,130	0,164	0,196	0,221	0,089	-0,000	-0,068	-0,077	0,040	0,000	-0,095	-0,059	-0,140	-0,003	-0,036	-0,017	-0,226	-0,068	-0,067	0,036	-0,151	0,160	-0,064
Sales/Aircraft	-0,055	-0,077	-0,010	-0,050	-0,036	-0,029	0,004	0,060	0,051	-0,170	-0,034	-0,014	0,055	0,071	0,015	-0,015	-0,034	0,005	0,021	0,445	0,651	0,762	0,760	-0,426	0,724	0,755	0,719	0,647	0,676	0,718	0,714	0,703	0,754	0,754	0,381	-0,382	0,381	0,002
Skytrax	0,017	0,017	0,052	0,066	0,066	0,079	0,090	0,090	0,017	-0,099	-0,015	-0,030	-0,030	-0,030	-0,015	-0,078	-0,078	-0,078	-0,078	0,303	0,430	0,428	0,421	-0,204	0,437	0,406	0,459	0,427	0,403	0,480	0,472	0,436	0,470	0,471	0,306	-0,282	0,274	0,046
Total Liabs Mio	-0,031	-0,026	-0,014	-0,043	-0,042	-0,058	-0,018	-0,022	-0,049	-0,083	-0,046	-0,028	-0,006	-0,001	0,005	0,034	0,032	0,049	0,083	0,538	0,862	0,974	0,972	-0,560	0,929	0,965	0,985	0,958	0,947	0,975	0,971	0,928	0,982	0,982	0,440	-0,467	0,473	-0,046
Equity Mio	0,004	-0,002	-0,017	-0,044	-0,018	-0,029	0,044	0,088	0,050	-0,076	0,002	0,033	-0,025	-0,032	-0,112	-0,047	-0,009	0,025	0,026	0,517	0,761	0,829	0,825	-0,467	0,746	0,831	0,862	0,837	0,810	0,790	0,769	0,829	0,818	0,819	0,497	-0,494	0,500	-0,046
Labour Costs Mio	-0,030	-0,028	-0,007	-0,025	-0,023	-0,035	0,004	0,016	-0,012	-0,079	-0,031	-0,009	0,006	0,011	-0,010	0,015	0,014	0,028	0,028	0,446	0,810	0,978	0,985	-0,550	0,909	0,987	0,935	0,950	0,905	0,924	0,920	0,966	0,956	0,956	0,399	-0,438	0,445	-0,051
Ancill. Pax Revenue	0,064	0,061	0,013	-0,012	-0,014	-0,076	-0,024	-0,026	-0,028	-0,092	-0,065	0,009	0,034	0,019	-0,002	0,012	0,004	0,009	0,043	0,370	0,484	0,580	0,576	-0,158	0,600	0,558	0,629	0,556	0,545	0,666	0,669	0,482	0,654	0,653	0,371	-0,358	0,364	-0,046
Cash&Liq y/e	-0,052	-0,057	-0,015	-0,022	-0,020	-0,029	-0,002	0,052	-0,018	-0,084	-0,014	-0,025	-0,007	0,009	-0,019	0,009	0,046	0,072	0,033	0,574	0,795	0,895	0,889	-0,543	0,848	0,883	0,863	0,872	0,851	0,879	0,872	0,843	0,907	0,907	0,495	-0,521	0,527	-0,047
Interest bearing Debt	0,018	0,030	0,032	-0,026	-0,038	-0,063	-0,030	-0,045	-0,069	-0,097	-0,032	-0,014	-0,006	-0,005	-0,015	0,024	0,029	0,036	0,037	0,407	0,718	0,823	0,827	-0,362	0,801	0,818	0,913	0,847	0,830	0,889	0,883	0,772	0,882	0,883	0,410	-0,445	0,448	-0,030
EBITDA	-0,008	-0,009	-0,003	-0,007	-0,008	-0,006	0,008	0,019	-0,266	-0,032	-0,018	-0,012	-0,005	0,120	-0,005	0,023	0,024	0,050	0,053	0,270	0,317	0,288	0,279	-0,179	0,265	0,277	0,281	0,293	0,305	0,303	0,304	0,263	0,295	0,295	0,184	-0,164	0,165	-0,005
Debt/Equity	-0,001	-0,003	-0,010	-0,013	-0,016	-0,017	-0,020	-0,022	-0,032	-0,028	-0,030	-0,028	-0,024	-0,019	-0,046	0,023	-0,010	-0,019	-0,013	0,077	0,117	0,048	0,034	-0,000	0,069	0,024	0,085	0,079	0,095	0,109	0,113	0,045	0,067	0,067	-0,004	0,065	-0,065	-0,002
Flights Number	-0,016	-0,023	-0,011	-0,032	-0,019	-0,037	-0,028	-0,018	-0,046	-0,110	-0,051	-0,007	-0,008	0,013	-0,008	0,029	0,038	0,055	0,071	0,575	0,841	0,943	0,938	-0,640	0,865	0,940	0,910	0,951	0,958	0,897	0,885	0,919	0,910	0,910	0,336	-0,358	0,365	-0,053
Unit Labour costs/Employee	-0,127	-0,093	-0,106	-0,111	-0,106	-0,043	-0,036	0,004	-0,037	-0,118	-0,046	-0,044	0,075	0,090	0,042	0,052	0,064	0,091	0,095	0,074	0,178	0,287	0,294	-0,103	0,281	0,295	0,281	0,228	0,300	0,278	0,289	0,179	0,290	0,290	0,075	-0,177	0,190	-0,086
OPEX less labour and fuel	-0,022	-0,023	-0,005	-0,026	-0,032	-0,051	-0,012	-0,003	-0,023	-0,085	-0,046	-0,019	-0,006	0,002	-0,008	0,013	0,041	0,071	0,053	0,546	0,877	0,991	0,991	-0,619	0,903	0,996	0,947	0,961	0,936	0,930	0,920	0,974	0,954	0,954	0,447	-0,431	0,437	-0,048
Pax per flight	-0,141	-0,130	-0,141	-0,082	-0,066	-0,026	0,037	0,034	0,018	-0,146	-0,072	-0,120	0,034	0,024	0,050	0,044	0,058	0,120	0,114	0,075	0,032	-0,032	-0,041	0,153	0,067	-0,072	-0,006	-0,073	0,025	0,085	0,105	-0,124	0,020	0,021	0,134	-0,116	0,121	-0,040
Ancill. Rev per Pax	0,073	0,076	0,012	-0,010	-0,015	-0,086	-0,061	-0,054	0,054	-0,016	0,018	0,062	0,099	0,060	0,016	-0,016	-0,051	-0,064	-0,057	-0,096	-0,096	-0,050	-0,044	0,160	-0,039	-0,046	0,001	-0,116	-0,142	-0,029	-0,024	-0,089	-0,022	-0,022	0,077	-0,065	0,075	-0,065
Network airports	-0,049	-0,039	-0,016	-0,038	-0,032	-0,018	-0,004	-0,042	-0,048	-0,123	-0,053	-0,070	-0,040	0,023	0,032	0,076	0,052	0,059	0,084	0,506	0,723	0,748	0,736	-0,481	0,707	0,730	0,758	0,808	0,781	0,787	0,775	0,751	0,785	0,785	0,299	-0,321	0,327	-0,044
Global Alliance	-0,033	-0,033	-0,082	-0,064	-0,064	-0,048	0,033	0,100	-0,011	-0,027	-0,001	-0,011	-0,011	-0,011	-0,001	0,050	0,050	0,050	0,050	0,167	0,265	0,338	0,339	-0,172	0,328	0,337	0,334	0,364	0,372	0,358	0,350	0,321	0,353	0,352	0,142	0,198	-0,173	-0,164
Tonnesk Cargo	-0,036	-0,038	0,000	-0,017	0,003	-0,014	0,022	0,032	-0,006	-0,077	-0,016	0,008	0,005	0,003	-0,015	-0,011	-0,007	0,007	0,023	0,454	0,791	0,923	0,927	-0,614	0,852	0,930	0,903	0,906	0,853	0,847	0,830	0,951	0,900	0,900	0,403	-0,487	0,492	-0,044
Liquidity/Sales	-0,074	-0,073	-0,058	0,000	-0,044	0,041	0,071	0,097	0,038	-0,035	0,049	0,002	-0,003	0,019	0,000	-0,031	-0,041	-0,026	-0,051	0,013	-0,039	-0,044	-0,044	0,020	-0,053	-0,041	-0,033	-0,079	-0,032	-0,049	-0,046	-0,075	-0,032	-0,032	0,028	-0,448	0,449	-0,013
Net Debt Mio	0,059	0,078	0,054	-0,023	-0,041	-0,070	-0,041	-0,096	-0,085	-0,083	-0,036	-0,004	-0,004	-0,012	-0,009	0,028	0,012	0,005	0,031	0,209	0,507	0,592	0,601	-0,167	0,589	0,591	0,738	0,639	0,628	0,694	0,689	0,553	0,667	0,667	0,264	-0,296	0,297	-0,012
NetDebt/EBITDA	0,022	0,060	0,030	0,059	0,024	0,014	0,004	-0,008	0,006	-0,229	-0,044	0,042	-0,005	0,015	0,032	-0,016	0,032	0,009	0,035	0,013	0,055	0,092	0,095	-0,060	0,086	0,095	0,105	0,127	0,098	0,101	0,096	0,103	0,100	0,100	-0,010	0,158	-0,159	0,009
Journey length	-0,029	0,000	-0,031	-0,053	-0,005	-0,051	-0,010	0,013	-0,004	-0,054	0,046	0,033	0,022	0,009	-0,024	-0,012	0,000	-0,014	-0,010	0,101	0,216	0,269	0,270	-0,012	0,329	0,247	0,305	0,255	0,154	0,354	0,357	0,269	0,349	0,349	0,250	-0,060	0,068	-0,057
AC Age	-0,014	-0,051	-0,099	-0,121	-0,065	-0,093	-0,058	-0,038	-0,051	-0,063	-0,043	-0,027	-0,010	0,037	0,051	0,069	0,101	0,105	0,150	0,096	0,118	0,160	0,161	-0,147	0,163	0,158	0,122	0,101	0,108	0,108	0,118	0,113	0,135	0,134	0,019	-0,053	0,061	-0,057
Tonnes per aircraft	-0,018	-0,046	0,051	0,034	0,093	0,052	0,046	0,059	0,013	-0,128	0,023	0,010	0,007	0,000	-0,036	-0,046	-0,056	-0,072	-0,054	0,290	0,515	0,586	0,589	-0,416	0,534	0,592	0,618	0,545	0,505	0,532	0,512	0,627	0,608	0,609	0,318	-0,487	0,483	0,018
Flights/Destinations	0,078	0,018	0,020	0,019	0,016	-0,009	-0,016	0,010	-0,027	-0,071	-0,029	0,075	-0,003	-0,007	-0,069	-0,042	-0,015	-0,006	0,005	0,327	0,492	0,643	0,646	-0,442	0,572	0,656	0,601	0,651	0,674	0,566	0,554	0,623	0,583	0,583	0,145	-0,129	0,136	-0,048

Table 39 Pearson Correlation Coefficients Network Airlines Page 2 of 2

Network Carrier Airlines	Network	LargeNet/Mixed	Small Network	RASK	CASK	Log Ees	SLF	Fuel CASK	Non Fuel CASK	RRPK Yield	Pax/Employees	Employees/Fleet	Invest/Assetbase	Sales/Employees	Sales/Aircraft	Skytrax	Total Liabs Mio	Equity Mio	Labour Costs Mio
2000	-	0,006	-0,006	0,076	0,065	0,040	-0,119	-0,201	0,118	0,166	-0,121	0,029	-0,085	-0,174	-0,055	0,017	-0,031	0,004	-0,030
2001	-	0,006	-0,006	0,078	0,087	0,040	-0,087	-0,153	0,130	0,153	-0,121	-0,023	0,067	-0,164	-0,077	0,017	-0,026	-0,002	-0,028
2002	-	0,068	-0,068	0,138	0,113	0,067	-0,062	-0,222	0,174	0,185	-0,139	0,194	-0,050	-0,191	-0,010	0,052	-0,014	-0,017	-0,007
2003	-	0,036	-0,036	0,034	0,040	0,064	-0,066	-0,279	0,109	0,085	-0,137	0,215	-0,060	-0,232	-0,050	0,066	-0,043	-0,044	-0,025
2004	-	0,036	-0,036	-0,011	-0,014	0,062	-0,005	-0,219	0,037	0,011	-0,123	0,189	-0,005	-0,212	-0,036	0,066	-0,042	-0,018	-0,023
2005	-	0,008	-0,008	-0,017	-0,025	0,024	-0,009	-0,147	0,007	0,006	-0,082	0,132	-0,212	-0,173	-0,029	0,079	-0,058	-0,029	-0,035
2006	-	0,033	-0,033	0,006	-0,002	0,053	0,013	-0,010	-0,003	0,014	-0,075	0,103	-0,030	-0,130	0,004	0,090	-0,018	0,044	0,004
2007	-	0,033	-0,033	0,054	0,020	0,056	0,032	0,019	0,014	0,047	-0,078	0,097	-0,007	-0,087	0,060	0,090	-0,022	0,088	0,016
2008	-	-0,013	0,013	0,023	0,034	0,008	0,002	0,191	-0,014	0,039	-0,051	0,086	0,045	0,081	0,051	0,017	-0,049	0,050	-0,012
2009	-	-0,087	0,087	0,140	0,194	-0,145	-0,361	0,145	0,170	0,145	-0,043	-0,090	-0,000	0,023	-0,170	-0,099	-0,083	-0,076	-0,079
2010	-	-0,034	0,034	-0,033	-0,014	-0,045	-0,070	0,024	-0,024	-0,038	-0,035	0,001	-0,093	-0,061	-0,034	-0,015	0,046	-0,002	-0,031
2011	-	-0,013	0,013	-0,034	-0,018	-0,036	-0,095	0,136	-0,055	0,031	0,007	-0,037	0,070	0,009	-0,014	-0,030	0,028	0,033	0,009
2012	-	-0,013	0,013	0,014	0,025	-0,042	0,074	0,277	-0,044	-0,009	0,046	-0,058	0,011	0,118	0,055	-0,030	0,006	-0,025	0,006
2013	-	-0,013	0,013	0,012	0,006	-0,033	0,093	0,230	-0,052	-0,018	0,072	-0,071	0,037	0,152	0,071	-0,030	-0,001	-0,032	0,011
2014	-	0,034	-0,034	0,034	0,034	-0,076	0,007	0,279	0,035	0,016	0,107	0,120	0,029	0,204	0,015	-0,015	0,005	0,112	0,010
2015	-	0,013	-0,013	0,001	-0,021	-0,045	0,004	0,040	-0,035	-0,027	0,095	-0,109	0,100	0,130	-0,015	-0,078	0,034	-0,047	0,015
2016	-	0,013	-0,013	-0,024	-0,042	-0,038	0,001	0,082	-0,018	-0,043	0,102	-0,135	0,054	0,164	-0,034	-0,078	-0,032	-0,009	0,014
2017	-	0,013	-0,013	0,000	-0,026	-0,028	0,037	0,100	-0,058	-0,043	0,122	-0,141	0,035	0,196	0,005	-0,078	0,049	0,025	0,028
2018	-	0,013	-0,013	-0,008	-0,034	-0,022	-0,038	0,001	-0,029	-0,060	0,137	-0,144	0,193	0,221	-0,021	-0,078	0,083	0,026	0,038
EBIT Mio	-	0,442	-0,442	0,093	-0,021	0,439	0,204	0,021	0,019	0,018	0,073	0,233	0,030	0,089	0,445	0,303	0,538	0,517	0,446
Operating Cashflow	-	0,625	-0,625	0,214	0,142	0,706	0,301	0,049	0,136	0,096	0,214	0,462	0,026	0,000	0,651	0,430	0,862	0,761	0,810
Sales Mio	-	0,645	-0,645	0,318	0,283	0,843	0,330	0,186	0,254	0,190	0,312	0,593	0,062	0,068	0,762	0,428	0,974	0,829	0,978
OPEX Mio	-	0,637	-0,637	0,327	0,301	0,843	0,327	0,197	0,271	0,199	0,318	0,600	0,066	0,077	0,760	0,421	0,972	0,825	0,985
Investing Cash Flow t-1	-	-0,378	0,378	-0,320	-0,272	-0,480	-0,148	-0,144	-0,257	-0,257	-0,170	-0,343	0,372	-0,040	-0,426	-0,204	-0,560	-0,467	-0,550
Cost of Fuel Mio	-	0,653	-0,653	0,190	0,167	0,787	0,351	0,330	0,094	0,055	0,261	0,487	0,078	0,000	0,724	0,437	0,929	0,746	0,909
Non Fuel OPEX Mio	-	0,618	-0,618	0,359	0,333	0,842	0,314	0,156	0,316	0,236	0,326	0,618	0,060	0,095	0,755	0,406	0,965	0,831	0,987
Fixed Asset Base Mio	-	0,690	-0,690	0,221	0,189	0,830	0,322	0,109	0,171	0,107	0,284	0,543	0,093	0,059	0,719	0,459	0,985	0,862	0,935
Fleet Size year end	-	0,698	-0,698	0,273	0,242	0,885	0,330	0,131	0,224	0,163	0,323	0,560	0,066	0,140	0,647	0,427	0,958	0,837	0,950
Pax Mio	-	0,635	-0,635	0,200	0,163	0,817	0,367	0,118	0,145	0,081	0,181	0,459	0,077	0,003	0,674	0,403	0,947	0,810	0,905
ASK Mio	-	0,712	-0,712	0,124	0,091	0,841	0,379	0,125	0,062	0,003	0,270	0,511	0,114	0,036	0,718	0,480	0,975	0,790	0,924
RPK Mio	-	0,694	-0,694	0,114	0,082	0,822	0,385	0,132	0,051	0,018	0,256	0,490	0,115	0,017	0,714	0,472	0,971	0,769	0,920
Ave. Employees	-	0,662	-0,662	0,371	0,340	0,875	0,291	0,135	0,326	0,263	0,403	0,697	0,055	0,226	0,703	0,436	0,928	0,829	0,966
Tonnes Fuel Mio	-	0,708	-0,708	0,215	0,183	0,859	0,356	0,145	0,156	0,089	0,310	0,579	0,089	0,068	0,754	0,470	0,982	0,818	0,956
CO2 Tonnes Fuel Mio	-	0,708	-0,708	0,216	0,183	0,859	0,356	0,145	0,156	0,089	0,310	0,578	0,089	0,067	0,754	0,471	0,982	0,819	0,956
Free Cash Flow	-	0,380	-0,380	0,011	-0,020	0,352	0,172	0,019	0,029	-0,064	0,111	0,248	0,070	0,036	0,381	0,306	0,440	0,497	0,399
>50% State owned	-	-0,371	0,371	0,005	0,020	-0,214	-0,175	0,084	0,054	0,098	-0,151	-0,173	-0,143	-0,151	-0,382	-0,282	-0,467	-0,494	-0,438
Listed	-	0,359	-0,359	-0,007	-0,017	0,217	0,179	0,096	-0,055	-0,104	0,157	0,164	0,138	0,160	0,381	0,274	0,473	0,500	0,445
Private	-	0,076	-0,076	0,011	-0,015	-0,026	-0,033	0,084	0,004	0,036	0,038	0,063	0,034	0,064	0,002	0,046	-0,046	-0,046	-0,051
Network	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LargeNet/Mixed	-	1,000	-1,000	-0,120	-0,177	0,737	0,215	0,002	-0,200	-0,151	0,366	0,511	0,022	0,330	0,352	0,630	0,671	0,583	0,587
Small Network	-	-1,000	1,000	0,120	0,177	-0,737	-0,215	-0,002	0,200	0,151	-0,366	-0,511	-0,022	-0,330	-0,352	-0,630	-0,671	-0,583	-0,587
RASK	-	-0,120	0,120	1,000	0,971	0,169	-0,389	0,426	0,941	0,968	-0,237	0,217	-0,193	0,031	0,227	-0,252	0,233	0,271	0,363
CASK	-	-0,177	0,177	0,971	1,000	0,141	-0,381	0,427	0,971	0,943	-0,208	0,201	-0,151	0,026	0,204	-0,293	0,204	0,236	0,344
Log employees	-	0,737	-0,737	0,169	0,141	1,000	0,407	-0,052	0,160	0,109	0,547	0,783	0,103	0,427	0,675	0,512	0,835	0,727	0,834
SLF	-	0,215	-0,215	-0,389	-0,381	0,407	1,000	-0,291	-0,337	-0,463	0,097	0,266	0,129	0,037	0,462	0,310	0,343	0,262	0,319
Fuel CASK	-	0,002	-0,002	0,426	0,427	-0,052	-0,291	1,000	0,210	0,340	-0,009	-0,107	-0,023	0,346	0,154	-0,145	0,130	0,089	0,165
Non Fuel CASK	-	-0,200	0,200	0,941	0,971	0,160	-0,337	0,210	1,000	0,932	-0,207	0,230	-0,164	0,041	0,178	-0,294	0,182	0,226	0,325
RRPK Yield	-	-0,151	0,151	0,968	0,943	0,109	-0,463	0,340	0,932	1,000	-0,243	0,195	-0,180	-0,061	0,098	-0,284	0,110	0,180	0,239
Pax/Employees	-	0,366	-0,366	-0,237	-0,208	0,547	0,097	-0,009	-0,207	-0,243	1,000	0,693	0,029	0,729	0,293	0,331	0,292	0,236	0,341
Employees/Fleet	-	0,511	-0,511	0,217	0,201	0,783	0,266	-0,107	0,230	0,195	0,693	1,000	0,099	0,629	0,644	0,460	0,557	0,498	0,622
Invest/Assetbase	-	0,022	-0,022	-0,193	-0,151	0,103	0,129	-0,023	-0,164	-0,180	0,029	0,099	1,000	0,029	0,153	0,095	0,090	0,077	0,074
Sales/Employees	-	0,330	-0,330	0,031	0,026	0,427	0,037	0,346	0,041	-0,061	0,729	0,629	0,029	1,000	0,081	-0,232	0,051	-0,068	0,112
Sales/Aircraft	-	0,352	-0,352	0,227	0,204	0,675	0,462	0,154	0,178	0,098	0,293	0,644	0,153	0,081	1,000	0,429	0,744	0,612	0,750
Skytrax	-	0,630	-0,630	-0,252	-0,293	0,512	0,310	-0,145	-0,294	-0,284	0,331	0,460	0,095	-0,232	0,429	1,000	0,445	0,454	0,383
Total Liabs Mio	-	0,671	-0,671	0,233	0,204	0,835	0,343	0,130	0,182	0,110	0,292	0,557	0,090	0,051	0,744	0,445	1,000	0,804	0,959
Equity Mio	-	0,583	-0,583	0,271	0,236	0,727	0,262	0,089	0,226	0,180	0,236	0,498	0,077	-0,068	0,612	0,454	0,804	1,000	0,793
Labour Costs Mio	-	0,587	-0,587	0,363	0,344	0,834	0,319	0,165	0,325	0,239	0,341	0,622	0,074	0,112	0,750	0,383	0,959	0,793	1,000
Ancill. Pax Revenue	-	0,376	-0,376	0,031	0,027	0,497	0,262	0,030	0,016	0,046	0,186	0,302	0,149	0,075	0,551	0,304	0,648	0,485	0,589
Cash&Liq y/e	-	0,583	-0,583	0,284	0,247	0,754	0,317	0,133	0,230	0,168	-0,235	0,517	0,060	0,010	0,732	0,395	0,891	0,791	0,872
Interest bearing Debt	-	0,669	-0,669	0,089	0,076	0,760	0,313	0,027	0,069	-0,004	-0,239	0,439	0,138	-0,032	0,616	0,408	0,901	0,733	0,827
EBITDA	-	0,276	-0,276	0,047	0,002	0,238	0,138	-0,035	0,010	-0,014	-0,025	0,079	-0,018	0,036	0,168	0,235	0,279	0,268	0,263
Debt/Equity	-	0,097	-0,097	-0,075	-0,099	0,071	0,036	-0,024	-0,101	-0,082	-0,000	-0,014	0,043	-0,005	-0,008	0,055	0,085	-0,041	0,023
Flights Number	-	0,599	-0,599	0,363	0,328	0,842	0,298	0,123	0,322	0,264	-0,232	0,525	0,029	-0,087	0,654	0,314	0,913	0,804	0,912
Unit Labour costs/Employee	-	-0,230	0,230	0,170	0,196	0,148	0,492	0,071	0,208	0,067	0,172	-0,016	0,049	0,466	0,514	-0,086	0,308	0,216	0,344
OPEX less labour and fuel	-	0,628	-0,628	0,353	0,323	0,837	0,309	0,149	0,308	0,232	-0,314	0,609	0,051	-0,084	0,750	0,414	0,959	0,843	0,970
Pax per flight	-	-0,070	0,070	-0,502	-0,492	-0,076	0,573	-0,125	-0,505	-0,568	0,144	-0,085	0,137	0,271	0,231	0,400	0,009	0,001	-0,070
Ancill. Rev per Pax	-	-0,236	0,236	-0,062	-0,018	-0,105	0,179	-0,020	-0,023	-0,084	-0,112	0,046	0,108	0,118	0,238	0,112	-0,004	0,013	-0,015
Network airports	-	0,718	-0,718	0,063	0,023	0,767	0,375	0,001	0,020	0,024	-0,158	0,455	0,096	-0,097	0,515	0,427	0,760	0,625	0,691
Global Alliance	-	0,113	-0,113	0,165	0,183	0,411	0,253	0,064	0,186	0,119	0,049	0,208	0,054	0,133	0,403	0,076	0,341	0,287	0,329
Tonnesk Cargo	-	0,661	-0,661	0,359	0,326	0,814	0,273	0,183	0,299	0,249	-0,325	0,640	0,031	-0,139	0,702	0,442	0,890	0,857	0,905
Liquidity/Sales	-	-0,151	0,151	-0,122	-0,115	-0,187	0,216	-0,143	-0,086	-0,131	0,425	-0,135	0,075	0,275	0,093	0,083	-0,026	0,038	-0,030
Net Debt Mio	-	0,571	-0,571	-0,054	-0,049	0,591	0,240	-0,047	-0,048	-0,111	-0,187	0,291	0,156	-0,052	0,404	0,323	0,703	0,531	0,611
NetDebt/EBITDA	-	0,110	-0,110	0,121	0,102	0,196	0,013	0,016	0,105	0,114	-0,197	0,112	-0,118	-0,089	0,056	-0,028	0,101	0,072	0,100
Journey length	-	0,438	-0,438	-0,290	-0,304	0,368	0,177	0,028	-0,347	-0,367	-0,614	0,403	0,097	-0,274	0,336	0,403	0,317	0,168	0,263
AC Age	-	-0,142	0,142	0,254	0,245	0,042	-0,005	0,249	0,205	0,151	-0,257	0,017	-0,171	0,047	0,158	-0,364	0,137	0,065	0,173
Tonnes per aircraft	-	0,541	-0,541	0,207	0,162	0,601	0,213	0,084	0,144	0,131	-0,382	0,597	-0,009	-0,165	0,618	0,437	0,583	0,635	0,571
Flights/Destinations	-	0,222	-0,222	0,504	0,488	0,614	0,040	0,110	0,506	0,468	-0,198	0,366	-0,011	-0,115	0,439	-0,029	0,600	0,556	0,657

Network Carrier Airlines	Ancill. Pax Revenue	Cash&Liq y/e	Int.bearing Debt	EBITDA	Debt/Equity	Flights Number	Unit Labour/Eee	OPEX less labour and fuel	Pax per flight	Ancill. Rev per Pax	Network airports	Global Alliance	Tonnesk Cargo	Liquidity/Sales	Net Debt Mio	NetDebt/EBITDA	Journey length	AC Age	Tonnes per aircraft	Flights/Dest.
2000	0,064	-0,052	0,018	-0,008	-0,001	-0,016	-0,127	-0,022	-0,141	0,073	-0,049	-0,033	-0,036	-0,074	0,059	0,022	-0,029	-0,014	-0,018	0,078
2001	0,061	-0,057	0,030	-0,009	-0,003	-0,023	-0,093	-0,023	-0,130	0,076	-0,039	-0,033	-0,038	-0,073	0,078	0,060	0,000	-0,051	-0,046	0,018
2002	0,013	-0,015	0,032	-0,003	-0,010	-0,011	-0,106	-0,005	-0,141	0,012	-0,016	-0,082	0,000	-0,058	0,054	0,030	-0,031	-0,099	0,051	0,020
2003	-0,012	-0,022	-0,026	-0,007	-0,013	-0,032	-0,111	-0,026	-0,082	-0,010	-0,038	-0,064	-0,017	0,000	-0,023	0,059	-0,053	-0,121	0,034	0,019
2004	-0,014	-0,020	-0,038	-0,008	-0,016	-0,019	-0,106	-0,032	-0,066	-0,015	-0,032	-0,064	0,003	-0,044	-0,041	0,024	-0,005	-0,065	0,093	0,016
2005	-0,076	-0,029	-0,063	-0,006	-0,017	-0,037	-0,043	-0,051	-0,026	-0,086	-0,018	0,048	-0,014	0,041	-0,070	0,014	-0,051	-0,093	0,052	-0,009
2006	-0,024	-0,002	-0,030	0,008	-0,020	-0,028	-0,036	-0,012	0,037	-0,061	-0,004	0,033	0,022	0,071	-0,041	0,004	-0,010	-0,058	0,046	-0,016
2007	-0,026	0,052	-0,045	0,019	-0,022	-0,018	0,004	-0,003	0,034	-0,054	-0,042	0,100	0,032	0,097	-0,096	-0,008	0,013	-0,038	0,059	0,010
2008	-0,028	-0,018	-0,069	-0,266	-0,032	-0,046	-0,037	-0,023	0,018	0,054	-0,048	-0,011	-0,006	0,038	-0,085	0,006	-0,004	-0,051	0,013	-0,027
2009	-0,092	-0,084	-0,097	-0,032	-0,028	-0,110	-0,118	-0,085	-0,146	-0,016	-0,123	-0,027	-0,077	-0,035	-0,083	-0,229	-0,054	-0,063	-0,128	-0,071
2010	-0,065	-0,014	-0,032	-0,018	-0,030	-0,051	-0,046	-0,046	0,072	0,018	-0,053	-0,001	-0,016	0,049	-0,036	-0,044	0,046	-0,043	0,023	-0,029
2011	0,009	-0,025	-0,014	-0,012	-0,028	-0,007	-0,044	-0,019	-0,120	0,062	-0,070	-0,011	0,008	0,002	-0,004	0,042	0,033	-0,027	0,010	0,075
2012	0,034	-0,007	-0,006	-0,005	-0,024	-0,008	0,075	-0,006	0,034	0,099	-0,040	-0,011	0,005	-0,003	-0,004	-0,005	0,022	-0,010	0,007	-0,003
2013	0,019	0,009	-0,005	0,120	-0,019	0,013	0,090	0,002	0,024	0,060	0,023	0,011	0,003	0,019	0,012	0,015	0,009	0,037	0,000	-0,007
2014	0,002	-0,019	-0,015	-0,005	-0,046	-0,008	0,042	-0,008	0,050	0,016	0,032	-0,001	-0,015	0,000	-0,009	0,032	-0,024	0,051	-0,036	-0,069
2015	0,012	0,009	0,024	0,023	0,023	0,029	0,052	0,013	0,044	-0,016	0,076	0,050	-0,011	-0,031	0,028	-0,016	-0,012	0,069	-0,046	-0,042
2016	0,004	0,046	0,029	0,024	-0,010	0,038	0,064	0,041	0,058	-0,051	0,052	0,050	-0,007	-0,041	0,012	0,032	0,000	0,101	-0,056	-0,015
2017	0,009	0,072	0,036	0,050	-0,019	0,055	0,091	0,071	0,120	-0,064	0,059	0,050	-0,007	-0,026	0,005	0,009	-0,014	0,105	-0,072	-0,006
2018	0,043	0,033	0,037	0,053	-0,013	0,071	0,095	0,053	0,114	-0,057	0,084	0,050	-0,023	-0,051	0,031	0,035	-0,010	0,150	-0,054	0,005
EBIT Mio	0,370	0,574	0,407	0,270	0,077	0,575	0,074	0,546	-0,075	-0,096	0,506	0,167	0,454	0,013	0,209	0,013	0,101	0,096	0,290	0,327
Operating Cashflow	0,484	0,795	0,718	0,317	0,117	0,841	0,178	0,877	-0,032	-0,096	0,723	0,265	0,791	-0,039	0,507	0,055	0,216	0,118	0,515	0,492
Sales Mio	0,580	0,895	0,823	0,288	0,048	0,943	0,287	0,991	-0,032	-0,050	0,748	0,338	0,923	-0,044	0,592	0,092	0,269	0,160	0,586	0,643
OPEX Mio	0,576	0,889	0,827	0,279	0,034	0,938	0,294	0,991	-0,041	-0,044	0,736	0,339	0,927	-0,044	0,601	0,095	0,270	0,161	0,589	0,646
Investing Cash Flow t-1	-0,158	-0,543	-0,362	-0,179	-0,000	-0,640	-0,103	-0,619	0,153	0,160	-0,481	-0,172	-0,614	0,020	-0,167	-0,060	-0,012	-0,147	-0,416	-0,442
Cost of Fuel Mio	0,600	0,848	0,801	0,265	0,069	0,865	0,281	0,903	-0,067	-0,039	0,707	0,328	0,852	-0,053	0,589	0,086	0,329	0,163	0,534	0,572
Non Fuel OPEX Mio	0,558	0,883	0,818	0,277	0,024	0,940	0,295	0,996	-0,072	-0,046	0,730	0,337	0,930	-0,041	0,591	0,095	0,247	0,158	0,592	0,656
Fixed Asset Base Mio	0,629	0,863	0,913	0,281	0,085	0,910	0,281	0,947	-0,006	0,001	0,758	0,334	0,903	-0,033	0,738	0,105	0,305	0,122	0,618	0,601
Fleet Size year end	0,556	0,872	0,847	0,293	0,079	0,951	0,228	0,961	-0,073	-0,116	0,808	0,364	0,906	-0,079	0,639	0,127	0,255	0,101	0,545	0,651
Pax Mio	0,545	0,851	0,830	0,305	0,095	0,958	0,300	0,936	-0,025	-0,142	0,781	0,372	0,853	-0,032	0,628	0,098	0,154	0,108	0,505	0,674
ASK Mio	0,666	0,879	0,889	0,303	0,109	0,897	0,278	0,930	0,085	-0,029	0,787	0,358	0,847	-0,049	0,694	0,101	0,354	0,108	0,532	0,566
RPK Mio	0,669	0,872	0,883	0,304	0,113	0,885	0,289	0,920	0,105	-0,024	0,775	0,350	0,830	-0,046	0,689	0,096	0,357	0,118	0,512	0,554
Ave. Employees	0,482	0,843	0,772	0,263	0,045	0,919	0,179	0,974	-0,124	-0,089	0,751	0,321	0,951	-0,075	0,553	0,103	0,269	0,113	0,627	0,623
Tonnes Fuel Mio	0,654	0,907	0,882	0,295	0,067	0,910	0,290	0,954	0,020	-0,022	0,785	0,353	0,900	-0,032	0,667	0,100	0,349	0,135	0,608	0,583
CO2 Tonnes Fuel Mio	0,653	0,907	0,883	0,295	0,067	0,910	0,290	0,954	0,021	-0,022	0,785	0,352	0,900	-0,032	0,667	0,100	0,349	0,134	0,609	0,583
Free Cash Flow	0,371	0,495	0,410	0,184	-0,004	0,336	0,075	0,447	0,134	0,077	0,299	0,142	0,403	0,028	0,264	-0,010	0,250	0,019	0,318	0,145
>50% State owned	-0,358	-0,521	-0,445	-0,164	-0,065	-0,358	-0,177	-0,431	0,116	0,065	-0,321	0,198	-0,487	-0,448	-0,296	0,158	-0,060	-0,053	-0,487	-0,129
Listed	0,364	0,527	0,448	0,165	-0,065	0,365	0,190	0,437	0,121	0,075	0,327	-0,173	0,492	0,449	0,297	-0,159	0,068	0,061	0,483	0,136
Private	0,046	-0,047	-0,030	-0,005	-0,002	-0,053	-0,086	-0,048	-0,040	-0,065	-0,044	-0,164	-0,044	-0,013	-0,012	0,009	-0,057	-0,057	0,018	-0,048
Network	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LargeNet/Mixed	0,376	0,583	0,669	0,276	0,097	0,599	-0,230	0,628	-0,070	-0,236	0,718	0,113	0,661	-0,151	0,571	0,110	0,438	-0,142	0,541	0,222
Small Network	-0,376	-0,583	-0,669	-0,276	-0,097	-0,599	0,230	-0,628	0,070	0,236	-0,718	-0,113	-0,661	0,151	-0,571	-0,110	-0,438	0,142	-0,541	-0,222
RASK	0,031	0,284	0,089	0,047	-0,075	0,363	0,170	0,353	-0,502	-0,062	0,063	0,165	0,359	-0,122	-0,054	0,121	-0,290	0,254	0,207	0,504
CASK	0,027	0,247	0,076	0,002	-0,099	0,328	0,196	0,323	-0,492	-0,018	0,023	0,183	0,326	-0,115	-0,049	0,102	-0,304	0,245	0,162	0,488
Log employees	0,497	0,754	0,760	0,238	0,071	0,842	0,148	0,837	-0,076	-0,105	0,767	0,411	0,814	-0,187	0,591	0,196	0,368	0,042	0,601	0,614
SLF	0,262	0,317	0,313	0,138	0,036	0,298	0,492	0,309	0,573	0,179	0,375	0,253	0,273	0,216	0,240	0,013	0,177	-0,005	0,213	0,040
Fuel CASK	0,030	0,133	0,027	-0,035	-0,024	0,123	0,071	0,149	-0,125	-0,020	0,001	0,064	0,183	-0,143	-0,047	0,016	0,028	0,249	0,084	0,110
Non Fuel CASK	0,016	0,230	0,069	0,010	-0,101	0,322	0,208	0,308	-0,505	-0,023	0,020	0,186	0,299	-0,086	-0,048	0,105	-0,347	0,205	0,144	0,506
RRPK Yield	0,046	0,168	-0,004	-0,014	-0,082	0,264	0,067	0,232	-0,568	-0,084	0,024	0,119	0,249	-0,131	-0,111	0,114	-0,367	0,151	0,131	0,468
Pax/Employees	0,186	-0,235	-0,239	-0,025	-0,000	-0,232	0,172	-0,314	0,144	-0,112	-0,158	0,049	-0,325	0,425	-0,187	-0,197	-0,614	-0,257	-0,382	-0,198
Employees/Fleet	0,302	0,517	0,439	0,079	-0,014	0,525	-0,016	0,609	-0,085	0,046	0,455	0,208	0,640	-0,135	0,291	0,112	0,403	0,017	0,597	0,366
Invest/Assetbase	0,149	0,060	0,138	-0,018	0,043	0,029	0,049	0,051	0,137	0,108	0,096	0,054	0,031	0,075	0,156	-0,118	0,097	-0,171	-0,009	-0,011
Sales/Employees	0,075	0,010	-0,032	0,036	-0,005	-0,087	0,466	-0,084	0,271	0,118	-0,097	0,133	-0,139	0,275	-0,052	-0,089	-0,274	0,047	-0,165	-0,115
Sales/Aircraft	0,551	0,732	0,616	0,168	-0,008	0,654	0,514	0,750	0,231	0,238	0,515	0,403	0,702	0,093	0,404	0,056	0,336	0,158	0,618	0,439
Skytrax	0,304	0,395	0,408	0,235	0,055	0,314	-0,086	0,414	0,400	0,112	0,427	0,076	0,442	0,083	0,323	-0,028	0,403	-0,364	0,437	-0,029
Total Liabs Mio	0,648	0,891	0,901	0,279	0,085	0,913	0,308	0,959	0,009	-0,004	0,760	0,341	0,890	-0,026	0,703	0,101	0,317	0,137	0,583	0,600
Equity Mio	0,485	0,791	0,733	0,268	-0,041	0,804	0,216	0,843	0,001	0,013	0,625	0,287	0,857	0,038	0,531	0,072	0,168	0,065	0,635	0,556
Labour Costs Mio	0,589	0,872	0,827	0,263	0,023	0,912	0,344	0,970	-0,070	-0,015	0,691	0,329	0,905	-0,030	0,611	0,100	0,263	0,173	0,571	0,657
Ancill. Pax Revenue	1,000	0,689	0,707	0,170	-0,009	0,450	0,362	0,535	0,164	0,493	0,398	0,222	0,377	0,086	0,558	0,046	0,376	0,091	0,211	0,283
Cash&Liq y/e	0,689	1,000	0,772	0,262	-0,014	0,830	0,357	0,880	0,002	0,037	0,694	0,281	0,806	0,185	0,454	0,040	0,243	0,141	0,526	0,553
Interest bearing Debt	0,707	0,772	1,000	0,240	0,022	0,779	0,303	0,805	0,012	0,075	0,685	0,330	0,760	-0,025	0,917	0,136	0,342	0,050	0,534	0,515
EBITDA	0,170	0,262	0,240	1,000	0,063	0,283	0,075	0,282	0,052	-0,086	0,300	0,063	0,247	-0,010	0,171	0,018	0,064	-0,029	0,146	0,133
Debt/Equity	-0,009	-0,014	0,022	0,063	1,000	0,070	-0,053	0,024	-0,043	-0,078	0,174	0,035	0,009	-0,073	0,039	0,010	0,050	-0,048	-0,044	-0,009
Flights Number	0,450	0,830	0,779	0,283	0,070	1,000	0,285	0,946	-0,191	-0,195	0,782	0,378	0,892	-0,048	0,570	0,120	0,064	0,122	0,545	0,774
Unit Labour costs/Employee	0,362	0,357	0,303	0,075	-0,053	0,285	1,000	0,265	0,293	0,308	0,081	0,217	0,173	0,358	0,201	-0,024	-0,078	0,288	0,069	0,314
OPEX less labour and fuel	0,535	0,880	0,805	0,282	0,024	0,946	0,265	1,000	-0,072	-0,062	0,743	0,337	0,933	-0,046	0,574	0,092	0,235	0,148	0,597	0,649
Pax per flight	0,164	0,002	0,012	0,052	-0,043	-0,191	0,293	-0,072	1,000	0,374	-0,045	-0,065	-0,108	0,178	0,016	-0,099	-0,239	-0,079	-0,015	-0,426
Ancill. Rev per Pax	0,493	0,037	0,075	-0,086	-0,078	-0,195	0,308	-0,062	0,374	1,000	-0,191	-0,037	-0,118	0,108	0,082	-0,064	0,333	0,069	0,022	-0,235
Network airports	0,398	0,694	0,685	0,300	0,174	0,782	0,081	0,743	-0,045	-0,191	1,000	0,365	0,741	-0,032	0,523	0,083	0,202	-0,078	0,499	0,318
Global Alliance	0,222	0,281	0,330	0,063	0,035	0,378	0,217	0,337	-0,065	-0,037	0,365	1,000	0,305	0,237	0,285	0,189	-0,043	-0,180	0,165	0,328
Tonnesk Cargo	0,377	0,806	0,760	0,247	0,009	0,892	0,173	0,933	-0,108	-0,118	0,741	0,305	1,000	-0,053	0,558	0,092	0,239	0,121	0,782	0,574
Liquidity/Sales	0,086	0,185	-0,025	-0,010	-0,073	-0,048	0,358	-0,046	0,178	0,108	-0,032	0,237	-0,053	1,000	-0,151	-0,333	-0,303	-0,240	-0,136	-0,075
Net Debt Mio	0,558	0,454	0,917	0,171	0,039	0,570	0,201	0,574	0,016	0,082	0,523	0,285	0,558	-0,151	1,000	0,166	0,327	-0,018	0,419	0,374
NetDebt/EBITDA	0,046	0,040	0,136	0,018	0,010	0,120	-0,024	0,092	-0,099	-0,064	0,083	0,189	0,092	-0,333	0,166	1,000	0,120	0,151	0,115	0,157
Journey length	0,376	0,243	0,342	0,064	0,050	0,064	-0,078	0,235	-0,239	0,333	0,202	-0,043	0,239	-0,303	0,327	0,120	1,000	0,284	0,372	0,177
AC Age	0,091	0,141	0,050	-0,029	-0,048	0,122	0,288	0,148	-0,079	0,069	-0,078	-0,180	0,121	-0,240	-0,018	0,151	0,284	1,000	0,144	0,179
Tonnes per aircraft	0,211	0,526	0,534	0,146	-0,044	0,545	0,069	0,597	-0,015	0,022	0,499	0,165	0,782	-0,136	0,419	0,115	0,372	0,144	1,000	0,307
Flights/Destinations	0,283	0,553	0,515	0,133	-0,009	0,774	0,314	0,649	-0,426	-0,235	0,318	0,328	0,574	-0,075	0,374	0,157	0,177	0,179	0,307	1,000

Table 40: Pearson Correlation Coefficients Low-Cost Carrier Airlines Page 1 of 2

Low Cost Carrier Airlines	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	EBIT Mio	Op.Cashflow Mio	Sales Mio	OPEX Mio	Invest.Cash Flow t-1	Cost Fuel Mio	Non Fuel OPEX Mio	Fixed Asset Base Mio	Fleet Size y/e	Pax Mio	ASK Mio	RPK Mio	Ave. Ees	Tonnes Fuel Mio	CO2 Tonnes Fuel Mio	Free Cash Flow	>50% State owned
2000	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	1,000	-0,022	-0,022	-0,027	-0,032	-0,032	-0,032	-0,032	-0,032	-0,032	-0,032	-0,032	-0,032	-0,036	-0,036	-0,032	-0,032	-0,070	-0,088	-0,186	-0,192	0,073	-0,166	-0,191	-0,139	-0,170	-0,155	-0,168	-0,159	-0,190	-0,060	-0,060	-0,018	-0,036
2003	-	-	-0,022	1,000	-0,031	-0,039	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,051	-0,051	-0,045	-0,045	-0,083	-0,106	-0,206	-0,213	0,091	-0,211	-0,197	-0,164	-0,186	-0,164	-0,196	-0,186	-0,200	-0,085	-0,085	-0,049	-0,051
2004	-	-	-0,022	-0,031	1,000	-0,039	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,045	-0,051	-0,051	-0,045	-0,045	-0,085	-0,086	-0,193	-0,199	0,080	-0,204	-0,182	-0,163	-0,168	-0,151	-0,185	-0,176	-0,189	-0,085	-0,085	0,007	-0,051
2005	-	-	-0,027	-0,039	-0,039	1,000	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,063	-0,063	-0,055	-0,055	-0,102	-0,112	-0,210	-0,216	0,091	-0,216	-0,200	-0,189	-0,176	-0,163	-0,189	-0,185	-0,214	-0,105	-0,105	0,014	-0,063
2006	-	-	-0,032	-0,045	-0,045	-0,055	1,000	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,073	-0,073	-0,065	-0,065	-0,049	-0,061	-0,199	-0,216	-0,002	-0,193	-0,213	-0,146	-0,150	-0,130	-0,146	-0,150	-0,205	-0,062	-0,062	0,025	-0,073
2007	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	1,000	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,073	-0,073	-0,065	-0,065	-0,027	-0,018	-0,118	-0,126	0,036	-0,139	-0,109	-0,096	-0,111	-0,098	-0,110	-0,117	-0,097	-0,048	-0,048	-0,026	-0,073
2008	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	1,000	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,073	-0,073	-0,065	-0,065	-0,049	-0,063	-0,078	-0,089	0,056	-0,058	-0,098	-0,071	-0,072	-0,064	-0,069	-0,079	-0,061	-0,027	-0,027	-0,034	-0,073
2009	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	1,000	-0,065	-0,065	-0,065	-0,065	-0,065	-0,073	-0,073	-0,065	-0,065	-0,101	-0,090	-0,058	-0,055	-0,057	-0,033	-0,062	-0,063	-0,032	-0,045	-0,058	-0,068	-0,038	-0,024	-0,024	-0,041	-0,073
2010	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	-0,065	1,000	-0,065	-0,065	-0,065	-0,065	-0,073	-0,073	-0,065	-0,065	-0,047	-0,025	-0,033	-0,032	0,001	-0,058	-0,015	-0,031	0,023	-0,005	-0,015	-0,028	-0,007	-0,014	-0,014	-0,103	-0,073
2011	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	-0,065	-0,065	1,000	-0,065	-0,065	-0,065	-0,073	-0,073	-0,065	-0,065	-0,050	-0,049	0,030	0,039	0,056	0,037	0,037	-0,005	0,055	0,023	0,026	0,015	0,031	0,012	0,012	-0,061	-0,073
2012	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	1,000	-0,065	-0,065	-0,073	-0,073	-0,065	-0,065	0,039	-0,024	0,090	0,078	-0,112	0,129	0,045	0,014	0,069	0,038	0,051	0,037	0,054	0,025	0,025	0,039	-0,073
2013	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	1,000	-0,065	-0,073	-0,073	-0,065	-0,065	0,035	0,030	0,115	0,116	0,064	0,156	0,086	0,014	0,079	0,051	0,066	0,051	0,071	0,019	0,019	-0,106	-0,073
2014	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	1,000	-0,073	-0,073	-0,065	-0,065	-0,003	-0,042	0,155	0,171	-0,244	0,192	0,148	0,049	0,090	0,070	0,106	0,089	0,096	0,030	0,030	0,028	-0,073
2015	-	-	-0,036	-0,051	-0,051	-0,063	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	1,000	-0,082	-0,073	-0,073	0,065	0,058	0,102	0,100	0,037	0,092	0,098	0,043	0,024	0,017	0,029	0,033	0,029	0,002	0,002	-0,166	0,134
2016	-	-	-0,036	-0,051	-0,051	-0,063	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,082	1,000	-0,073	-0,073	0,055	0,019	0,100	0,131	-0,102	0,043	0,167	0,049	0,052	0,057	0,060	0,073	0,075	0,028	0,028	0,140	0,134
2017	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,073	-0,073	1,000	-0,065	0,125	0,158	0,112	0,108	-0,110	0,060	0,126	0,141	0,121	0,134	0,131	0,152	0,128	0,081	0,081	0,071	0,167
2018	-	-	-0,032	-0,045	-0,045	-0,055	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,065	-0,073	-0,073	-0,065	1,000	0,142	0,198	0,144	0,137	0,034	0,126	0,132	0,212	0,149	0,178	0,202	0,222	0,213	0,100	0,100	0,228	0,167
EBIT Mio	-	-	-0,070	-0,083	-0,085	-0,102	-0,049	-0,027	-0,049	-0,101	-0,047	-0,050	0,039	0,035	-0,003	0,065	0,055	0,125	0,142	1,000	0,942	0,643	0,472	-0,513	0,702	0,315	0,778	0,770	0,834	0,726	0,753	0,545	0,760	0,760	0,455	-0,156
Operating Cashflow Mio	-	-	-0,088	-0,106	-0,086	-0,112	-0,061	-0,018	-0,063	-0,090	-0,025	-0,049	-0,024	0,030	-0,042	0,058	0,019	0,158	0,198	0,942	1,000	0,661	0,523	-0,542	0,741	0,369	0,862	0,824	0,886	0,811	0,832	0,604	0,852	0,852	0,440	-0,194
Sales Mio	-	-	-0,186	-0,206	-0,193	-0,210	-0,199	-0,118	-0,078	-0,058	-0,033	0,030	0,090	0,115	0,155	0,102	0,100	0,112	0,144	0,643	0,661	1,000	0,969	-0,319	0,954	0,904	0,843	0,936	0,900	0,926	0,928	0,967	0,521	0,521	0,316	-0,408
OPEX Mio	-	-	-0,192	-0,213	-0,199	-0,216	-0,216	-0,126	-0,089	-0,055	-0,032	0,039	0,078	0,116	0,171	0,100	0,131	0,108	0,137	0,472	0,523	0,969	1,000	-0,227	0,906	0,975	0,771	0,871	0,811	0,888	0,880	0,968	0,454	0,454	0,268	-0,418
Investing Cash Flow t-1	-	-	0,073	0,091	0,080	0,091	-0,002	0,036	0,056	-0,057	0,001	0,056	-0,112	0,064	-0,244	0,037	-0,102	-0,110	0,034	-0,513	-0,542	-0,319	-0,227	1,000	-0,416	-0,109	-0,444	-0,441	-0,488	-0,407	-0,408	-0,233	-0,506	-0,506	-0,471	0,162
Cost of Fuel Mio	-	-	-0,166	-0,211	-0,204	-0,216	-0,193	-0,139	-0,058	-0,033	-0,058	0,037	0,129	0,156	0,192	0,092	0,043	0,060	0,126	0,702	0,741	0,954	0,906	-0,416	1,000	0,789	0,889	0,950	0,925	0,953	0,947	0,906	0,663	0,663	0,313	-0,370
Non Fuel OPEX Mio	-	-	-0,191	-0,197	-0,182	-0,200	-0,213	-0,109	-0,098	-0,062	-0,015	0,037	0,045	0,086	0,148	0,098	0,167	0,126	0,132	0,315	0,369	0,904	0,975	-0,109	0,789	1,000	0,650	0,763	0,690	0,786	0,778	0,928	0,310	0,310	0,224	-0,412
Fixed Asset Base Mio	-	-	-0,139	-0,164	-0,163	-0,189	-0,146	-0,096	-0,071	-0,063	-0,031	-0,005	0,014	0,014	0,049	0,043	0,049	0,141	0,212	0,778	0,862	0,843	0,771	-0,444	0,889	0,650	1,000	0,911	0,929	0,944	0,951	0,824	0,710	0,710	0,308	-0,311
Fleet Size year end	-	-	-0,170	-0,186	-0,168	-0,176	-0,150	-0,111	-0,072	-0,032	0,023	0,055	0,069	0,079	0,090	0,024	0,052	0,121	0,149	0,770	0,824	0,936	0,871	-0,441	0,950	0,763	0,911	1,000	0,985	0,976	0,977	0,914	0,732	0,732	0,381	-0,377
Pax Mio	-	-	-0,155	-0,164	-0,151	-0,163	-0,130	-0,098	-0,064	-0,045	-0,005	0,023	0,038	0,051	0,070	0,017	0,057	0,134	0,178	0,834	0,886	0,900	0,811	-0,488	0,925	0,690	0,929	0,985	1,000	0,958	0,969	0,874	0,760	0,760	0,398	-0,342
ASK Mio	-	-	-0,168	-0,196	-0,185	-0,189	-0,146	-0,110	-0,069	-0,058	-0,015	0,026	0,051	0,066	0,106	0,029	0,060	0,131	0,202	0,726	0,811	0,926	0,888	-0,407	0,953	0,786	0,944	0,976	0,958	1,000	0,996	0,921	0,742	0,742	0,387	-0,376
RPK Mio	-	-	-0,159	-0,186	-0,176	-0,185	-0,150	-0,117	-0,079	-0,068	-0,028	0,015	0,037	0,051	0,089	0,033	0,073	0,152	0,222	0,753	0,832	0,928	0,880	-0,408	0,947	0,778	0,951	0,977	0,969	0,996	1,000	0,920	0,741	0,741	0,402	-0,356
Ave. Employees	-	-	-0,190	-0,200	-0,189	-0,214	-0,205	-0,097	-0,061	-0,038	-0,007	0,031	0,054	0,071	0,096	0,029	0,075	0,128	0,213	0,545	0,604	0,967	0,968	-0,233	0,906	0,928	0,824	0,914	0,874	0,921	0,920	1,000	0,484	0,484	0,327	-0,385
Tonnes Fuel Mio	-	-	-0,060	-0,085	-0,085	-0,105	-0,062	-0,048	-0,027	-0,024	-0,014	0,012	0,025	0,019	0,030	0,002	0,028	0,081	0,100	0,760	0,852	0,521	0,454	-0,506	0,663	0,310	0,710	0,732	0,760	0,742	0,741	0,484	1,000	1,000	0,460	-0,138
CO2 Tonnes Fuel Mio	-	-	-0,060	-0,085	-0,085	-0,105	-0,062	-0,048	-0,027	-0,024	-0,014	0,012	0,025	0,019	0,030	0,002	0,028	0,081	0,100	0,760	0,852	0,521	0,454	-0,506	0,663	0,310	0,710	0,732	0,760	0,742	0,741	0,484	1,000	1,000	0,460	-0,138
Free Cash Flow	-	-	-0,018	-0,049	0,007	0,014	0,025	-0,026	-0,034	-0,041	-0,103	-0,061	0,039	-0,106	0,028	-0,166	0,140	0,071	0,228	0,455	0,440	0,316	0,268	-0,471	0,313	0,224	0,308	0,381	0,398	0,387	0,402	0,327	0,460	0,460	1,000	-0,033
>50% State owned	-	-	-0,036	-0,051	-0,051	-0,063	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	-0,073	0,134	0,134	0,167	0,167	-0,156	-0,194	-0,408	-0,418	0,162	-0,370	-0,412	-0,311	-0,377	-0,342	-0,376	-0,356	-0,385	-0,138	-0,138	-0,033	1,000
Listed	-	-	-0,334	-0,205	0,066	-0,142	0,094	0,094	0,094	0,094	0,094	0,094	0,094	0,094	0,094	-0,069	-0,069	-0,100	-0,100	0,204	0,250	0,512	0,521	-0,240	0,468	0,510	0,394	0,465	0,425	0,462	0,440	0,493	0,179	0,179	0,028	-0,771
Private	-	-	0,568	0,386	-0,039	0,302	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,055	-0,063	-0,063	-0,055	-0,055	-0,122	-0,145	-0,283	-0,286	0,170	-0,264	-0,276	-0,222	-0,249	-0,232	-0,246	-0,238	-0,284	-0,105	-0,105	-0,002	-0,063
LCC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RASK	-	-	0,732	0,162	0,010	-0,035	-0,111	-0,050	-0,070	-0,056	-0,091	-0,060	-0,012	-0,023	-0,037	0,096	0,031	-0,014	-0,042	-0,308	-0,417	-0,426	-0,421	0,296	-0,459	-0,370	-0,521	-0,508	-0,492	-0,547	-0,518	-0,444	-0,399	-0,399	-0,120	0,404
CASK	-	-	0,765	0,146	0,029	-0,032	-0,111	-0,063	-0,067	-0,060	-0,083	-0,055	-0,038	-0,037	-0,032	0,067	0,046	-0,016	-0,027	-0,404	-0,471	-0,468	-0,416	0,340	-0,492	-0,344	-0,543	-0,542	-0,537	-0,548	-0,527	-0,455	-0,374	-0,374	-0,125	0,368
log Employees	-	-	-0,388	-0,247	-0,220	-0,193	-0,129	-0,021	0,014	0,037	0,061	0,087	0,106	0,122	0,141	0,046	0,059	0,038	0,055	0,447	0,487	0,886	0,884	-0,288	0,815	0,855	0,687	0,831	0,774	0,809	0,789	0,888	0,387	0,387	0,202	-0,442
SLF	-	-	-0,483	-0,208	-0,155	-0,087	-0,055	-0,032	-0,038	-0,041	-0,028	0,040	0,032	0,045	0,065	0,054	0,093	0,145	0,149	0,544	0,573	0,805	0,744	-0,358	0,737	0,692	0,723	0,763	0,763	0,734	0,750	0,769	0,346	0,346	0,166	-0,380
Fuel CASK	-	-	0,087	-0,201	-0,247	-0,213	-0,155	-0,082	0,140	0,016	-0,119	0,095	0,282	0,244	0,188	0,136	-0,125	-0,137	-0,030	-0,012	-0,131	0,094	0,067	-0,025	0,161	0,013	-0,112	-0,039	-0,050	-0,095	-0,086	-0,009	-0,135	-0,135	-0,152	0,154
Non Fuel CASK	-	-	0,775	0,171	0,056	-0,010	-0,097	-0,056	-0,084	-0,064	-0,072	-0,067	-0,069	-0,064	-0,053	0,054	0,060	-0,002	-0,024	-0,413	-0,469	-0,489	-0,433	0,352	-0,521	-0,354	-0,545	-0,552	-0,545	-0,552	-0,531	-0,465	-0,369	-0,369	0,112	0,361
Fuel tonnes/RPK	-	-	0,163	0,107	0,120	0,315	0,249	0,082	-0,118	-0,118	-0,118	-0,118	-0,118	-0,118	-0,118	-0,133	0,004	0,045	0,037	-0,247	-0,301	-0,538	0,534	0,329	-0,520	-0,501	-0,448	-0,489	-0,459	-0,459	-0,451	-0,497	-0,224	0,224	0,039	0,430
RRPK yield	-	-	0,837	0,161	0,023	-0,027	-0,083	-0,045	-0,056	-0,045	-0,070	-0,061	-0,031	-0,041	-0,053	0,046	0,002	-0,029	-0,037	-0,298	-0,373	-0,459	-0,448	0,274	-0,460	-0,408	-0,477	-0,498	-0,480	-0,513	-0,491	-0,462	-0,319	-0,319	0,101	0,336
Pax/Employees	-	-	-0,035	-0,047	-0,046	-0,055	-0,062	-0,064	-0,064	-0,065	-0,064	-0,064	-0,064	-0,065	-0,065	-0,074	0,149	0,206	0,211	-0,131	-0,163	-0,358	0,368	0,137	-0,322	-0,365	-0,268	-0,328	-0,295	-0,327	-0,309	-0,337	-0,114	-0,114	0,028	0,885
Employees/Fleet	-	-	-0,154	0,000	-0,088	-0,134	-0,157	-0,001	-0,015	-0,070	-0,117	-0,095	-0,052	-0,033	-0,023	0,116	0,159	0,128	0,217	-0,501	-0,511	-0,228	-0,107	0,473	-0,321	-0,014	-0,375	-0,406	-0,437	-0,337	-0,332	-0,122	-0,453	-0,453	0,093	0,673
Invest/Assetbase	-	-	-0,032	0,050	-0,013	-0,226	-0,244	0,030	-0,040	-0,075	-0,023	0,044	0,032	0,049	0,015	0,121	0,026	0,010	0,098	-0,016	0,004	0,365	0,431	0,350	0,276	0,480	0,189	0,273	0,198	0,299	0,277	0,420	0,013	0,013	-0,035	-0,015
Sales/Employee	-	-	-0,246	-0,158	-0,135	0,007	0,039	-0,027	0,018	-0,009	0,010	0,098	0,205	0,201	0,219	0,103	-0,026	-0,123	-0,193	0,418	0,386	0,563	0,502	-0,396	0,559	0,434	0,445	0,499	0,477	0,462	0,449	0,411	0,246	0,246	0,005	-0,688
Sales/Aircraft	-	-	-0,336	-0,125	-0,195	-0,136	-0,149	-0,025	0,017	-0,058	-0,110	0,005	0,147	0,165	0,209	0,181	0,112	-0,022	0,016	-0,256	-0,285	0,359	0,475	0,219	0,209	0,580	0,011	0,048	-0,030	0,104	0,092	0,353	-0,352	-0,352	-0,120	-0,191
Skytrax	-	-	0,117	0,166	0,166	0,060	-0,015	-0,015	-0,015	-0,015	-0,015	-0,015	-0,015	-0,015	-0,015	-0,075	-0,075	-0,015	-0,015	-0,149	-0,187	-0,173	-0,236	0,020	-0,225	-0,225	-0,114	-0,250	-0,213	-0,272	-0,240	-0,215	-0,510	-0,510	-0,267	-0,304
Total Liabs Mio	-	-	-0,147	-0,190	-0,181	-0,198	-0,155	-0,106	-0,078	-0,040	0,002	0,041	0,021	0,022	0,048	0,073	0,082	0,117	0,175	0,666	0,788	0,812	0,782	-0,383	0,876	0,674	0,949	0,880	0,873	0,939	0,931	0,804	0,750	0,750	0,247	-0,332
Equity Mio	-	-	-0,109	-0,091	-0,087	-0,122	-0,061	-0,020	-0,032	-0,028	-0,001	0,003	0,026	0,021	0,020	0,001	-0,030	0,108	0,127	0,906	0,921	0,713	0,565	-0,573	0,784	0,407	0,862	0,862	0,915	0,805	0,820	0,654	0,741	0,741	0,324	-0,246
Labour Costs Mio	-	-	-0,180	-0,202	-0,189	-0,222	-0,222	-0,148	-0,081	-0,067	-0,032	0,008	0,077	0,066	0,128	0,082	0,104	0,124	0,205	0,449	0,490	0,926	0,926	-0,197	0,835	0,906	0,770	0,811	0,781	0,815	0,825	0,944	0,275	0,275	0,209	-0,393
Ancill. Pax Revenue	-	-	-0,073	-0,099	-0,098	-0,117	-0,123	-0,110	-0,090	-0,080	-0,069	-0,055	0,146	0,168	0,219	0,191	-0,036	0,006	0,034	0,542	0,420	0,607	0,474	-0,223	0,589	0,378	0,490	0,510	0,519	0,454	0,475	0,468	0,176	0,176	0,202	-0,166
Cash&Liq y/e	-	-	-0,137	-0,127	-0,093	-0,111	0,012	0,000	-0,031	0,007	0,017	0,106	0,139	0,026	0,051	-0,065	-0,065	0,025	0,033	0,702	0,734	0,646	0,526	-0,626	0,709	0,390	0,750	0,787	0,810	0,718	0,711	0,603	0,612	0,612	0,295	-0,319
Interest bearing Debt	-	-	-0,130	-0,178	-0,174	-0,160	-0,124	-0,095	-0,073	-0,045	-0,008	0,041	0,041	0,018	0,031	0,049	0,073	0,100	0,118	0,519	0,670	0,655	0,660	-0,315	0,746	0,565	0,849	0,728	0,705	0,831	0,810	0,655	0,717	0,717	0,183	-0,291
EBITDA	-	-	-0,094	-0,110	-0,114	-0,142	-0,094	-0,069	-0,080	-0,109	-0,057	-0,059	0,025	0,022	0,041	0,038	0,051	0,150	0,254	0,938	0,954	0,736	0,611	-0,459	0,805	0,462	0,909	0,844	0,892	0,855	0,874	0,672	0,795	0,795	0,433	-0,208
Debt/Equity	-	-	-0,025	-0,077	-0,061	-0,019	-0,053	-0,041	-0,022	-0,044	-0,031	0,028	0,114	-0,190	-0,066	-0,049	-0,054	0,120	0,264	-0,189	-0,095	0,016	0,092	0,180	0,030	0,117	0,159	-0,059	-0,095	0,088	0,073	0,066	-0,121	-0,121	-0,076	-0,062
Flights number	-	-	-0,169	-0,167	-0,151	-0,154	-0,119	-0,086	-0,047	-0,029	0,015	0,043	0,054	0,063	0,081	0,012	0,042	0,102	0,140	0,797	0,831	0,909	0,819	-0,474	0,923	0,703	0,889	0,983	0,986	0,937	0,942	0,883	0,698	0,698	0,363	-0,352
Unit Labour costs	-	-	0,096	-0,060	-0,038	-0,079	-0,126	-0,147	0,011	-0,011	0,034	0,068	0,151	0,057	0,135	0,059	0,004	-0,068	-0,081	-0,106	-0,120	0,081	0,090	-0,053	0,019	0,120	0,016	-0,065	-0,057	-0,063	-0,045	0,018	-0,324	-0,324	-0,222	-0,464
OPEX less labour and fuel	-	-	-0,188	-0,190	-0,174	-0,187	-0,203	-0,095	-0,100	-0,059	-0,010	0,044	0,035	0,089	0,148	0,099	0,179	0,122	0,108	0,269	0,324	0,869	0,956	-0,082	0,751	0,993	0,597	0,726	0,643	0,753	0,741	0,894	0,309	0,309	0,221	-0,404
Pax per Flight	-	-	0,038	-0,004	-0,052	-0,012	0,037	0,043	-0,023	-0,015	-0,013	0,006	0,016	0,029	0,045	-0,068	-0,048	0,002	0,015	0,437	0,510	0,457	0,432	-0,322	0,494	0,367	0,567	0,495	0,516	0,535	0,540	0,420	0,444	0,444	0,164	-0,788
Ancill. Rev per Pax	-	-	-0,084	-0,109	-0,105	-0,119	-0,123	-0,100	-0,070	-0,055	-0,051	-0,045	0,189	0,200	0,238	0,189	-0,048	-0,024	-0,013	0,347	0,209	0,465	0,352	-0,129	0,436	0,282	0,319	0,323	0,317	0,275	0,289	0,321	-0,030	-0,030	0,073	-0,121
Network Airports	-	-	-0,284	-0,321	-0,270	-0,207	-0,136	-0,092	-0,022	0,008	0,076	0,100	0,138	0,155	0,152	0,037	0,037	0,070	0,105	0,516	0,593	0,867	0,887	-0,322	0,866	0,832	0,769	0,846	0,796	0,885	0,863	0,864	0,591	0,591	0,291	-0,476
Global Alliance	-	-	-0,052	-0,075	-0,075	-0,092	-0,107	-0,107	-0,107	-0,107	-0,107	-0,107	0,070	0,070	0,070	0,198	0,198	0,070	0,070	-0,367	-0,401	-0,194	-0,102	0,291	-0,231	-0,026	-0,391	-0,291	-0,318	-0,288	-0,281	-0,152	-0,203	-0,203	-0,090	0,678
Liquidity/Sales	-	-	-0,044	0,116	0,087	0,043	0,269	0,129	0,028	0,079	0,051	0,078	0,054	-0,058	-0,065	-0,177	-0,180	-0,106	-0,122	0,339	0,378	0,096	-0,007	-0,494	0,168	-0,100	0,292	0,277	0,324	0,209	0,194	0,062	0,342	0,342	0,079	-0,330
Net Debt	-	-	-0,076	-0,139	-0,153	-0,126	-0,153	-0,113	-0,069	-0,057	-0,019	-0,011	-0,030	0,007	0,008	0,095	0,123	0,104	0,121	0,219	0,380	0,411	0,485	-0,021	0,483	0,449	0,582	0,418	0,379	0,578	0,557	0,436	0,503	0,503	0,050	-0,164
NetDebt/EBITDA	-	-	0,047	-0,484	-0,232	-0,050	-0,180	0,006	0,060	0,079	0,118	-0,052	0,073	-0,067	-0,034	0,113	0,076	0,106	0,081	0,035	0,095	0,133	0,163	-0,064	0,138	0,164	0,236	0,121	0,091	0,201	0,178	0,163	0,067	0,067	0,018	0,137
Journey Length	-	-	-0,267	-0,232	-0,191	-0,114	-0,066	-0,044	-0,007	-0,034	-0,023	0,024	0,045	0,071	0,134	0,057	0,072	0,048	0,115	-0,136	-0,023	0,458	0,594	0,132	0,389	0,658	0,348	0,298	0,197	0,441	0,402	0,513	0,008	0,008	0,010	-0,351
AC Age	-	-	-0,121	-0,041	-0,058	-0,086	-0,156	-0,128	-0,102	-0,086	-0,104	-0,109	-0,076	-0,064	-0,009	0,124	0,173	0,197	0,228	-0,046	-0,111	-0,188	-0,181	0,195	-0,199	-0,158	-0,213	-0,214	-0,181	-0,223	-0,188	-0,160	-0,102	-0,102	0,073	0,831
Flights/Destinations	-	-	-0,186	0,033	0,038	-0,047	-0,039	-0,009	-0,017	-0,020	-0,010	0,017	0,010	0,008	0,025	-0,024	0,003	0,037	0,042	0,590	0,589	0,665	0,552	-0,396	0,633	0,468	0,624	0,729	0,738	0,634	0,639	0,633	0,383	0,383	0,179	-0,305

Table 40: Pearson Correlation Coefficients Low-Cost Carrier Airlines Page 2 of 2

Low Cost Carrier Airlines	Listed	Private	LCC	RASK	CASK	log Ees	SLF	FuelCASK	NonFuel CASK	Fuel tonnes/RPK	RRPK yield	Pax/Employees	Employees/Fleet	Invest/Assetbase	Sales/Employee	Sales/Aircraft	Skytrax	Total Liabs Mio	Equity Mio	Labour Costs Mio	Ancill. Pax Revenue	Cash&Liq y/e	Interest bearing Debt	EBITDA	Debt/Equity	Flights number	Unit Labour costs	OPEX less labour and fuel	Pax per Flight	Ancill. Rev per Pax	Network Airports	Global Alliance	Liquidity/Sales	Net Debt	NetDebt/EBITDA	Journey Length	AC Age	Flights/Dest.
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	-0,334	0,568	-	0,732	0,765	-0,388	-0,483	0,087	0,775	0,163	0,837	-0,035	-0,154	-0,032	-0,246	-0,336	0,117	-0,147	-0,109	-0,180	-0,073	-0,137	-0,130	-0,094	-0,025	-0,169	0,096	-0,188	0,038	-0,084	-0,284	-0,052	-0,044	-0,076	0,047	-0,267	-0,121	-0,186
2003	-0,205	0,386	-	0,162	0,146	-0,247	-0,208	-0,201	0,171	0,107	0,161	-0,047	0,000	0,050	-0,158	-0,125	0,166	-0,190	-0,091	-0,202	-0,099	-0,127	-0,178	-0,110	-0,077	-0,167	-0,060	-0,190	-0,004	-0,109	-0,321	-0,075	0,116	-0,139	-0,484	-0,232	-0,041	0,033
2004	0,066	-0,039	-	0,010	0,029	-0,220	-0,155	-0,247	0,056	0,120	0,023	-0,046	-0,088	-0,013	-0,135	-0,195	0,166	-0,181	-0,087	-0,189	-0,098	-0,093	-0,174	-0,114	-0,061	-0,151	-0,038	-0,174	-0,052	-0,105	-0,270	-0,075	0,087	-0,153	-0,232	-0,191	-0,058	0,038
2005	-0,142	0,302	-	-0,035	-0,032	-0,193	-0,087	-0,213	-0,010	0,315	-0,027	-0,055	-0,134	-0,226	0,007	-0,136	0,060	-0,198	-0,122	-0,222	-0,117	-0,111	-0,160	-0,142	-0,019	-0,154	-0,079	-0,187	-0,012	-0,119	-0,207	-0,092	0,043	-0,126	-0,050	-0,114	-0,086	-0,047
2006	0,094	-0,055	-	-0,111	-0,111	-0,129	-0,055	-0,155	-0,097	0,249	-0,083	-0,062	-0,157	-0,244	0,039	-0,149	-0,015	-0,155	-0,061	-0,222	-0,123	0,012	-0,124	-0,094	-0,053	-0,119	-0,126	-0,203	0,037	-0,123	-0,136	-0,107	0,269	-0,153	-0,180	-0,066	-0,156	-0,039
2007	0,094	-0,055	-	-0,050	-0,063	-0,021	-0,032	-0,082	-0,056	0,082	-0,045	-0,064	-0,001	0,030	-0,027	-0,025	-0,015	-0,106	-0,020	-0,148	-0,110	0,000	-0,095	-0,069	-0,041	-0,086	-0,147	-0,095	0,043	-0,100	-0,092	-0,107	0,129	-0,113	0,006	-0,044	-0,128	-0,009
2008	0,094	-0,055	-	-0,070	-0,067	0,014	-0,038	0,140	-0,084	-0,118	-0,056	-0,064	-0,015	-0,040	0,018	0,017	-0,015	-0,078	-0,032	-0,081	-0,090	-0,031	-0,073	-0,080	-0,022	-0,047	0,011	-0,100	-0,023	-0,070	-0,022	-0,107	0,028	-0,069	0,060	-0,007	-0,102	-0,017
2009	0,094	-0,055	-	-0,056	-0,060	0,037	-0,041	0,016	-0,064	-0,118	-0,045	-0,065	-0,070	-0,075	-0,009	-0,058	-0,015	-0,040	-0,028	-0,067	-0,080	0,007	-0,045	-0,109	-0,044	-0,029	-0,011	-0,059	-0,015	-0,055	0,008	-0,107	0,079	-0,057	0,079	-0,034	-0,086	-0,020
2010	0,094	-0,055	-	-0,091	-0,083	0,061	-0,028	-0,119	-0,072	-0,118	-0,070	-0,064	-0,117	-0,023	0,010	-0,110	-0,015	0,002	-0,001	-0,032	-0,069	0,017	-0,008	-0,057	-0,031	0,015	0,034	-0,010	-0,013	-0,051	0,076	-0,107	0,051	-0,019	0,118	-0,023	-0,104	-0,010
2011	0,094	-0,055	-	-0,060	-0,055	0,087	0,040	0,095	-0,067	-0,118	-0,061	-0,064	-0,095	0,044	0,098	0,005	-0,015	0,041	0,003	0,008	-0,055	0,106	0,041	-0,059	0,028	0,043	0,068	0,044	0,006	-0,045	0,100	-0,107	0,078	-0,011	-0,052	0,024	-0,109	0,017
2012	0,094	-0,055	-	-0,012	-0,038	0,106	0,032	0,282	-0,069	-0,118	-0,031	-0,064	-0,052	0,032	0,205	0,147	-0,015	0,021	0,026	0,077	0,146	0,139	0,041	0,025	0,114	0,054	0,151	0,035	0,016	0,189	0,138	0,070	0,054	-0,030	0,073	0,045	-0,076	0,010
2013	0,094	-0,055	-	-0,023	-0,037	0,122	0,045	0,244	-0,064	-0,118	-0,041	-0,065	-0,033	0,049	0,201	0,165	-0,015	0,022	0,021	0,066	0,168	0,026	0,018	0,022	-0,190	0,063	0,057	0,089	0,029	0,200	0,155	0,070	-0,058	0,007	-0,067	0,071	-0,064	0,008
2014	0,094	-0,055	-	-0,037	-0,032	0,141	0,065	0,188	-0,053	-0,118	-0,053	-0,065	-0,023	0,015	0,219	0,209	-0,015	0,048	0,020	0,128	0,219	0,051	0,031	0,041	-0,066	0,081	0,135	0,148	0,045	0,238	0,152	0,070	-0,065	0,008	-0,034	0,134	-0,009	0,025
2015	-0,069	-0,063	-	0,096	0,067	0,046	0,054	0,136	0,054	-0,133	0,046	-0,074	0,116	0,121	0,103	0,181	-0,075	0,073	0,001	0,082	0,191	-0,065	0,049	0,038	-0,049	0,012	0,059	0,099	-0,068	0,189	0,037	0,198	-0,177	0,095	0,113	0,057	0,124	-0,024
2016	-0,069	-0,063	-	0,031	0,046	0,059	0,093	-0,125	0,060	0,004	0,002	0,149	0,159	0,026	-0,026	0,112	-0,075	0,082	-0,030	0,104	-0,036	-0,065	0,073	0,051	-0,054	0,042	0,004	0,179	-0,048	-0,048	0,037	0,198	-0,180	0,123	0,076	0,072	0,173	0,003
2017	-0,100	-0,055	-	-0,014	-0,016	0,038	0,145	-0,137	-0,002	0,045	-0,029	0,206	0,128	0,010	-0,123	-0,022	-0,015	0,117	0,108	0,124	0,006	0,025	0,100	0,150	0,120	0,102	-0,068	0,122	0,002	-0,024	0,070	0,070	-0,106	0,104	0,106	0,048	0,197	0,037
2018	-0,100	-0,055	-	-0,042	-0,027	0,055	0,149	-0,030	-0,024	0,037	-0,037	0,211	0,217	0,098	-0,193	0,016	-0,015	0,175	0,127	0,205	0,034	0,033	0,118	0,254	0,264	0,140	-0,081	0,108	0,015	-0,013	0,105	0,070	-0,122	0,121	0,081	0,115	0,228	0,042
EBIT Mio	0,204	-0,122	-	-0,308	-0,404	0,447	0,544	-0,012	-0,413	-0,247	-0,298	-0,131	-0,501	-0,016	0,418	-0,256	-0,149	0,666	0,906	0,449	0,542	0,702	0,519	0,938	-0,189	0,797	-0,106	0,269	0,437	0,347	0,516	-0,367	0,339	0,219	0,035	-0,136	-0,046	0,590
Operating Cashflow Mio	0,250	-0,145	-	-0,417	-0,471	0,487	0,573	-0,131	-0,469	-0,301	-0,373	-0,163	-0,511	0,004	0,386	-0,285	-0,187	0,788	0,921	0,490	0,420	0,734	0,670	0,954	-0,095	0,831	-0,120	0,324	0,510	0,209	0,593	-0,401	0,378	0,380	0,095	-0,023	-0,111	0,589
Sales Mio	0,512	-0,283	-	-0,426	-0,468	0,886	0,805	0,094	-0,489	-0,538	-0,459	-0,358	-0,228	0,365	0,563	0,359	-0,173	0,812	0,713	0,926	0,607	0,646	0,655	0,736	0,016	0,909	0,081	0,869	0,457	0,465	0,867	-0,194	0,096	0,411	0,133	0,458	-0,188	0,665
OPEX Mio	0,521	-0,286	-	-0,421	-0,416	0,884	0,744	0,067	-0,433	-0,534	-0,448	-0,368	-0,107	0,431	0,502	0,475	-0,236	0,782	0,565	0,926	0,474	0,526	0,660	0,611	0,092	0,819	0,090	0,956	0,432	0,352	0,887	-0,102	-0,007	0,485	0,163	0,594	-0,181	0,552
Investing Cash Flow t-1	-0,240	0,170	-	0,296	0,340	-0,288	-0,358	-0,025	0,352	0,329	0,274	0,137	0,473	0,350	-0,396	0,219	0,020	-0,383	-0,573	-0,197	-0,223	-0,626	-0,315	-0,459	0,180	-0,474	-0,053	-0,082	-0,322	-0,129	-0,322	0,291	-0,494	-0,021	-0,064	0,132	0,195	-0,396
Cost of Fuel Mio	0,468	-0,264	-	-0,459	-0,492	0,815	0,737	0,161	-0,521	-0,520	-0,460	-0,322	-0,321	0,276	0,559	0,209	-0,225	0,876	0,784	0,835	0,589	0,709	0,746	0,805	0,030	0,923	0,019	0,751	0,494	0,436	0,866	-0,231	0,168	0,483	0,138	0,389	-0,199	0,633
Non Fuel OPEX Mio	0,510	-0,276	-	-0,370	-0,344	0,855	0,692	0,013	-0,354	-0,501	-0,408	-0,365	0,014	0,480	0,434	0,580	-0,225	0,674	0,407	0,906	0,378	0,390	0,565	0,462	0,117	0,703	0,120	0,993	0,367	0,282	0,832	-0,026	-0,100	0,449	0,164	0,658	-0,158	0,468
Fixed Asset Base Mio	0,394	-0,222	-	-0,521	-0,543	0,687	0,723	-0,112	-0,545	-0,448	-0,477	-0,268	-0,375	0,189	0,445	0,011	-0,114	0,949	0,862	0,770	0,490	0,750	0,849	0,909	0,159	0,889	0,016	0,597	0,567	0,319	0,769	-0,391	0,292	0,582	0,236	0,348	-0,213	0,624
Fleet Size year end	0,465	-0,249	-	-0,508	-0,542	0,831	0,763	-0,039	-0,552	-0,489	-0,498	-0,328	-0,406	0,273	0,499	0,048	-0,250	0,880	0,862	0,811	0,510	0,787	0,728	0,844	-0,059	0,983	-0,065	0,726	0,495	0,323	0,846	-0,291	0,277	0,418	0,121	0,298	-0,214	0,729
Pax Mio	0,425	-0,232	-	-0,492	-0,537	0,774	0,763	-0,050	-0,545	-0,459	-0,480	-0,295	-0,437	0,198	0,477	-0,030	-0,213	0,873	0,915	0,781	0,519	0,810	0,705	0,892	-0,095	0,986	-0,057	0,643	0,516	0,317	0,796	-0,318	0,324	0,379	0,091	0,197	-0,181	0,738
ASK Mio	0,462	-0,246	-	-0,547	-0,548	0,809	0,734	-0,095	-0,552	-0,459	-0,513	-0,327	-0,337	0,299	0,462	0,104	-0,272	0,939	0,805	0,815	0,454	0,718	0,831	0,855	0,088	0,937	-0,063	0,753	0,535	0,275	0,885	-0,288	0,209	0,578	0,201	0,441	-0,223	0,634
RPK Mio	0,440	-0,238	-	-0,518	-0,527	0,789	0,750	-0,086	-0,531	-0,451	-0,491	-0,309	-0,332	0,277	0,449	0,092	-0,240	0,931	0,820	0,825	0,475	0,711	0,810	0,874	0,073	0,942	-0,045	0,741	0,540	0,289	0,863	-0,281	0,194	0,557	0,178	0,402	-0,188	0,639
Ave. Employees	0,493	-0,284	-	-0,444	-0,455	0,888	0,769	-0,009	-0,465	-0,497	-0,462	-0,337	-0,122	0,420	0,411	0,353	-0,215	0,804	0,654	0,944	0,468	0,603	0,655	0,672	0,066	0,883	0,018	0,894	0,420	0,321	0,864	-0,152	0,062	0,436	0,163	0,513	-0,160	0,633
Tonnes Fuel Mio	0,179	-0,105	-	-0,399	-0,374	0,387	0,346	-0,135	-0,369	-0,224	-0,319	-0,114	-0,453	0,013	0,246	-0,352	-0,510	0,750	0,741	0,275	0,176	0,612	0,717	0,795	-0,121	0,698	-0,324	0,309	0,444	-0,030	0,591	-0,203	0,342	0,503	0,067	0,008	-0,102	0,383
CO2 Tonnes Fuel Mio	0,179	-0,105	-	-0,399	-0,374	0,387	0,346	-0,135	-0,369	-0,224	-0,319	-0,114	-0,453	0,013	0,246	-0,352	-0,510	0,750	0,741	0,275	0,176	0,612	0,717	0,795	-0,121	0,698	-0,324	0,309	0,444	-0,030	0,591	-0,203	0,342	0,503	0,067	0,008	-0,102	0,383
Free Cash Flow	0,028	-0,002	-	-0,120	-0,125	0,202	0,166	-0,152	-0,112	0,039	-0,101	-0,028	-0,093	-0,035	0,005	-0,120	-0,267	0,247	0,324	0,209	0,202	0,295	0,183	0,433	-0,076	0,363	-0,222	0,221	0,164	0,073	0,291	-0,090	0,079	0,050	0,018	0,010	0,073	0,179
>50% State owned	-0,771	-0,063	-	0,404	0,368	-0,442	-0,380	0,154	0,361	0,430	0,336	0,885	0,673	0,015	-0,688	-0,191	-0,304	-0,332	-0,246	-0,393	-0,166	-0,319	-0,291	-0,208	-0,062	-0,352	-0,464	-0,404	-0,788	-0,121	-0,476	0,678	-0,330	-0,164	-0,137	-0,351	0,831	-0,305
Listed	1,000	-0,588	-	-0,643	-0,639	0,641	0,652	-0,049	-0,650	-0,607	-0,649	-0,680	-0,459	-0,105	0,723	0,374	0,209	0,418	0,315	0,501	0,213	0,397	0,364	0,269	0,069	0,440	0,403	0,496	0,639	0,184	0,606	-0,490	0,276	0,207	0,048	0,454	-0,585	0,407
Private	-0,588	1,000	-	0,494	0,534	-0,442	-0,539	-0,119	0,560	0,405	0,591	-0,059	-0,136	0,146	-0,258	-0,344	0,060	-0,233	-0,182	-0,286	-0,124	-0,218	-0,202	-0,157	-0,028	-0,242	-0,041	-0,264	0,000	-0,134	-0,345	-0,092	-0,014	-0,116	-0,249	-0,265	-0,140	-0,249
LCC	-	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RASK	-0,643	0,494	-	1,000	0,970	-0,631	-0,644	0,367	0,956	0,323	0,972	0,331	0,330	-0,073	-0,499	-0,134	0,139	-0,559	-0,427	-0,370	-0,077	-0,476	-0,555	-0,412	-0,170	-0,489	0,036	-0,358	-0,391	-0,023	-0,635	0,382	-0,346	-0,388	-0,216	-0,495	0,348	-0,402
CASK	-0,639	0,534	-	0,970	1,000	-0,663	-0,728	0,285	0,995	0,371	0,976	0,306	0,359	-0,043	-0,565	-0,132	0,062	-0,539	-0,515	-0,400	-0,220	-0,556	-0,496	-0,463	-0,095	-0,549	0,025	-0,318	-0,346	-0,167	-0,598	0,400	-0,408	-0,273	-0,171	-0,391	0,326	-0,524
log Employees	0,641	-0,442	-	-0,631	-0,663	1,000	0,838	-0,022	-0,677	-0,615	-0,673	-0,384	-0,197	0,426	0,605	0,444	-0,235	0,695	0,586	0,833	0,422	0,631	0,561	0,523	-0,028	0,821	0,039	0,833	0,308	0,335	0,868	-0,175	0,204	0,308	0,247	0,548	-0,281	0,705
SLF	0,652	-0,539	-	-0,644	-0,728	0,838	1,000	0,003	-0,746	-0,601	-0,726	-0,307	-0,264	0,109	0,644	0,363	0,079	0,664	0,648	0,794	0,520	0,626	0,512	0,609	0,024	0,775	0,184	0,642	0,433	0,425	0,705	-0,243	0,242	0,253	0,122	0,386	-0,191	0,729
Fuel CASK	-0,049	-0,119	-	0,367	0,285	-0,022	0,003	1,000	0,186	-0,208	0,254	0,152	0,143	-0,145	0,195	0,303	0,091	-0,134	-0,051	0,085	0,353	-0,066	-0,203	-0,070	-0,143	-0,030	-0,290	-0,007	-0,092	0,407	0,001	0,272	-0,267	-0,202	-0,124	-0,182	0,251	-0,139
Non Fuel CASK	-0,650	0,560	-	0,956	0,995	-0,677	-0,746	0,186	1,000	0,402	0,974	0,297	0,353	-0,028	-0,600	-0,168	0,054	-0,538	-0,522	-0,419	-0,263	-0,563	-0,487	-0,468	-0,082	-0,560	-0,005	-0,325	-0,345	-0,214	-0,613	0,381	-0,390	-0,259	-0,162	-0,381	0,308	-0,522
Fuel tonnes/RPK	-0,607	0,405	-	0,323	0,371	-0,615	-0,601	-0,208	0,402	1,000	0,361	0,503	0,298	-0,114	-0,610	-0,342	-0,143	-0,468	-0,368	-0,550	-0,257	-0,442	-0,406	-0,320	-0,053	-0,469	-0,415	-0,471	-0,365	-0,239	-0,524	0,219	-0,278	-0,231	-0,146	-0,290	0,397	-0,476
RRPK yield	-0,649	0,591	-	0,972	0,976	-0,673	-0,726	0,254	0,974	0,361	1,000	0,268	0,231	-0,068	-0,526	-0,254	0,112	-0,496	-0,406	-0,416	-0,158	-0,453	-0,461	-0,374	-0,100	-0,490	0,010	-0,393	-0,310	-0,116	-0,614	0,278	-0,283	-0,290	-0,161	-0,462	0,236	-0,440
Pax/Employees	-0,680	-0,059	-	0,331	0,306	-0,384	-0,307	0,152	0,297	0,503	0,268	1,000	0,588	0,016	-0,606	-0,178	-0,271	-0,287	-0,208	-0,346	-0,143	-0,273	-0,250	-0,176	-0,047	-0,304	-0,407	-0,358	-0,685	-0,103	-0,409	0,596	-0,284	-0,142	0,150	-0,309	0,804	-0,270
Employees/Fleet	-0,459	-0,136	-	0,330	0,359	-0,197	-0,264	0,143	0,353	0,298	0,231	0,588	1,000	0,247	-0,619	0,451	-0,218	-0,334	-0,563	-0,083	-0,227	-0,580	-0,271	-0,437	0,181	-0,434	-0,233	0,040	-0,643	-0,125	-0,261	0,731	-0,653	0,005	0,142	0,190	0,669	-0,428
Invest/Assetbase	-0,105	0,146	-	-0,073	-0,043	0,426	0,109	-0,145	-0,028	-0,114	-0,068	0,016	0,247	1,000	-0,061	0,265	-0,397	0,244	0,028	0,365	0,107	0,038	0,223	0,073	0,089	0,245	-0,251	0,496	-0,257	0,107	0,326	0,233	-0,138	0,242	0,242	0,439	0,007	0,204
Sales/Employee	0,723	-0,258	-	-0,499	-0,565	0,605	0,644	0,195	-0,600	-0,610	-0,526	-0,606	-0,619	-0,061	1,000	0,367	0,210	0,425	0,446	0,466	0,511	0,489	0,354	0,414	-0,036	0,492	0,518	0,412	0,578	0,495	0,584	-0,498	0,348	0,144	0,038	0,297	-0,569	0,451
Sales/Aircraft	0,374	-0,344	-	-0,134	-0,132	0,444	0,363	0,303	-0,168	-0,342	-0,254	-0,178	0,451	0,265	0,367	1,000	0,073	0,057	-0,276	0,471	0,217	-0,226	0,060	-0,152	-0,235	-0,010	0,406	0,590	0,025	0,321	0,364	-0,224	-0,436	0,198	0,157	0,667	-0,009	-0,056
Skytrax	0,209	0,060	-	0,139	0,062	-0,235	0,079	0,091	0,054	-0,143	0,112	-0,271	-0,218	-0,397	0,210	0,073	1,000	-0,248	-0,119	0,020	0,150	-0,125	-0,278	-0,142	-0,215	-0,226	0,702	-0,284	0,272	0,226	-0,340	-0,449	-0,006	-0,258	-0,166	-0,108	-0,254	0,015
Total Liabs Mio	0,418	-0,233	-	-0,559	-0,539	0,695	0,664	-0,134	-0,538	-0,468	-0,496	-0,287	-0,334	0,244	0,425	0,057	-0,248	1,000	0,745	0,711	0,356	0,684	0,949	0,832	0,207	0,832	-0,047	0,642	0,565	0,201	0,821	-0,293	0,261	0,737	0,266	0,471	-0,266	0,531
Equity Mio	0,315	-0,182	-	-0,427	-0,515	0,586	0,648	-0,051	-0,522	-0,368	-0,406	-0,208	-0,563	0,028	0,446	-0,276	-0,119	0,745	1,000	0,566	0,524	0,882	0,573	0,896	-0,173	0,908	-0,116	0,350	0,449	0,327	0,573	-0,446	0,526	0,182	0,033	-0,091	-0,183	0,771
Labour Costs Mio	0,501	-0,286	-	-0,370	-0,400	0,833	0,794	0,085	-0,419	-0,550	-0,416	-0,346	-0,083	0,365	0,466	0,471	0,020	0,711	0,566	1,000	0,554	0,532	0,548	0,583	0,123	0,789	0,276	0,851	0,425	0,447	0,779	-0,147	-0,000	0,349	0,162	0,516	-0,137	0,583
Ancill. Pax Revenue	0,213	-0,124	-	-0,077	-0,220	0,422	0,520	0,353	-0,263	-0,257	-0,158	-0,143	-0,227	0,107	0,511	0,217	0,150	0,356	0,524	0,554	1,000	0,453	0,174	0,514	-0,085	0,541	0,229	0,318	0,232	0,964	0,361	-0,204	0,076	-0,048	-0,014	0,036	-0,037	0,453
Cash&Liq y/e	0,397	-0,218	-	-0,476	-0,556	0,631	0,626	-0,066	-0,563	-0,442	-0,453	-0,273	-0,580	0,038	0,489	-0,226	-0,125	0,684	0,882	0,532	0,453	1,000	0,534	0,695	-0,203	0,844	-0,101	0,339	0,381	0,306	0,541	-0,394	0,743	0,070	0,009	-0,033	-0,345	0,801
Interest bearing Debt	0,364	-0,202	-	-0,555	-0,496	0,561	0,512	-0,203	-0,487	-0,406	-0,461	-0,250	-0,271	0,223	0,354	0,060	-0,278	0,949	0,573	0,548	0,174	0,534	1,000	0,716	0,344	0,649	-0,073	0,552	0,528	0,057	0,748	-0,263	0,211	0,881	0,345	0,567	-0,294	0,346
EBITDA	0,269	-0,157	-	-0,412	-0,463	0,523	0,609	-0,070	-0,468	-0,320	-0,374	-0,176	-0,437	0,073	0,414	-0,152	-0,142	0,832	0,896	0,583	0,514	0,695	0,716	1,000	0,060	0,835	-0,062	0,414	0,531	0,321	0,644	-0,392	0,277	0,456	0,135	0,107	-0,097	0,567
Debt/Equity	0,069	-0,028	-	-0,170	-0,095	-0,028	0,024	-0,143	-0,082	-0,053	-0,100	-0,047	0,181	0,089	-0,036	0,235	0,215	0,207	-0,173	0,123	-0,085	-0,203	0,344	0,060	1,000	-0,151	0,182	0,112	0,172	-0,017	0,124	-0,205	-0,227	0,520	0,458	0,571	-0,159	-0,239
Flights number	0,440	-0,242	-	-0,489	-0,549	0,821	0,775	-0,030	-0,560	-0,469	-0,490	-0,304	-0,434	0,245	0,492	-0,010	-0,226	0,832	0,908	0,789	0,541	0,844	0,649	0,835	-0,151	1,000	-0,093	0,657	0,445	0,350	0,783	-0,300	0,368	0,293	0,070	0,184	-0,208	0,805
Unit Labour costs	0,403	-0,041	-	0,036	0,025	0,039	0,184	0,290	-0,005	-0,415	-0,010	-0,407	-0,233	-0,251	0,518	0,406	0,702	-0,047	-0,116	0,276	0,229	-0,101	-0,073	-0,062	0,182	-0,093	1,000	0,074	0,431	0,303	0,087	-0,305	-0,125	-0,030	0,039	0,171	-0,271	-0,120
OPEX less labour and fuel	0,496	-0,264	-	-0,358	-0,318	0,833	0,642	-0,007	-0,325	-0,471	-0,393	-0,358	0,040	0,496	0,412	0,590	-0,284	0,642	0,350	0,851	0,318	0,339	0,552	0,414	0,112	0,657	0,074	1,000	0,340	0,228	0,819	-0,008	-0,124	0,462	0,160	0,675	-0,159	0,422
Pax per Flight	0,639	0,000	-	-0,391	-0,346	0,308	0,433	-0,092	-0,345	-0,365	-0,310	-0,685	-0,643	-0,257	0,578	0,025	0,272	0,565	0,449	0,425	0,232	0,381	0,528	0,531	0,172	0,445	0,431	0,340	1,000	0,118	0,532	-0,655	0,250	0,410	-0,117	0,255	-0,586	0,180
Ancill. Rev per Pax	0,184	-0,134	-	-0,023	-0,167	0,335	0,425	0,407	-0,214	-0,239	-0,116	-0,103	-0,125	0,107	0,495	0,321	0,226	0,201	0,327	0,447	0,964	0,306	0,057	0,321	-0,017	0,350	0,303	0,228	0,118	1,000	0,252	-0,149	0,008	-0,105	0,038	0,084	-0,041	0,322
Network Airports	0,606	-0,345	-	-0,635	-0,598	0,868	0,705	0,001	-0,613	-0,524	-0,614	-0,409	-0,261	0,326	0,584	0,364	-0,340	0,821	0,573	0,779	0,361	0,541	0,748	0,644	0,124	0,783	0,087	0,819	0,532	0,252	1,000	-0,211	0,077	0,580	0,308	0,629	-0,289	0,409
Global Alliance	-0,490	-0,092	-	0,382	0,400	-0,175	-0,243	0,272	0,381	0,219	0,278	0,596	0,731	0,233	-0,498	0,224	-0,449	-0,293	-0,446	-0,147	-0,204	-0,394	-0,263	-0,392	-0,205	-0,300	-0,305	-0,008	-0,655	-0,149	-0,211	1,000	-0,444	-0,089	-0,018	-0,047	0,671	-0,318
Liquidity/Sales	0,276	-0,014	-	-0,346	-0,408	0,204	0,242	-0,267	-0,390	-0,278	-0,283	-0,284	-0,653	-0,138	0,348	-0,436	-0,006	0,261	0,526	-0,000	0,076	0,743	0,211	0,277	-0,227	-0,368	-0,125	-0,124	0,250	0,008	0,077	-0,444	1,000	-0,167	-0,176	-0,268	-0,552	0,569
Net Debt	0,207	-0,116	-	-0,388	-0,273	0,308	0,253	-0,202	-0,259	-0,231	-0,290	-0,142	0,005	0,242	0,144	0,198	-0,258	0,737	0,182	0,349	-0,048	0,070	0,881	0,456	0,520	0,293	-0,030	0,462	0,410	-0,105	0,580	-0,089	-0,167	1,000	0,402	0,688	-0,154	-0,041
NetDebt/EBITDA	0,048	-0,249	-	-0,216	-0,171	0,247	0,122	-0,124	-0,162	-0,146	-0,161	0,150	0,142	0,242	0,038	0,157	-0,166	0,266	0,033	0,162	-0,014	0,009	0,345	0,135	0,458	0,070	0,039	0,160	-0,117	0,038	0,308	-0,018	-0,176	0,402	1,000	0,460	0,040	-0,045
Journey Length	0,454	-0,265	-	-0,495	-0,391	0,548	0,386	-0,182	-0,381	-0,290	-0,462	-0,309	0,190	0,439	0,297	0,667	-0,108	0,471	-0,091	0,516	0,036	-0,033	0,567	0,107	0,571	0,184	0,171	0,675	0,255	0,084	0,629	-0,047	-0,268	0,688	0,460	1,000	-0,274	-0,006
AC Age	-0,585	-0,140	-	0,348	0,326	-0,281	-0,191	0,251	0,308	0,397	0,236	0,804	0,669	0,007	-0,569	-0,009	-0,254	-0,266	-0,183	-0,137	-0,037	-0,345	-0,294	-0,097	-0,159	-0,208	-0,271	-0,159	-0,586	-0,041	-0,289	0,671	-0,552	-0,154	0,040	-0,274	1,000	-0,276
Flights/Destinations	0,407	-0,249	-	-0,402	-0,524	0,705	0,729	-0,139	-0,522	-0,476	-0,440	-0,270	-0,428	0,204	0,451	-0,056	0,015	0,531	0,771	0,583	0,453	0,801	0,346	0,567	-0,239	0,805	-0,120	0,422	0,180	0,322	0,409	-0,318	0,569	-0,041	-0,045	-0,006	-0,276	1,000

Table 41: Testing of the Control Variables with Dependent Variable OCF

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	2966,992	1664,92	1,78	0,0765	.
2000	-251,2	278,632	-0,9	0,3685	3,202323
2001	-129,438	254,582	-0,51	0,6118	2,673369
2002	-343,101	251,2	-1,37	0,1738	5,140278
2003	-336,66	234,716	-1,43	0,1533	5,932988
2004	-421,062	214,505	-1,96	0,0512	4,955257
2005	-197,522	197,256	-1	0,3181	5,193177
2006	58,73377	178,964	0,33	0,7432	5,085369
2007	1,031097	183,497	0,01	0,9955	5,766602
2008	6,107613	181,324	0,03	0,9732	6,440366
2009	-81,1876	167,41	-0,48	0,6283	5,830066
2010	-81,1458	158,537	-0,51	0,6094	5,22846
2011	-19,8375	159,824	-0,12	0,9014	5,003609
2012	60,61142	161,589	0,38	0,708	5,114732
2013	219,8158	151,471	1,45	0,1485	4,494292
2014	20,3461	139,066	0,15	0,8838	3,788257
2015	-115,415	127,309	-0,91	0,3659	3,174833
2016	-294,622	120,476	-2,45	0,0155*	2,843172
2017	-32,3258	121,477	-0,27	0,7905	2,709761
2018	-86,5686	112,425	-0,77	0,4423	2,320999
Sales	0,473294	0,06712	7,05	<,0001*	1104,4
OPEX	5,873592	7,49162	0,78	0,4341	12711693
Investing Cash Flow t-1	-0,00404	0,03732	-0,11	0,914	3,774046
Cost of Fuel	-6,51009	7,49163	-0,87	0,3861	622319,9
Non Fuel OPEX	-6,16258	7,48969	-0,82	0,4117	8021636
Fixed Asset Base	-0,0228	0,0342	-0,67	0,5059	189,8367
Fleet Size year end	-2,40268	1,53042	-1,57	0,1182	272,4289
Pax Mio	-11,8183	9,04754	-1,31	0,1932	302,2026
ASK Mio	-0,04899	0,00876	-5,59	<,0001*	2062,696
RPK Mio	0,057935	0,01026	5,64	<,0001*	1950,912
ave.Employees Mio	-0,00064	0,00878	-0,07	0,9424	305,4219
Free Cash Flow	0,215411	0,03632	5,93	<,0001*	2,143731
>50% State owned	-45,5195	251,415	-0,18	0,8565	45,87626
Listed	-92,4146	227,122	-0,41	0,6846	37,96126
Private	0	0	.	.	0
LCC	-183,956	144,492	-1,27	0,2047	13,2611
Network	0	0	.	.	0
LargeNet/Mixed	450,7401	176,936	2,55	0,0117*	24,63773
Small Network	0	0	.	.	0
RASK	2639,303	17448,8	0,15	0,8799	502
CASK	-326460	386412	-0,84	0,3994	276930,8
log employees	-448,739	283,957	-1,58	0,1159	79,30723
SLF	-3987,18	2035,12	-1,96	0,0517	56,70135
Fuel CASK	318057,1	386800	0,82	0,412	10571,7
Non Fuel CASK	328525,9	386339	0,85	0,3963	250126,9
RRPK yield	-3629,07	11701,8	-0,31	0,7568	476,9957
Pax/Employees	435,3585	387,088	1,12	0,2623	4,06167
Employees/Fleet	6,122386	3,24731	1,89	0,061	101,9189
Invest/Assetbase	-16,2885	177,966	-0,09	0,9272	3,09151
Sales/Employees	1528,028	735,553	2,08	0,0392*	28,70151
Sales/aircraft	-27,1728	12,2441	-2,22	0,0278*	50,9089
Skytrax	-81,4697	84,1763	-0,97	0,3345	5,80462
Total Liabs Mio	0,065326	0,0329	1,99	0,0486*	226,4478
Equity Mio	0,076639	0,0374	2,05	0,0419*	24,07467
Labour Costs Mio	-0,22521	0,11431	-1,97	0,0504	236,6585
Ancill. Pax Revenue Mio	-0,07128	0,07703	-0,93	0,356	14,42365
Cash&Liq y/e	-0,0096	0,05422	-0,18	0,8597	20,42078
Interest bearing Debt Mio	0,028593	0,02361	1,21	0,2274	19,41367
EBITDA	-0,00033	0,00531	-0,06	0,951	1,41572
Debt/Equity	0,735366	0,68939	1,07	0,2876	1,584514
Flights number	0,002092	0,00092	2,27	0,0247*	209,2396
Unit Labour costs/Employee	370,476	2465,5	0,15	0,8807	8,077874
OPEX less Labour and Fuel	0	0	.	.	0
Pax/Flight	11,00588	2,95748	3,72	0,0003*	20,08839
Ancill. Rev per Pax	-0,01852	4,29773	0	0,9966	11,51128
Network Airports	2,297395	0,80409	2,86	0,0048*	22,02905
Global Alliance	26,68401	87,1471	0,31	0,7598	5,732232
Liquidity/Sales	-70,2182	235,192	-0,3	0,7656	4,90566
Net Debt Mio	0	0	.	.	0
NetDebt/EBITDA	0,568713	1,31439	0,43	0,6658	1,368367
Journey length	0,066769	0,09274	0,72	0,4725	16,05051
AC Age	16,59179	13,809	1,2	0,2312	7,913887
Flights/Destinations	0,185678	0,08459	2,2	0,0295*	26,71791

4.6 Multiple Regression Results Predicting Airline Financial Performance

Including all independent variables for analysis resulted in two models that explain between 72% and 75% of the variance in the sample data as adjusted R squared for the time period 2000 to 2019 where n = 242. All models calculated were four factor models with the testing of 50 independent variables. In addition, I created two subsamples for both the network carrier and the low-cost pool to test if total pool data obscured specific attributes of the two distinct business models. Due to data availability, the network carrier pool could additionally test for airline size. In each case the fewest number of covariants with minimal effect on the adjusted R squared value and without multicollinearity was regarded as desirable for the purposes of predictability of success and avoiding 'overfit'. The results of these models are summarised in Table 42 to Table 50.

> 'A parsimonious but less true model can have a higher predictive validity than a truer but less parsimonious model."
> (Hagerty & Srvinivasan, 1991:84)

Table 42: Results of Model Fit of two Airline Models using all data

Variable Name	Sample Size	Model 1	Model 2
R squared	242	0.788	0.753
R squared adjusted	242	0.766	0.727

Table 43: Results of Model Fit of two Network Carrier Models using Network Carrier data only

Variable Name	Sample Size	Model 3	Model 4
R squared	187	0.844	0.821
R squared adjusted	187	0.822	0.796

Table 44: Results of Model Fit of two Low Cost Carrier Models using Low Cost Carrier Data only

Variable Name	Sample Size	Model 5	Model 6
R squared	66	0.888	0.885
R squared adjusted	66	0.834	0.831

Data Pool with all Airlines included

Model 1:

Operating Cash Flow in Euro M = 24.81*(Passenger Numbers) +6,250.89*(Yield per RPK) +0.30*(Journey Length in km) +383.49*(Investment in Asset Base$_{t-1}$) - 1,180.70 +Error

Table 45: Multiple Regression Model 1 All Airlines Group

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	-1.180,701	191,640	- 6,160	<,0001	.
RRPK yield	6.250,888	1.094,618	5,710	<,0001	1,218
Pax Mio	24,808	1,031	24,060	<,0001	1,145
Journey length	0,304	0,044	6,930	<,0001	1,047
Invest/Assetbase	- 383,492	194,903	- 1,970	0,050	1,082
2000	- 434,345	328,004	- 1,320	0,187	1,295
2001	- 559,299	326,099	- 1,720	0,088	1,280
2002	- 230,309	253,964	- 0,910	0,366	1,533
2003	- 257,200	227,167	- 1,130	0,259	1,621
2004	- 228,575	224,785	- 1,020	0,310	1,587
2005	- 199,279	212,019	- 0,940	0,348	1,750
2006	- 8,334	198,640	- 0,040	0,967	1,828
2007	- 37,681	195,292	- 0,190	0,847	1,905
2008	- 276,306	188,951	- 1,460	0,145	2,040
2009	- 480,910	185,434	- 2,590	0,010	2,087
2010	- 441,592	184,998	- 2,390	0,018	2,077
2011	- 457,984	186,946	- 2,450	0,015	1,997
2012	- 462,264	187,185	- 2,470	0,014	2,002
2013	- 320,366	186,860	- 1,710	0,088	1,995
2014	- 504,506	186,295	- 2,710	0,007	1,983
2015	- 290,102	185,798	- 1,560	0,120	1,973
2016	- 304,946	185,079	- 1,650	0,101	1,957
2017	79,341	188,374	0,420	0,674	1,901
2018	- 118,099	188,457	- 0,630	0,532	1,902

Note: Investing Cash Flow is negative cash out in the input tables to JMP Pro for SAS, so the sign is reversed in the equation above

Note: 2001 Attack on Word Trade Centre, NYC
Note: 2002/2003 SARS Pandemic
Note: 2003/204 Iraq War
Note: 2007/2008 Global Financial Crisis
Note: 2009 Oil price collapse
Note: 2010 Icelandic volcano eruption

Model 2:

Operating Cash Flow in Euro M = 25.18*(Passenger Numbers) -4,597,69*(Labour Costs per employee) +5,637.84*(Yield per RRPK) +168.55*(Membership of a Global Airline Alliance) -340.09 +Error

Table 46: Multiple Regression Model 2 All Airlines Group

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	- 340,090	210,795	- 1,610	0,108	.
RRPK yield	5.637,841	1.400,591	4,030	<,0001	1,708
Pax Mio	25,176	1,124	22,400	<,0001	1,166
Unit Labour costs/Employee	- 4.597,689	1.902,467	- 2,420	0,017	1,203
Global Alliance	168,552	85,335	1,980	0,050	1,374
2000	- 400,453	362,489	- 1,100	0,271	1,355
2001	- 511,624	359,391	- 1,420	0,156	1,332
2002	- 260,483	282,943	- 0,920	0,358	1,631
2003	- 322,247	250,594	- 1,290	0,200	1,691
2004	- 262,185	246,835	- 1,060	0,289	1,641
2005	- 220,168	229,398	- 0,960	0,338	1,756
2006	- 58,053	216,238	- 0,270	0,789	1,856
2007	- 78,993	212,183	- 0,370	0,710	1,928
2008	- 293,723	205,977	- 1,430	0,155	2,078
2009	- 498,873	202,763	- 2,460	0,015	2,138
2010	- 445,898	201,219	- 2,220	0,028	2,106
2011	- 468,216	203,530	- 2,300	0,022	2,029
2012	- 435,398	202,349	- 2,150	0,033	2,005
2013	- 296,828	201,761	- 1,470	0,143	1,994
2014	- 478,408	200,876	- 2,380	0,018	1,976
2015	- 307,590	200,378	- 1,540	0,126	1,966
2016	- 329,757	199,888	- 1,650	0,100	1,957
2017	83,711	202,857	0,410	0,680	1,889
2018	- 104,607	202,715	- 0,520	0,606	1,887

Note: 2001 Attack on Word Trade Centre, NYC
Note: 2002/2003 SARS Pandemic
Note: 2003/204 Iraq War
Note: 2007/2008 Global Financial Crisis
Note: 2009 Oil price collapse
Note: 2010 Icelandic volcano eruption

Data Pool with all Network Carriers/Groups included

Model 3:

Operating Cash Flow in Euro M = 22.35*(Passenger Numbers) -4,832.71*(Labour Costs per employee) +0.28*(Tonnes 000 of Cargo) +0.28*(Free Cash Flow) +361.95 +Error

Table 47: Multiple Regression Model 3 Network Group

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	361,952	185,164	1,950	0,052	
Tonnesk Cargo	0,277	0,123	2,250	0,026	4,698
Unit Labour costs/Employee	-4.832,709	1.806,213	- 2,680	0,008	1,239
Pax Mio	22,351	2,411	9,270	<,0001	5,403
Free Cash Flow	0,275	0,054	5,070	<,0001	1,353
2000	- 171,332	275,221	- 0,620	0,535	1,352
2001	- 253,977	274,158	- 0,930	0,356	1,342
2002	- 205,912	239,867	- 0,860	0,392	1,524
2003	- 354,500	227,318	- 1,560	0,121	1,588
2004	- 322,110	227,612	- 1,420	0,159	1,592
2005	- 283,409	216,858	- 1,310	0,193	1,643
2006	- 70,929	208,563	- 0,340	0,734	1,700
2007	- 152,406	209,768	- 0,730	0,469	1,719
2008	- 381,845	198,062	- 1,930	0,056	1,852
2009	- 460,678	166,811	- 2,760	0,006	1,751
2010	- 469,984	193,219	- 2,430	0,016	1,912
2011	- 507,117	195,981	- 2,590	0,011	1,814
2012	- 485,127	193,926	- 2,500	0,013	1,776
2013	- 258,670	191,700	- 1,350	0,179	1,735
2014	- 391,501	187,492	- 2,090	0,038	1,801
2015	- 278,318	178,437	- 1,560	0,121	1,503
2016	- 236,213	177,909	- 1,330	0,186	1,495
2017	92,301	185,439	0,500	0,619	1,624
2018	67,727	183,115	0,370	0,712	1,583

Note: 2001 Attack on Word Trade Centre, NYC
Note: 2002/2003 SARS Pandemic
Note: 2003/204 Iraq War
Note: 2007/2008 Global Financial Crisis
Note: 2009 Oil price collapse
Note: 2010 Icelandic volcano eruption

Model 4:

Operating Cash Flow in Euro M = 27.54*(Passenger Numbers) +0.22*(Journey length in km) +3,962.22*(Yield per passenger km) -4.81*(Net Debt/EBITDA ratio) -818.03 +Error

Table 48: Multiple Regression Model 4 Network Group

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	- 818,034	236,101	- 3,460	0,001	.
Pax Mio	27,536	1,284	21,440	<,0001	1,335
Journey length	0,220	0,060	3,680	<,0001	1,303
RRPK Yield	3.962,224	1.460,199	2,710	0,007	1,796
NetDebt/EBITDA	- 4,812	2,257	- 2,130	0,035	1,135
2000	- 202,090	312,681	- 0,650	0,519	1,520
2001	- 339,130	312,158	- 1,090	0,279	1,515
2002	- 129,137	273,804	- 0,470	0,638	1,730
2003	- 200,805	251,324	- 0,800	0,426	1,691
2004	- 217,636	245,776	- 0,890	0,377	1,617
2005	- 164,198	235,922	- 0,700	0,487	1,693
2006	5,660	227,489	0,020	0,980	1,761
2007	- 19,178	230,091	- 0,080	0,934	1,802
2008	- 256,664	218,558	- 1,170	0,242	1,965
2009	- 532,949	193,312	- 2,760	0,007	2,048
2010	- 486,802	210,713	- 2,310	0,022	1,981
2011	- 442,064	213,608	- 2,070	0,040	1,877
2012	- 436,371	214,052	- 2,040	0,043	1,884
2013	- 270,602	212,327	- 1,270	0,204	1,854
2014	- 444,984	209,689	- 2,120	0,035	1,962
2015	- 258,454	196,010	- 1,320	0,189	1,580
2016	- 216,843	194,991	- 1,110	0,268	1,564
2017	213,016	200,864	1,060	0,291	1,659
2018	- 17,841	199,891	- 0,090	0,929	1,643

Note: 2001 Attack on Word Trade Centre, NYC
Note: 2002/2003 SARS Pandemic
Note: 2003/204 Iraq War
Note: 2007/2008 Global Financial Crisis
Note: 2009 Oil price collapse
Note: 2010 Icelandic volcano eruption

Data Pool with all Low-Cost Carriers included

Model 5:

Operating Cash Flow in Euro M = 16.33*(Passenger Numbers) -34,559,78*(Fuel Cost per ASK) -0.67*(Journey Length in km) +21.56*(Debt/Equity Ratio) +948.37 +Error

Table 49: Multiple Regression Model 5 Low-Cost Airlines

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	948,374	367,617	2,580	0,013	.
Pax Mio	16,327	1,091	14,960	<,0001	1,574
Fuel CASK	-34.559,780	14.645,020	- 2,360	0,023	2,609
Debt/Equity	21,556	7,568	2,850	0,007	2,257
Journey Length	- 0,668	0,137	- 4,880	<,0001	2,860
2000	-	-	.	.	-
2001	-	-	.	.	-
2002	- 140,584	287,937	- 0,490	0,628	1,504
2003	- 223,249	244,963	- 0,910	0,367	2,143
2004	- 184,004	245,658	- 0,750	0,458	2,156
2005	- 112,063	207,333	- 0,540	0,592	2,267
2006	33,940	184,613	0,180	0,855	2,359
2007	108,591	178,589	0,610	0,546	2,207
2008	58,132	172,042	0,340	0,737	2,048
2009	- 111,530	173,170	- 0,640	0,523	2,075
2010	- 104,552	175,746	- 0,590	0,555	2,137
2011	- 110,416	168,342	- 0,660	0,515	1,961
2012	- 26,967	170,691	- 0,160	0,875	2,016
2013	218,588	180,269	1,210	0,232	2,249
2014	- 7,450	174,339	- 0,040	0,966	2,103
2015	199,580	162,682	1,230	0,226	2,252
2016	- 35,555	164,961	- 0,220	0,830	2,316
2017	- 5,523	169,491	- 0,030	0,974	1,988
2018	29,137	166,214	0,180	0,862	1,912

Note: 2001 Attack on Word Trade Centre, NYC
Note: 2002/2003 SARS Pandemic
Note: 2003/204 Iraq War
Note: 2007/2008 Global Financial Crisis
Note: 2009 Oil price collapse
Note: 2010 Icelandic volcano eruption

Model 6:

Operating Cash Flow in Euro M = 15.97*(Passenger Numbers) +227.63*(Investment/Asset Base$_{t-1}$) -9.55*(Employees/Fleet ratio) - 0.085*(Flights/Destinations ratio) +413.50 +Error

Table 50: Multiple Regression Model 6 Low-Cost Airlines

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	413,503	355,632	1,160	0,251	.
Pax Mio	15,970	2,258	7,070	<,0001	6,591
Invest/Assetbase	- 227,629	109,914	- 2,070	0,044	1,408
Employees/Fleet	- 9,551	4,240	- 2,250	0,029	3,924
Flights/Destinations	- 0,085	0,042	- 2,050	0,046	2,954
2000	-	-	.	.	-
2001	-	-	.	.	-
2002	- 185,943	337,661	- 0,550	0,585	2,024
2003	78,773	257,557	0,310	0,761	2,319
2004	17,037	268,185	0,060	0,950	2,514
2005	- 183,420	240,638	- 0,760	0,450	2,989
2006	- 140,844	221,239	- 0,640	0,528	3,315
2007	57,322	200,432	0,290	0,776	2,721
2008	- 142,118	195,968	- 0,730	0,472	2,601
2009	- 282,130	198,550	- 1,420	0,162	2,670
2010	- 224,359	198,925	- 1,130	0,266	2,680
2011	- 294,897	194,394	- 1,520	0,136	2,560
2012	- 254,835	187,750	- 1,360	0,182	2,388
2013	- 149,178	184,466	- 0,810	0,423	2,305
2014	- 346,612	181,788	- 1,910	0,063	2,238
2015	47,169	169,401	0,280	0,782	2,391
2016	- 95,914	164,265	- 0,580	0,562	2,248
2017	48,017	168,931	0,280	0,778	1,933
2018	117,898	166,729	0,710	0,483	1,883

Note: Investing Cash Flow is negative cash out in the input tables to JMP Pro for SAS, so the sign is reversed in the equation above

Note: 2001 Attack on Word Trade Centre, NYC
Note: 2002/2003 SARS Pandemic
Note: 2003/204 Iraq War
Note: 2007/2008 Global Financial Crisis
Note: 2009 Oil price collapse
Note: 2010 Icelandic volcano eruption

4.7 Discussion

Research in this phase 1 sought to identify the key parameters affecting airline performance in three airline groups. The testing of the independent variables gave six models that are indicative of the dependent variable Operating Cash Flow accounting for more than 70% of the sample variation.

Operating Cash Flow (OCF) delivered better models than *Operating Profit (EBIT)* as the dependent variable, probably because aircraft financing and depreciation charges are an individual company decision varying between operators and because respective aircraft fleets are at different stages in their fleet life cycle between operators. The depreciation of the aircraft fleet and associated engines is the major part of the depreciation charge of most airlines. The more recent the fleet acquisition the higher the capital costs and related depreciation charges. Control Parameters using the dependent variable EBIT are shown in Appendix 12.8

The results of the Quantitative Analysis are discussed in three sections, i. all business models, ii mixed/network carrier business models and, iii. low-cost carrier models. Breaking the data pool down into three segments improved the predictability of the models indicating that the distinct characteristics of each business model are reflected in the statistical results. Within the large network/mixed model group both LCC and network carrier hub-based business models operate as distinct legal entities but they are actively managed and integrated as a single transport system.

4.7.1 All Business Models

The data pool with all business models included (n = 242) indicates that high ***passenger numbers*** *and managing yield* are crucial to delivering strong operating cash flow in each of the two multiple regression models. Higher passenger numbers generally increase total revenues and reduce the unit passenger cost of carry through economies of scale. Higher passenger numbers can clearly create more revenue, but also offer the opportunity to use more efficient revenue management systems to increase ***yield***. There is a scale effect at work with greater fleet sizes and seat numbers enabling a more efficient use of aircraft assets through aircraft substitution, and by managing passenger booking classes and fares conditions to extract the maximum revenue per passenger. The larger an airline gets the more the opportunities are available to manage both the number of aircraft and number of seats placed on a route to demand, and also to switch offer to meet demand at short notice (Doganis, 2013). ***Yield*** or the revenue generated by unit capacity travelled is most effectively managed by large airlines with high seat numbers, multiple aircraft types and highly developed airline revenue management systems. There may be a positive scale effect as large airlines tend to have complex sophisticated passenger revenue management systems as well as larger fleets.

In the better of the two models (Model 1), improved OCF performance is additionally indicative of ***longer journeys*** and ***reinvestment in the asset base*** $_{(t-1)}$. Longer journeys reduce unit operating costs (including fuel) and are subject to less competition from ground transport improving yield, while investment in the asset base in the form of property, fleet, engines, ground equipment, IT and revenue management systems seems vital on an ongoing basis to remain competitive. Each new generation of aircraft and engines show significant improvement in operating cost efficiencies over the predecessor but higher capital costs. Although capital expenditure plans by airlines are normally made over a much longer planning horizon, investments cannot be made in an industry (with weak and volatile cash flow and low investment grade ratings) before the funds are generated. The ability to generate operating cash flow to refresh the fixed asset base would seem to be part of a virtuous circle in drawing more passengers with more attractive, personalised and convenient services, and in replacing ageing assets that have lower energy appetites. Airlines that can generate their own cash flows for investments are in a stronger position than those that have the problem of finding third party financing and paying interest. High quality, novel and attractive products and services are also important in drawing passengers within the same business model type. Investment in IT systems and in complex revenue management models can improve yields. In the case of aircraft leasing, airlines that use operating leased aircraft (often for shorter term use) will not show them in the fixed asset base but will show the costs of leasing in the profit and loss account and in reduced operating cash flow. Finance leased aircraft (normally for longer-term use) are, for accounting purposes treated much the same as owned aircraft and included in the asset base giving rise to non-cash and interest charges in the profit and loss, but not affecting operating cash flow since they consume cash only at the time of purchase and through financing in the financing cash flow. In 2018 the IASB changed the accounting treatment of leases in financial statements requiring that they be capitalised (IFRS 16) thus making data year on year data analysis more difficult, but ensuring the future consistency of the treatment of all capital assets.

In Model 2 with the lower fit, ***lower unit labour costs*** and ***membership of a global airline alliance*** are indicative of better performance. In the case of the latter, membership of a global alliance improves network connectivity making the passenger network offering more attractive, and offers savings and synergies on marketing and operational costs. Most network models and few low-cost carriers are members of such alliances. (Unit) labour is normally the most expensive operating cost after fuel, and has traditionally been addressed by airline management through continual restructuring programmes. Start-ups and younger carriers have usually had an advantage in this cost category not having to honour older, expensive and multiple staff agreements and starting with a clean slate when beginning airline operations.

It is to be noted that passenger numbers, yield management and membership of an alliance are associated with scale - while re-investment in the asset base, longer journeys and lower labour costs are associated with reducing unit operating costs.

4.7.2 Network Carriers/Groups

In the network carrier pool (n = 187) the best fit model indicates that ***passenger numbers*** again are vital for maximising operating cash flow and generating a positive contribution after direct operating costs. Passenger numbers feature in both the models supported by ***strong yield management*** in one model, and a ***cargo operation*** in another which seems an important contribution to network model viability.

In model 3 ***lower unit labour*** costs and in model 4 ***longer journey lengths*** indicate network carrier´s efforts to reduce unit operating costs to make the model type more viable. The other two parameters that make up the models, a ***lower Net Debt to EBITDA ratio*** (Model 4) and ***higher free cash flow*** (Model 3) indicate network carrier efforts to reduce debt costs to increase the credit rating for capital markets, pay down debt or pay for non-capital expenditure. Interest bearing debt net of cash funds, divided by the earnings before depreciation (Net Debt/EBITDA), is a measure used by the major credit rating agencies to rate airlines investment potential. A low ratio here indicates high credit worthiness to investors. Free cash flow is the operating funds remaining after asset investment which can be used to pay down debt, return to investors or hold for non-capital expenditure.

4.7.3 Low-Cost Carriers

In the low-cost carrier data pool, the sample size was significantly smaller with many carriers not providing comprehensive data especially in the early 2000´s (n = 66). *Higher* ***passenger numbers*** and scale are a feature of both multiple regression models. In the better Model 5 a ***lower ratio of employees to the aircraft fleet*** resulted in a better model than using unit labour costs - indicating the simpler business processes of the model and possibly greater outsourcing to achieve economies of scale. Model 6 also indicated that LCCs might be less able to accommodate longer passenger journeys without losing their inherent production advantages. A further parameter showed that this group had a ***higher proportion of debt financing compared to equity,*** emphasising the lower cost of debt and the good credit ratings of Ryanair and Easyjet which highly influence the statistics of this sample data set.

The regression model with a lower fit (Model 6) replaced the employees to fleet ratio with ***lower fuel Cost per ASK and a lower ratio of flights to destinations*** - indicating that this business model might be reaching saturation point in some markets. ***Fuel Cost per ASK*** is influenced by global fuel pick-up point, purchasing contracts, storage and transportation, insurance and strategic fuel hedging policy (fuel volume and

USD). There will be some distorting effect here to actual fuel usage as tonnes of kerosene. Hedging effectively smooths the cost for planning and financial management rather than reducing it unless an airline is involved in commodity speculation. The cost of a hedging contract is an additional expense. The independent variable is negatively indicative of operating cash flow indicating that the higher the unit cost of fuel the lower the OCF. This may additionally indicate that the cost of fuel cannot be recovered by simply adding fuel surcharges to ticket prices, since ticket prices and earnings would be expected to be fully elastic. Fuel consumption is related to both efficient use and flown capacity. More fuel is consumed if an airline flies more but also if airlines burn their fuel inefficiently. This independent variable in the multiple regression model thus suffers from two effects, scale and efficiency. OCF is improved if fuel costs can be minimised, but the model must also indicate that airlines flying longer sectors (and larger fuel users) might be more efficient unit fuel users. Long range cruising is more fuel efficient than short-haul flying. Shorter segments involve the wasteful fuel events of take-off, landing and aircraft holding patterns. Modern aircraft also consume less fuel than older versions of the same type due to incremental improvements in aerodynamics, total weight and combustion technology. Long-haul flying although inherently more fuel efficient, is subject to the politics of national borders which can result in some indirect routing. Unit fuel efficiency as (Fuel Tonnes/per million ASK) was used in testing the model, but with a poorer overall fit indicating the yield differences between the two major business models are reflected in unit fuel consumption. The volume of fossil fuels burned might be a predictor of the carbon charges levied in Europe from 2020. From this fact it might be fair to predict that any business able to reduce the total cost of fuel and carbon by using renewable fuels, or minimising the consumption and cost of kerosene and offsetting related carbon charges could be able to deliver a sustainable competitive advantage. Carbon related charges are additionally reduced by increasing the mix proportion of renewable to oil sourced fuels.

The LCC data set emphasised the importance of ***re-investing in the capital base****$_{(t-1)}$*, replacing the aircraft fleet at regular intervals and with generally a younger fleet than the network carriers (5.6 years against the 9.4 years of the network carrier group).

4.7.4 Other variables

Although the state has distanced itself from running airlines since the 1980s in Europe in times of crisis there seems to be high levels of public support for a national carrier to protect the economy. There is no association found that ***public/private ownership*** affects airline performance. Whilst it is not shown from the data that the ***level of customer service*** offers direct evidence of superior airline performance, it might be evidence of having to 'tread water to remain competitive' with passenger expectations for both low-cost carriers and network models. Thus, at their respective price points airline passengers may expect a level of service that is different between the two major business models, with both meeting their expectations of value. This might additionally validate the idea that the choice of ***business model*** is important. Certainly, model fit improved when the business models were separated into their distinct sample groups. In examining the two network carrier models no significant evidence could be found that a larger or smaller model performed better than its counterpart, perhaps pointing towards success in the niche or captive home markets. It is noticed though, that service levels amongst these airlines do not show much variation in their service scoring. It may also highlight that, passengers despite loyalty schemes will switch carrier if a better deal is available elsewhere. No evidence was found that ***ancillary revenues*** significantly affected airline performance or that ***aircraft age*** was decisive with the latter likely revealing itself in lower fuel costs

4.8 Conclusions and Summary

This chapter has presented the results from the quantitative study of airlines' recent historical financial performance. A summary is presented in Table 51. The models detailed have implications for the short- and medium-term success of future business models - since existing business models will take time to migrate to new ones. It is demonstrated that the critical financial success factors for all airlines in the recent and volatile past seem to focus on a few parameters, i. generating passenger numbers and managing yield, ii. the unit cost of operations particularly in labour and fuel, and iii. reinvestment in the asset base. Huang et al. (2021) found labour costs of similar importance in a US airline study.

Network carriers benefit from delivering longer passenger journeys, low-cost carriers from shorter journeys that offer operational efficiencies for their business model. Network carriers seem to benefit from being part of a global alliance network, but there is no evidence not being part of an alliance penalises the low-cost models. It is noted however that only two LCCs were recorded as alliance members. This may be a consideration for the future should business models become more fragmented and should LCCs feed network carriers. Low-cost models seem more sensitive to the unit cost of fossil fuels, but both lower unit labour and lower unit fuel costs are welcomed by all airlines. Network carriers seem to benefit from low Net Debt/EBITDA ratios that improve their credit rating and low-cost carriers have higher debt/equity ratios linked to their credit worthiness and the current low cost of debt in 2019.

The factors identified have implications for regulatory policy in that as the scale of reinvestment required is increasing, the energy policy of the regulator might be used as a tool to direct investment, as higher fossil fuels costs are an increasing incentive to investment. Scale has implications for lower credit risk and operational efficiency, but growing monopoly power may have to be linked to increased social obligations in transportation links. Scale seems be often indicative of success (Doganis, 2013) and offers smaller players and new entrants scant hope of surviving either consolidation or as financially independent entities unless they can find a niche.

Reinvestment in the asset base indicates that airlines will not be advantaged in ‘sweating’ their older assets having possible implications for used aircraft values. Airlines often market their modern, clean, safe and energy efficient aircraft to consumers who are increasingly more environmentally aware. Reinvestment in assets also has implications for a positive passenger experience, yield management and the choice of business model. From the data it seems that both major business models can be successful if they meet passenger needs.

Table 51: Summary of the Six Multiple Regression Models by STOF Parameter

Business Model	Finance	Organisation	Technology	Service
All Carriers	1. Unit Cost of Labour (negative) 2.Yield as RRPK	1.Passenger numbers 2.Journey length 3.Member of a Global Alliance	1.Reinvestment in Capital Base	1.Reinvestment in Capital Base
Network Carriers/ Groups	1. Unit Cost of Labour (negative) 2.Free Cash Flow 3. Yield as RRPK 4.Net Debt/EBITDA (negative)	1.Passenger numbers 2.Journey length 3. Tonnes of Cargo		1. Tonnes of Cargo
LCCs	1.Cost of Fuel per ASK (negative) 2.Debt/Equity ratio (negative) 3.Employee/Fleet ratio (negative)	1.Passenger numbers 2.Journey length (negative) 3.Employee/Fleet ratio (negative) 4.Flights/Destination ratio (negative)	1.Reinvestment in Capital Base	1.Reinvestment in Capital Base 2.Flights/Destination ratio (negative)

Note: All relationships are positive except where noted.

The next chapter analyses the interviews recorded with senior airline officials and industry experts with a view to adding qualitative insights to the historical quantitative information used in this chapter.

Chapter 5 Grey Literature Review (Phase 2)

5.1 Introduction

In the previous chapter I analysed the quantitative parameters that have affected airline performance from 2000 to 2019. This chapter aims to explore a range of extra organisational factors for their impact on the airline businesses based on a document search from 2000 to 2021. The purpose is to review the broader, largely non-academic literature on the European airline market, airline and emissions regulation and developments in airline related technologies using both the Business Model Canvas and the MLP as a framework. This grey literature review differs substantially from the academic literature review in Chapter 2 in that analyses the current knowledge of industry experts and practitioners and the level of industry regulation with more than half the documents being published since 2015 (Phase 2, Figure 17). It opens the study to the widest possible expertise and knowledge which might be limited by a shorter but more direct and detailed interview sample. The literature sources include the grey literature from company and industry publications, trade magazines, consultancy reports, regulatory and government publications and industry conference material. The methodology for this review and a summary of the data is included in Chapter 3.

This chapter is structured in twelve parts. Following the introduction, the current environmental legislation relevant for the airline industry is reviewed in 5.2. Subsequently the structure of the Business Model Canvas structure of Osterwalder and Pigneur (2009) determines the next nine sections. The nine sections of the canvas are mapped against the (STOF) pressures arising from the three perspectives of the MLP. I choose the Osterwalder & Pigneur Canvas (2009) as it has more facets than other (simpler) models for structuring business models and I believe offers a greater understanding of the impact of the grey literature. This analytical exercise is performed to understand if the shifting and dynamic forces towards sustainability in the economic and competitive landscape, the actions of the regulator and in new technologies are impacting on airlines and how they react in operating their businesses.

The nine facets of the Business Model Canvas are: 5.3 Value Proposition, 5.4 Key Activities, 5.5 Key Resources, 5.6 Key Partners, 5.7 Customer Relationship, 5.8 Customer Segment, 5.9 Sales Channels, 5.10 Revenue Structure and, 5.11 Cost Structure. Finally, in 5.12 a summary key points are made.

5.2 The European Emissions Trading System (EU ETS) and CORSIA

This section details efforts within Europe and globally made towards reducing airline environmental footprint since 2000. Environmental legislation is potentially the most important restriction on the airline business since 2012 when aviation became included in the EU ETS (EU, 2021). Global environmental legislation for airlines has been tasked to ICAO a function of the United Nations (ICAO, 2016) The complex political relationships in civil aviation are shown in Figure 20. Legislation mainly affects the technological, operations and financial aspects of airline business models.

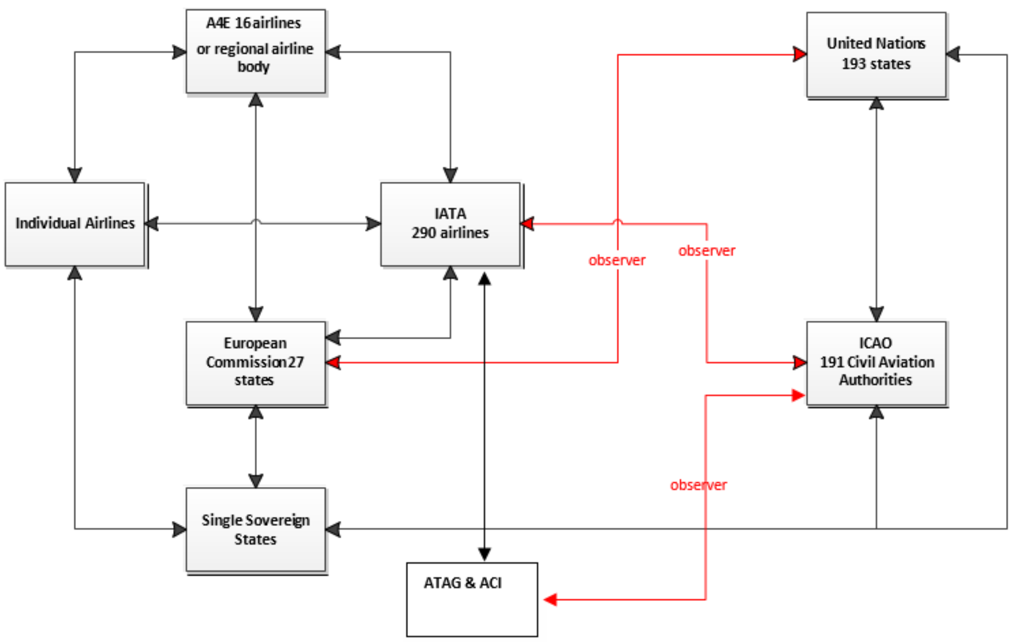


Figure 20: Key Political Interrelationships & Networks in the Airline Industry

Source: Author

5.2.1 The EU ETS

The EU ETS was set up in 2005 as the first international emissions trading system or ´carbon market´ (EU, 2021). The aim was to implement a cost-effective way of reducing Europe´s carbon emissions, but crucially only covers around 40% of the continent´s greenhouse gas emissions. There is a 2021 goal of reducing EU emissions by 55% before 2030 and climate neutrality by 2050 based on 1990 emissions levels (EU, 2021). The agreement covers all EU members, Iceland, Lichtenstein and Norway with Switzerland joining in 2020. The EU ETS aims to link with other schemes around the globe to spread the management of global emissions.

The EU ETS is mandatory and includes the emissions and sectors from the following industries, i. carbon dioxide from heat and energy generation, and from energy intensive industries such as oil, metal productions, glass, ceramics, paper and chemicals, ii. nitrous oxides from industrial processes and, iii. perfluorocarbons from aluminium manufacture. There are some small ´industry size´ related exemptions. Until the end of December 2023 it also applies to international flights within the European Economic Area with domestic aviation regarded part of national targets. For international air travel the EU ETS will be incorporated into CORSIA (see below) with the method unclear at the time of writing in 2021.

The EU ETS operates on a ´cap and trade´ principle with a cap on emissions from industry sectors being reduced over time so that total emissions fall. ´Installations´ as they are termed, can buy or sell emissions allowances to trade with each other at a given carbon price. A total limit on the allowances ensures that such allowances have monetary ´value´. The penalties charged are aimed at promoting low carbon technologies, but there is no direct mechanism to enforce this. Each year an installation must surrender allowances that cover its emissions or pay a fine. Unused allowances may be sold or kept for own future use. There are regular reviews of targets, prices and scope of the agreement. The EU ETS operate is four phases the current of which is 2021 to 2030 which aims for a 40% reduction on 1990 emissions levels as part of the Paris Agreement commitment by the EU. The EU ETS claims to have been effective with the EU claiming the agreement reduced total EEA emissions by 35% between 2005 and 2019 (EU; 2021).

5.2.2 Criticisms of the EU ETS

Friends of the Earth (2012), Carbon Market Watch (2014) and Appunn (2021) criticise the EU ETS for several significant loopholes notably, i. pushing European carbon emissions overseas, ii. the excessive use of free permits, and iii. allowing the carry forward of unused permits from previous periods. Additionally, under the EU ETS state support for coal or nuclear power is not prohibited and there are no mandatory targets for emissions reductions or renewable power generation, only carbon trading. The question of how effective the EU ETS has really been is a major concern with Bayer & Aklin (2020) claiming only a 3.8% reduction in EU emissions from 2008 to 2016 crediting the low carbon price. Corporate Europe Observatory (2013) claim that Emissions rose in Phase I (2005–2007). In Phase II (2008–2012) decreases in emissions were not linked to EU ETS but rather to the global financial economic crisis. Additionally Phases I & II of the EU ETS have not triggered transformational investment in sustainable renewable energy or low-carbon technology. The EU claim that since 2012 the EU ETS has contributed to reducing the carbon footprint of the aviation sector by more than 17 million tonnes per year with extremely high compliance in reporting (EU, 2021).

5.2.3 The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

In October 2016, an understanding was reached at ICAO in Montreal that committed 191 nation states to the first worldwide agreement on aircraft emissions from 2021, when approximately 80 nations or 77% of international aviation activity will initially take part (ICAO, 2018; TAKS, 2018). The pilot phase will be replaced by phase 1 in 2024 and phase 2 from 2027 to 2035. Several large CO2 emitters long opposed to any agreement, Russia, India and China became signatories, with Russia and India joining in 2027. In the text were commitments to develop sustainable fuels, share technology, agree best industry practise and to discuss problems surrounding the future of the industry (ICAO, 2016). The concord includes General Market Based Measures (GMBM) featuring taxes, levies, carbon offsetting and reduction (Figure 21), carbon-based trading for fossil fuels, and improved aircraft noise standards and emissions targets. Airlines must buy a carbon credit to cover international emissions. The accord represents countries flying more than 80 per cent of international traffic, but falls short of the goals of the Paris Agreement for carbon neutral growth from 2020 and the halving of aviation emissions from 2050. Barrett (2006), Ang & Marchal (2013) and Hoffmann (2011) made similar proposals in the academic literature before CORSIA was agreed. International air traffic covers around 65% of aviation emissions or 1.3% of global CO2 emissions (ICAO, 2021).

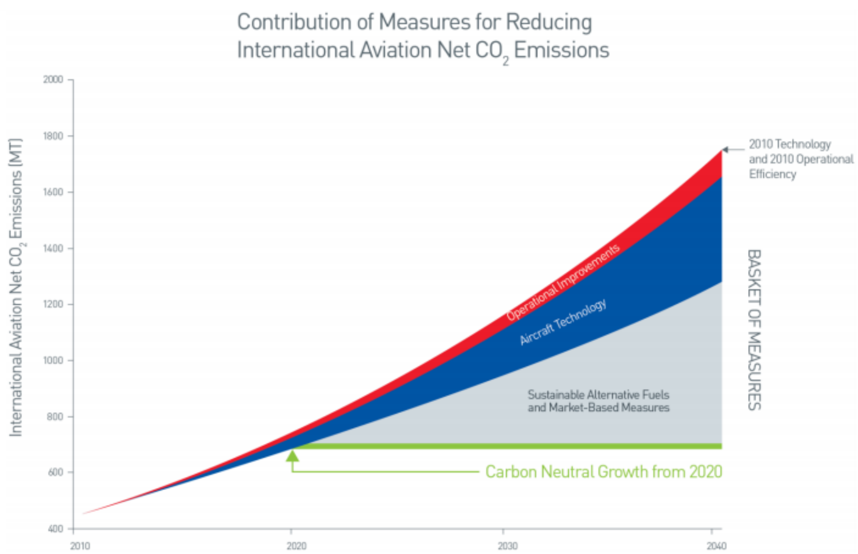


Figure 21: The Contribution of Measures for Reducing International Aviation CO2 Emissions

Source: ICAO (2015:12)

CORSIA addresses CO2 emissions from international aviation, which are not included under the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement, and therefore are not included in countries' Nationally Determined Contributions (NDCs), unlike the emissions from domestic aviation. The Paris Accord (UNFCCC) has a seven point plan of sustainable development goals providing a roadmap for climate action aimed at reducing emissions and building climate resilience. Global emissions of CO2 have increased by 50% cent since 1990, grew more quickly between 2010 and 2019 than in each of the three previous decades with the latter the hottest decade ever recorded (UN, 2020). The Paris Accord within the UNFCCC framework was adopted by nation states in December 2015 (UNFCCC, 2015). By late 2016, 194 members had signed the agreement which covers about 55% of carbon global emissions, committing them to limiting global temperature rises to 1.5C (max. 2C) above pre-industrial levels. The level of NDCs will be set by each country but are not binding under international law and there is no enforcement. As such, the agreement is fragile and there will only be a 'name and shame system'. Capital Economics believe a global economy moving towards three isolationist trading blocks, will make these international agreements more difficult to agree and enforce (Bootle, 2019). CORSIA aims to halve carbon emissions by 2050 on a 2005 baseline, and promises carbon neutral growth from 2020. The Directorate-General for Mobility and Transport of the EU describes the agreement seems as a ´delicate compromise´ designed to maximise the number of signatories (EU Flightpath, 2011).

While it is to be hoped the agreement is not simply a public relations exercise, there is a measure of pre-emptive action in the agreement in that it is likely legislation will be imposed on the industry in any event. Pressure from regulators, consumers, green groups and rival industries will increase and especially if the visible effects of climate change become more widespread.

5.2.4 The Potential Shortcomings of CORSIA

The criticisms of CORSIA from outside the industry are firstly, that the agreement only addresses the growth in international aviation by carbon offsetting, excluding domestic aviation which is regarded a national matter. It is also to be noted that the international price of carbon is expected to be lower than the projected EU price (TAKS, 2018). The price of carbon will be determined by a market mechanism which may not be high enough to effectively reduce emissions. The offset obligations under

CORSIA apply to all international flights between participating states, thus flights between a participating and a non-participating state are not subject to any offset obligations (TAKS, 2018). The UK´s position after Brexit is currently unclear. CORSIA appears to be weaker than the EU ETS in which it is to be incorporated with the dangers of using low quality offsets, poor direct tracking and double counting (Carbon Brief, 2019). The International Council on Clean Transport (ICCT) expects CORSIA to only modestly reduce emissions from international aviation to 2035, and unless extended, will only cover only 6% of international aviation emissions from between 2015 and 2050 (Macintosh & Wallace, 2009; Carbon Brief, 2016, 2019; Olmer & Rutherford, 2017; Graver et al., 2019, 2020).

Secondly, the agreement does not limit or cap emissions, allowing airlines to pollute as much as they wish as long as they buy a carbon credit. CORSIA also allows the ´efficient oil´ fossil fuels from modern wells in an attempt to discourage the use of ´dirty´ oil from less efficient sources - a concession given to the Middle Eastern oil producers (Carbon Brief, 2019). CORSIA also allows the use of biofuels allowed from palm oil which can emit more CO2 than fossil fuels overt the lifecycle, encourages deforestation, competes with the human water and food chain and reduces biodiversity. In the early years of CORSIA the number of offsets that need to be purchased are based on industry emissions (sectoral) growth since 2020 and not the individual airlines output, penalising the largest airlines, but after 2030 the calculation formula moves towards individual airline growth (Carbon Brief, 2019).

Thirdly, the agreement is voluntary until 2027, and for SIDS, landlocked and developing states also thereafter. There are no penalties for non-compliance, and two major aviation markets Russia and India have not initially joined the scheme.

Fourthly, the agreement excludes small airline emitters. These are those that emit less than 10,000 tonnes of CO2 p.a., plus those that operate less than 0.5% of international aviation traffic. Since there are dozens of small airlines globally this amounts to a substantial volume of CO2 that is not covered and may encourage the formation of small airlines to circumvent the agreement. It also excludes nearly all the grossly CO2 inefficient private jet operators (Carbon Brief, 2019).

Fifthly, CORSIA is full of strong case assumptions in that the fuel efficiency improvements from existing technologies are slowing, but within CORSIA are projected to maintain their current 1.5% to 2% p.a. for many years. Part of these improvements include SESAR, but it is unclear that the SESAR air traffic control infrastructure allowing for direct routing can be implemented in Europe to timescale thus ensuring that the fuel efficiencies from improved operations are realised. The NGO coalition also criticise ICAO for the lack of transparency and the non-publication of CORSIA reporting (Carbon Brief, 2019). Indeed, individual airlines may be even be penalised by ICAO for releasing data outside the central reporting mechanism.

Finally, more than 150 environmental organisations, economic groups and academics have rejected CORSIA as timid and ineffective at halting climate change at 1.5C. Due to the COVID19 pandemic the CORSIA baseline will now be the average of emissions from the years 2021-23 resulting in both delay and a higher baseline (compared to a previous baseline of the average of 2019-20) (Warwick, 2020). Although CORSIA will create demand for renewables, unless correctly sourced this could make climate change worse. Critics argue that an agreement that aims to limit the growth in international aviation to 50% of the emissions on a 2005 baseline and over 45 years, is not nearly aggressive enough. With emissions prior to 2020 grandfathered, the agreement only effectively manages 25-30% of the current international aviation related GHGs. In contrast to shipping, in 2018 the UN shipping agency the International Maritime Organisation (IMO) agreed to reduce total emissions by 2050 based on a 2008 baseline contrasting with ICAO´s weaker promise to hold aviation emissions at 2020 levels and not reduce them (IMO, 2021). Larsson et al. (2019) conclude that CORSIA will not significantly reduce international aviation emissions, recommending a range of much tougher policy instruments. ICAO will review and overhaul the agreement at the end of 2032 to suggest improvements and fine tune the agreement every three years from 2022.

The STOF forces on airlines arising from the actions of the (European) Regulator in the STR are included and summarised in Table 52.

The next nine sections review the grey literature, where I have aligned the STOF forces arising in the MLP and impacting on airline business models with the nine parameters of the Osterwalder & Pigneur Business Model Canvas (2009). The goal of the exercise is to highlight the most acute STOF forces with the component elements of a complex business model to recognise if changes are demanded. Table 52 summarises these findings by showing the competitive pressures in the STL described mainly by management consultants, from bodies that represent the industry and industry conferences. Pressures from the STR are detailed by the regulator or economic consultancies appointed or working with the regulator (Table 52). Pressures from the TN are illustrated by industry manufacturers, industry bodies and technical experts. The most numerous forces on business models arise from the STL and the STR with the greatest of the STOF tensions financial, followed by service and operational strains The brunt of the stresses on airline business models features indicated in Table 52, are on the value proposition, cost structure and key activities. The direct voices of airline senior management are largely missing from this literature, being represented more diffusely by the industry body IATA and through industry conferences.

Table 52: Summary of Grey Literature Review linking Business Model Perspectives to forces driving change (STOF) 1 of 2

Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Multi Level Perspective Level		
		Socio-Technical Landscape/Market	**Socio-Technical Regime/Non Market**	**Technological Niche/Technology**
Value Proposition	**S/T**	Airlines with modular service offer with high flexibility to demand, geography		Mass passenger customisation possible with new digital technologies
	S	Airline Business Model to be offered by market, but danger of lack of focus and increased costs		New aircraft technologies drive changes to networks and business models (range, cost)
	F	Multimodal European travel corridors threaten airline business models with shortest segments most	Integrated road/rail/air network needs development, agreement. Short haul flight quotas	
	F/O	LCCs and FSNC to combine activities at major rolling hubs for mutual benefit	Hub monopoly issues. FSNC and LCC dominance at key hubs may be broken up	High regulation favours incremental and not radical innovation
	S/O	Lack of ownership of decarbonisation message to customer	Europe´s leading role in the global airline business under threat without large scale investment	SAF technology offers energy security and simpler infrastructure challenges: 180 airports covers 90% international traffic
Key Activities	**F**	Airline financial management in terms of cash and credit ratings of more importance post COVID		Airlines plan and commit to SAF now, ehybrids and H2 later
	S/O	Airline recognition of Business Model failing/maturity with ongoing reviews to rebuild value, robustness, sustainability, flexibility	Regulator delivers roadmap to industry decarbonisation and new infrastructures, matches funding	
	T	Airlines build an internal knowledge brokerage to manage industry transformation		
	F	Airline cost control with focus on a few core hubs	Regulator adds cost pressure for emissions, fair competition, consumer rights	Airlines lobby for late industry decarbonisation and prioritisation of SAF for aviation
Key Resources	**O**	Hub access, connectivity and catchment areas key Business Model drivers		
	O	More skills and flexibility from airline staff required, all personnel are Business Model responsibles	Regulator to step up regulation in many fields, but skills of regulator deficient in assessing statistical models of competition	Airlines to grow skills in new technologies which will become more acute as transformation advances
Key Partners	**F**	Re-evaluation of supply chain in favour of airlines	Possible break up of airport and airline groups by regulator with onward cost/revenue effects for airlines	
	O	A4E lobbying with industry, regulator on timetables, costs	European regulator driving cost, timetable of global regulation	Airlines/SAF providers lobby for `EU Office of Sustainable Fuel´ for fair production and distribution
	T		European regulator champions developments in technology with derisking and matched investments	Airlines to influence developments in industry technology
	F		Regulator with limited investments in supporting airlines, fresh funds with green conditions	

Table 52: Summary of Grey Literature Review linking Business Model Perspectives to forces driving change (STOF) 2 of 2

Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Multi Level Perspective Level		
		Socio-Technical Landscape/Market	Socio-Technical Regime/Non Market	Technological Niche/Technology
Customer Relationship	S	Airlines to win back passenger confidence with security, health & safety, green branding and more service choice	Demise of airline national brands but some PSO to be regulated, end of state bailouts	
	O	Airlines promotion of multimode travel with dedicated partner	Regulator facilitates multimode travel infrastructure	
	F		Regulator adds to airline financial problems with definitions of (un)expected events, (non)refundable items and staged payment of tickets	
	T	Airlines own decarbonisation message. Customer can choose sustainability	Regulator requires airlines to disclose fuel/emissions costs on tickets	Zero emissions unlikely, but sustainable choices must be offered to reach net zero
Customer Segment	F/S	3 groups of airline need serving: business, leisure, visiting friends & relatives (income, age, reason) with a variety of service/cost offers	Regulator penalises shortest air segments, premium travel, executive jets, frequent flyers with costs	Technology enables mass customisation of airline passengers
	T			SAF leaves existing networks little changed but raises unit costs
	T			ehybrid aircraft hops redefine short haul services, costs & networks
	T			H2 aircraft redefines medium haul service, costs & networks
Sales Channel	S	Dedicated sales and service channels support passenger and cargo yields		
	S	Control of sales channel vital for airline yields. LCCS move to GDSs	Regulator acts to increase fares transparency and comparison websites	
Revenue Structure	F	Movement of long haul markets to Far East. EU short haul market saturated. Weak, volatile, ageing markets in Europe with modest demand	Approx. 15% of annual industry revenues needed for transformation with implications for higher fares	
	F	Monopoly of hub access keeps fares and hub profits high, passengers value connectivity	Increased regulation of hubs, consolidation, mergers, FFP, SPA, codeshares, alliances driving lower fares	Higher ticket prices due SAF and lower travel demand
Cost Structure	F	Airlines with high cost focus in post COVID recovery	Regulator to unbundle airport and air traffic services to reduce cost to airlines	New aircraft/engine technologies offer unit cost improvements but favour cash/credit rich airlines
	F	CAPEX postponement probably counterproductive with rising sustainability issues	ATC delay costs and travel times reduced by SES, SESAR	Reducing technology certification and time to market costs by 50% as potential
	F	CAPEX investment favours cash/credit strong, weak players will turn to leasing	Regulator to standardise airline accounting	
	F	Airline new entrants have potential for lower unit costs	Regulator to manage fair access to markets, hubs	
	F	Airlines must demonstrate how profits are made and falling unit cost trends to gain credit	Cost base will be driven by size, regulation, security, environmental concerns and health and safety	Digitalisation offers unit cost savings potential

5.3 The Value Proposition

In the STL four themes dominated in the opinion the authors affecting the value proposition, i. modular service offerings, ii. short segments and travel corridors, iii. airline cooperation and, iv. ownership of the decarbonisation message.

A key pressure to stabilise falling yields for airlines is to develop a new value proposition with a variety of modular **service** offerings which can be turned on/off as passenger demand requires (Hansson et al., 2003). Such service offerings might appeal to distinct markets and geographies rather than being offered flights and would involve building greater flexibility into business processes. Such flexibility might well outperform traditional innovators that are less adept to fast changing demand, but it is to be noted that it can be duplicated by any airline with sufficient resources. A highlighted danger is that running multiple and parallel business processes within an organisation may lead to a lack of focus and cost control. Service modularity in tailored service and product offers is seen as needed to sustain demand, with price, choice, convenience and comfort the critical passenger factors (Müller & Vorbach, 2015; Corbo, 2016).

A second theme was the move towards European integrated travel corridors in which road, rail and air services are **operated** and planned together to serve major traffic city pair flows (Wardman et al., 2002; EU, 2020). Airports would be integrated with the high-speed rail network to provide passenger choice and obviate the need to fly the shortest air sectors which create greater sustainably problems. Such a development would threaten any airline model with short sectors under 800 km (Wardman et al., 2002). Airlines, rail operators and the regulator should be involved in the joint structuring of such international solutions (Stecenko & Parkhimovich, 2020).

Thirdly, in a European market with profits elusive, business models were proposed where LCCs might **operate** in conjunction with Network Carriers to supply feed traffic at the major hubs. LCCs seeking to improve yields in mature markets must either take Network Carrier markets, or work with them. Network Carriers seeking to improve the performance of their short haul networks which are marginally profitable, might choose to work with their more profitable short haul cousins in wave scheduling for the benefit of both in ´rolling super hub´ operation. Certainly, Network Carriers need to reduce their cost base to compete with LCCs on short haul operations (Hansson et al., 2003; Burghouwt et al., 2015). As network destinations and travel time define and limit the operation of a business model, the skilled operation of a more limited travel network might have mutual benefits.

> ´Redefinition of hub-strategies, which may entail the integration of low-cost (subsidiary) carriers into the feeder networks of the full-service carriers in order to reach a lower cost level and to pre-empt competition. ´
> (Burghouwt et al., 2015:42)

Lastly, airlines with the closest direct contact with the passenger are urged to own the decarbonisation message, and turn it into a **service** value proposition to new (mainly younger) travellers seeking it (KPMG, 2021). It is to be noted that airline cooperation and consolidation and the use of travel corridors would lower total aircraft emissions with an effect on fares.

In the STR Europe is seen as highly competitive and safe market with 40% of world traffic (EU Flightpath, 2011). To maintain this share and deliver industry transformation an estimated 15% of annual industry revenues or Euro 100bn will be required with an obvious implication for the **finances** of fares models (OJEU, 2014). As traffic flows move eastwards and Gulf carriers encroach on home markets, a global leading role might come under threat to the disadvantage of its home carriers (Airline Leader, 2014).

The question of the significant leverage that LCCs hold over some secondary airports was discussed in terms of the negative effect on the implementation of travel corridors and linking transport modalities which might require longer term commitments (Olischer & Dörrenbächer, 2013).

In the TN the development of new technologies normally offers opportunities for new business models, but highly regulated airline environments likely favour incremental change within the industry. New **technologies** however may threaten airlines with the development of the Hyperloop, drone and air taxi sector technologies challenging passenger and cargo yields over shorter sectors (Roland Berger, 2017, 2018; IATA, 2017, 2021). Electric hybrid aircraft may allow airlines to continue to fly short sectors without emissions penalties and especially over water where rail is at a disadvantage, but not before 2035 with implications for business model networks.

New aircraft types in ehybrid, strut and blended wing technologies offer new cost propositions in up to 200 seat market. Such technical developments will limit and benefit airline networks in terms of range and operating costs, directly affecting operating existing business models (Bieger & Wittmer, 2011). Renewable electricity for ehybrid aircraft is the cleanest and unlimited long term power source, but SAF can reduce emissions by 30-60% and hydrogen 50-75%. Estimates are that 90% of aircraft fuel in Europe could be from a renewable source by 2050 with direct effects on airline capital and emissions costs (Holladay, 2020). SAFs from a wide range of feedstocks offer increased energy security for airlines. With increasing limits on fossil fuel use they might add significantly to operational stability if they can be scaled up. Approximately 50 billion tonnes of SAF will be needed by 2050, which can be blended with kerosene in up to 50% mixes. Developing SAF for the benefit of local communities would add credibility to an airline sustainable value proposition (Holladay, 2020).

With 51% of the global population living within 100km of an international airport, and 71% within any airport, replacing the **operational** fuel infrastructure at 180 hub airports covering 90% of international travel is a realistic proposition and significantly easier than in ground transportation (Baumgartner and Garot, 2021).

In summary, changes not only in passenger profiles, but in travel modes over shorter distances are likely to encourage more partner cooperation. Funding industry transformation will require significant new industry funding, putting upward pressure on ticket prices. The adoption of sustainable technologies is predicted to limit payload and network possibilities driving new operating models.

5.4 The Key Activities

In the STL there were four themes judged as having an influence on business models, i. financial management, ii. building sustainable processes and flexibility, iii. building a knowledge brokerage, and iv. a core hub focus.

Cash and credit lines will be a defining feature for the successful transformation of airlines (SCOPE, 2020, 2021). Managing airline **finances** in levels of debt and a strong credit rating will be vital to attract investment for the changes that lie ahead. Old assets will be of low value for securing credit from asset backed securities, with virtual circles around new aircraft assets both reducing emissions costs and having greater credit raising powers (KPMG, 2019, 2021).

Airline managers must be able to recognise when the current Business Model is failing and understand that which must be changed (Santos et al., 2019). That which can be bought cannot be put together without the necessary skills (Massa & Tucci, 2014; Lindgart et al., 2009). Building robust, sustainable and flexible **organisational** processes will be the key to managing volatility in the supply chain, the provision of services and in operations management (Müller & Vorbach, 2015; Bain, 2020). Cooperation with suppliers enhances flexibility and robustness but notably some LCCs have a poor history of cooperation and loyalty at secondary airports (Olischer & Dörrenbächer, 2013). Changing to sustainable processes will cause initial upheaval but be more cost effective over the longer term given the direction of industry travel.

Building and sustaining an internal knowledge brokerage will be a core competence in managing turbulent change in new **technologies** and in securing key personnel. The level of new skills needed for effective decision making and their implementation will rise as multiple new technologies are introduced (Nair et al., 2011).

> ´To evolve, the airline should have defined, strengthened and set priorities and operating models based on its core competencies. Core competence is the essential feature that determines the business model of an airline´.
> (Nair et al., 2011:10)

Controlling costs and **finances** during industry recovery and transformation is predicted to lead Network Carriers and LCCs to initially focus on a few core ´super hubs´ servicing both intercontinental and local markets (Hansson et al., 2003; Bilotkatch et al., 2013). Continuing on their existing trajectory might mean that during the next downturn Network Carrier lower cash flow will drive a round of bankruptcies and mergers, leaving short haul traffic to the LCCs (Hansson et al., 2003).

Using larger hubs might encourage the **operational** use of larger aircraft to control costs through lower frequencies, enabling the airline and airport infrastructure changes needed to cope with new fuels and new aircraft designs in ehybrids and hydrogen fuelled aircraft (Reynolds-Feighan & Button, 1999).

In the STR the key activities of the regulator delivering pressures on airline business models are, i. providing the roadmap to industry decarbonisation, ii. planning infrastructure renewal and, iii the regulation of emissions and industry consolidation. These are all out of an airline´s control but lobbying is expected.

The regulator is predicted to call for matched funding from public and private **finances** in response for accepting emissions regulation with implications for airline capital expenditure (EU Flightpath, 2011; Sustainable Aviation, 2020). Any airline merger activity is likely to be accompanied by calls for asset sales, fares reviews and forced intermodal travel agreements with monitoring. Greater use of market mechanisms will be applied for infrastructure services and the competition for hub passengers, recognising that currently LCCs don’t add much to connectivity unless they move to the major hubs. Thus, there is the potential for lower non fuel operating costs. Recent market liberalisation has increased capacity without lowering seat load factors, so there is much at stake by all players if there is multi party cooperation for industry growth (Butcher, 2010; Gonenc & Nicoletti, 2001).

A tougher emissions policy will cause airlines to rethink about what is profitable the costs of carbon compensation and the adoption of new **technologies**. The regulator understands that allowing unlimited carbon compensation and carbon capture and storage could encourage carbon lock-in. Global emissions harmonisation is required to stop a race to the bottom at major hubs, so that the regulator with the industry will seek to decouple aviation growth from emissions growth as emissions are currently rising four times faster than advances in technology (Holladay, 2020).

In the TN the pressure from changes in **technology** will force airlines to think about the practical introduction of SAF now. Commitments to SAF mandates and equal access purchase platforms are a first stage that would generate goodwill (IATA; 2015). Long haul services will require a complete switch to SAF and short haul the ending of some sectors or the operation of ehybrid and hydrogen powered aircraft (Roland Berger, 2017; KPMG, 2021). Technology changes will require ongoing rethinking of networks, payloads, aircraft lifecycles and adjustments to the business model (Lange, 2018). As renewable fuels will not be available in sufficient volumes for some years dual parallel running with airport partners requires the coordination of joint investments. Airlines can lobby for the late decarbonisation of the industry and the prioritisation of SAF for aviation given more alternatives for ground transport (Pavlenko et al., 2019).

> ´For decades to come we will have an electricity energy mix including fossil fuels and renewable energies. No one should claim the clean energy and leave the dirty energy to others. ´
> (Scholtz, 2020:130)

5.5 The Key Resources

In the STL the assessment was hub access will be a key **operational and financial** resource for airlines. With more LCCs seeking to move to the major hubs for yield, secondary airports will enjoy lower traffic levels giving rise to opportunities for new lower cost entrants. The key driver of new low-cost business models will be catchment areas and rail/road connectivity. New LCC operations at major hubs might drive integration or cooperation with Network Carriers. Airline cooperation and consolidation is likely to increase the pressure at major hubs to free up slots for new entrants (KPMG, 2021).

More flexible staff will be needed with a new behavioural mindset in developing new **operational** and core skills sets and in managing new technology and sustainable processes. The appointment of a Business Model responsible manager is seen as counterproductive since the business model will become the responsibility of all staff (Santos et al., 2009).

In the STR the regulator is predicted to step in to address the fairness of major hub access and needs an increased statistical skillset to evaluate mergers, airline alliances and cooperation, codeshares and block space agreements for their underlying **financial** fairness to customers (OJEU, 2014).

Technological forces arising in the TN will drive airlines to build competences and a knowledge brokerage in the developing aircraft and engine machinery and the digitalisation of data and yield management through mass customisation. As the industry moves away existing combustion technologies this problem will become more acute (Nair et al., 2011).

5.6 The Key Partners

The sentiment in the literature was that the pressure from **service** competition in the STL on airline operations will drive the re-evaluation of the supply chain. Closer cooperation with suppliers and partners may lead to a more equitable distribution of industry profits (Reynolds-Feighan & Button, 1999; Bain 2020). Airlines working with industry bodies such as Airlines for Europe (A4E) and IATA may to secure favourable legislation.

In the STR the key airline partner is the regulator. Airlines will continue to seek a global harmonisation of the legislation on emissions and compensation to minimise **financial** disadvantages. To achieve this the European regulator will have to work with other regional and global bodies. The regulator as partner is also seen as responsible for regulating airline ownership and mergers, alliances, inter airline agreements, airport and ATC charges, security, health and safety, hub access and refund and accounting rules for the **service and financial** benefit of the consumer. Regulator activity might include the breakup of monopoly airline or airport groups and related commercial activities. Joint planning and agreement with airlines and airports will be responsible for infrastructure renewal and training, including SES and SESAR, multimode transport systems and the vital cybersecurity of system hubs and multiple air traffic layers (SEO Amsterdam Economics, 2021).

The EU is expected to champion Europe as a global leader airline technology with a substantial contribution to high technology jobs and GDP and prevent US dominance (Ishutkina & Hansman, 2009). Key current research streams include the effect of climate damage on the industry, airport and ATM research and energy technology development (Baumgartner & Garot, 2021; EU, 2021). Unless the regulator continues to support and encourage investors in SAF and new aircraft and engine technologies there is the danger that investors might find other industries or geographies more **financially** attractive. Such support could be encouraged by advance purchases of SAF or other new technologies and announcing a date for the end use of kerosene as 31st December 2050 to keep CO_2 under 450 ppm (T&E UK, 2021).

Highly indebted governments are unlikely to **financially** bail out airlines in the future and seek to share infrastructure costs with the private sector including joint investments with the military. Existing state airline loans might be swapped to equity if they cannot be repaid (Christiansen, 2021). Green covenants are predicted to be applied to any fresh funds (KPMG, 2021).

In the TN SAF producers might champion an ´European Office of Sustainable Fuel´ to encourage the fair production, distribution and pricing of it and compulsory waste obligation use. Airlines might also engage in partnering Universities and research institutes for specific projects that might have **technology** transferable potential to other industries escaping from carbon lock-in (Sustainable Aviation SA, 2020).

There is a danger that existing combustion technology engine manufacturers might be bypassed with aircraft manufacturers developing new power units with start-ups, non-airline industry companies or developing in house solutions unless they can adapt. The return of older propellor technology might even be suitable for ehybrid aircraft having notably lower fuel consumption requirements (Wenger, 2014). Decoupling fuel and engine development is seen to speed up the **technological** development of both as the retrofitting of ´new on old´ technologies can only work as an interim solution.

Only when conventional technology improvements end will manufacturers take greater **financial** risks in developing more radical solutions unless these are partnered. Thus, there is an opportunity for funding from the state and venture capitalists for new entrants as well as new financing models. Such new **technology** companies might involve programmable materials, AI, real time intelligent manufacturing and WLAN electrical wireless systems which together have **financial benefits** in reducing aircraft weight (and CO2) by up to 30% and also lower time to market (ICCAIA, 2016).

5.7 The Customer Relationship

The opinion was that post COVID19, industry recovery in the STL will need airlines to win the confidence of passengers through greater **services** in health and safety in an environment with travel restrictions (BEUC, 2020; SCOPE, 2020; Burghouwt et al., 2015; McKinsey, 2020; Deloitte, 2021). Clear and green branding will grow in importance (Nair et al., 2011; Rutkowsky et al., 2020) and brand extensions offering **services** in choice, convenience, cost and comfort (Lindgart et al., 2009). Such innovation is likely to be incremental with passenger surveys indicating there is a lack of satisfaction with the infrastructure of European check-in and departure lounges.

The demise of national carriers (brands) supporting national interests in the STR is likely but with some public service obligations (PSO) for isolated communities. Fewer airlines will be supported with public **finances.** Post COVID19 the regulator will ensure clearer definitions of (non) refundable ticket elements and (un)expected events to protect consumer **finances**. A proposal for 20-25% of the fare on booking and 75-80% on travel, together with an industry insolvency guarantee would increase passenger confidence, but severely adversely affect airline **finance** cash flow, particularly Network Carriers which rely on unearned revenues to support weak winter cash positions. Promoting intermodal travel **services** through planning and building connectivity with intermodal rail/road/air code shares would be positive.

The regulator is keen as key in sustainability regulations, potentially by legislating airlines to disclose the **financial** cost of emissions/fuel on air tickets, noting that 60% of the flights in Europe on short sectors drive 50% of airline emissions (Graver et al., 2020). Airlines will likely be required to publish corporate average fuel economy targets (CAFE) (Roland Berger, 2020).

Pressure in the TN the customer **service** relationship should explain that zero emissions are likely not achievable and that net zero is much more likely (Appleyard, 2014; Scholtz, 2020; SEO Amsterdam Economics, 2021). Customers must be offered sustainable **service** choices in air travel for them to be chosen as there is a danger that commercial interests will dominate.

> ´Zero-emission is not possible. Hydrogen combustion emits 2.6x more water per energy than kerosene. This leads to contrails forming already at lower altitudes and hence more often. ´
> (Scholtz, 2020:41)

5.8 The Customer Segment

In the STL the view was that industry recovery is dependent on the level disposable incomes. In surveys age, reason for travel and frequency of travel have been identified as the key parameters of **service** choices. Three broad passenger groups business, leisure and visiting friends and relatives (VFR) need tailored **service** (Morphet & Bottini, 2017). Business passengers care about frequency, convenience, hub closeness and time to destination. VFR care about fares and timetable. Leisure passengers care mostly about fares. Passenger profiling will play a more important role in the fragmentation of business models and personalisation (modularisation) of service (Hansson et al., 2003). Even one passenger might require a different service offer and in a specific market. Winning airlines will be those least dependent on once high business yields, and the shortest segments (KPMG, 2021). Inefficient airlines will only be able to survive in customer niches (WEF, 2021).

In the STR it seems likely that regulator pressure will **financially** penalise the shortest flight segments under 1,500 km unless using SAF given these services are the highest unit emitters (Science Based Targets, 2021). This will disproportionally affect executive jet, regional and LCC business models. It seems possible that the regulator will seek to disproportionately burden frequent flyer and premium passengers with higher **financial** costs. Wide body economy travel is up to four times more carbon efficient than the similar in a premium cabin (Graver et al., 2020).

> ´Premium seating was found to emit between 2.6 and 4.3 times more CO2 per RPK than economy seating. Traveling in widebody economy class was found to have the lowest average carbon intensity at about 65 g CO2 per RPK. ´
> (Graver et al., 2020:ii)

After 2035 **technological** pressures from the TN indicate short hop services can be flown by ehybrid aircraft using batteries for peak power requiring network and handling adjustments to business models. Long haul services will be dominated by SAF due to fuel tank size requiring fewer network adjustments to these models. After 2040, hydrogen is predicted to lower unit operating costs improving airline **finances** and operate 40% of flights by 2050. There are however significant problems in its global transportation with its main use reserved for short and medium length sectors. It is likely that supersonic aircraft such as BOOM will find certification problematic given their environmental footprint (Komadina et al., 2012; IATA, 2017).

5.9 The Sales Channels

In the STL pressures are rising to develop tailored dedicated sales and **service** channels to protect **financial** yields and that ownership and capture of distribution channels would be vital in value capture. Separate service channels might be managed by the greater possibilities of digital automation (Hansson et al.,2003).
In the STR the regulator will step up pressures in fares transparency and online fare comparison channels, possibly adversely affecting airline **finances.** Potential travel service providers in Google and Facebook are currently unregulated and this will be addressed (GRA Consultants, 2017; Graver et al., 2020).

5.10 The Revenue Structure

In the STL the judgment was that there are threats to business model revenue **finances** in the saturation of the intra-European market and the movement of the long-haul market towards the East. LCC models are perceived to have some small growth options to Eastern Europe and Network Carrier models to the Far East (IATA, 2021). All business models are mature with levels of **service** reinvention necessary.

In the STR pressures on the revenue **finances** of airline business models include dangers from the regulator in addressing airline consolidation, frequent flyer programmes, block space agreements, codeshares and alliances all of which have been shown to increase fares and hub profits (Brueckner & Pels, 2004; Benacchio, 2008, Bonova et al., 2009; Bilotkatch et al., 2013, Burghouwt et al., 2015, 2017). With the level of consolidation in Europe reaching critical levels, action on behalf of passengers by the regulator threatens already weak yields. Studies indicate that passengers value the connectivity cooperative arrangements bring, but that the benefits take some years to flow through to the airlines themselves and affect mostly Network Carrier business models (Steere Davies Gleave, 2007; Perezgonzalez & Lin, 2010).

> *´Key markets in Europe are now reaching levels of concentration where competition may be at risk if there is further consolidation. ´*
> (GRA Consultants, 2017:3)

In the TN pressure for higher ticket prices resulting from the use of new **technologies,** initially in SAF and kerosene taxes are expected to lower the demand for air travel, and unless these charges are applied fairly globally might put the European industry at a disadvantage (Bramham et al., 2004; Spero & Toplenski, 2019; McKinsey 2020).

5.11 The Cost Structure

In the STL as airlines recover the conclusion was that there is likely to be a strong **financial** cost with a reduced capital investment focus. Every month of non-normal business increases the pressure on airlines (McKinsey, 2020; SCOPE, 2021; CAPA, 2021; IATA, 2021). Postponements to capital expenditure might be counterproductive as current investments in sustainability projects are predicted to have negative lifetime costs over a 15-to-25-year horizon (Abuzeinaba & Arif, 2014; KPMG, 2021; SEO Amsterdam Economics, 2021). Digitalisation, new aircraft types with higher seat configurations and industry consolidation (if permitted) offer opportunities to reduce non fuel unit operating costs.

´Investments in production facilities and projects in the energy sector often have a lifetime of 15 to 20 years. A policy framework with a similar timeframe provides investors with more certainty thereby lowering the project risk. A long-term vision towards 2050 helps to direct investments into renewable energy projects such as the production of sustainable liquid fuels´.
(SEO Amsterdam Economics, 2021:106)

Younger airlines and start-ups might have **financial** cost advantages if they can secure profitable hub slots, but will suffer the disadvantage of a weak track record for gaining credit. It is increasingly likely that airlines will have to be able to demonstrate a history in reducing unit costs and market profitability to secure fresh funding (Curley et al., 2020; KPMG, 2019, 2021).

In the STR **financial** cost pressures from more competition in airport handling and infrastructure and the forced unbundling and auctions of services by the regulator offers the possibility of lower unit costs at airports, ATC and runway charges over the next decades (Reynolds-Feighan & Button, 1999; Benacchio, 2008; Burghouwt et al., 2015). Downward cost pressures from the regulator are expected to continue with increasing market liberalisation, and the positive effect of SES, SESAR and CleanSky2 should reduce ATC delays. Unit costs will additionally be driven by increased scale, security, environmental and health and safety concerns (Curley et al., 2020).

In the TN fuel costs are predicted to be the most unpredictable and expensive **financial** operating cost. Increasing kerosene taxes and the cost of SAF (over kerosene) is expected to add at least 5% to the cost base (ATAG, 2020). The price of SAF will dependent on a supply of cheap feedstocks and the profitable use of the by-products of manufacture. Following a tax free and incentive period, longer term it can be expected that SAF might raise the price of air fares by 10% and if taxes are based on energy content and indexed annually (T&E UK, 2021). On current projections kerosene and SAF prices could equalise in the mid-2030s. For ehybrid aircraft ticket prices might rise by between 20-30% (Curley et al., 2020).

The **financial** cost of some capital assets might be reduced if the time to market and cost of certification of new technologies can be reduced as targeted. Open systems in regulation are likely to be much less costly than closed ones (EU Flightpath, 2011).

Existing combustion and materials technologies still offer opportunities to reduce the **financial cost** of fuel and emissions as many newly manufactured aircraft fail to reach given fuel burn figures. Fuel burn might be considered as the basis for landing fees (Olischer and Dörrenbächer, 2013). New aircraft types offer potential savings in maintenance despite higher capital costs (ATAG, 2020). Low-cost long-haul models in particular are likely to benefit from these **operational and financial** developments.

5.12 Discussion

The expert opinion in the grey literature indicates that airlines will have to adjust their business models given STOF forces arising from shifts in the MLP. The results of the grey literature review are summarised in Table 53. Shifts in the STL and STR are greatest with financial and operational STOF forces on airlines dominating.

Forces on BMI predominantly affect the value proposition, the cost base and the key activities. BMI can support a sustainability transition in the airline industry as ´locking in new processes´ offers a competitive advantage in an environment in which sustainability regulation is increasing. Airlines are dependent on the regulator in the STR and technology manufacturers in the TN, so aside from discourse, an airline´s most effective response is to change the business operation in anticipation of a more costly and harsher environmental backdrop. First mover advantage may offer early adopter benefits which can cascade into virtuous circles.

Table 53: Heat Map of STOF Forces arising from MLP in Grey Literature

STOF Forces/MLP Level	STL	STR	TN	Total
Service	8	3	2	**13**
Technology	1	2	7	**10**
Organisation/Operations	5	6	3	**14**
Finance	13	13	8	**34**
Total	**27**	**24**	**20**	**71**

The value proposition will be adjusted to accommodate more volatile demand. The response can take two main forms in the form of customer benefits or partner benefits – offering modular service packets potentially by market, and/or more partner cooperation. Airline business models offering the shortest segments will be most disadvantaged by the real rising cost of energy and STR pressures for multi modal transport. New aircraft technologies will impact changes to range, payload and unit costs and the networks which are a distinct feature of business models.

The key activities of airlines post recovery will likely focus on cost control and balance sheet management. Constant cost pressures while simultaneously securing credit from the capital markets for industry transforming investments will be difficult to steer. The early recognition by the senior management team of outmoded business models and unprofitable hub activity, while brokering new knowledge with partners will be essential skills in a successful sustainability transition. The key resources for airlines will be access to populous catchment areas, major hubs and their connectivity to ground transport. Personnel will likely be required to be more flexible and accept responsibility for business model adjustments requiring skills in new technologies as the older ones are replaced.

Key partners in the supply chain may well have to adjust to lower returns as revenue and cost pressures on airlines rise and interdependence becomes highlighted. The customer relationship will be based on secure and sustainable travel with a variety of service options. Given the greatest passenger journey contact, airlines should own the decarbonisation message and promote multimode travel with partners.

The customer segment will focus on meeting the needs three main passenger groups, business, leisure and VFR. With the regulator likely to disproportionately penalise segments under 1,500 km, frequent flyers and premium passengers, this will fragment existing business model service offers into the schedule sensitive, the flexibility sensitive, the service sensitive and the price sensitive. More control over dedicated service and sales channels will likely be offered by airlines to strengthen passenger and cargo yields, with the regulator likely to press to improve fares transparency and the disclosure on tickets of the cost of energy.

The revenue structure will probably be affected by a more modest demand within Europe, and a redirection of long-haul markets towards the East. Dynamic pricing and multimode travel will add complexity to yield management and more complex fare sharing models requiring higher data management skills. The cost structure will come under extreme focus, however deferring capital investments might prove counterproductive postponing the development of ´virtuous circles´ and increasing the danger of ´carbon lock-in´. Airlines will have to demonstrate cash generation to secure credit which will likely come with sustainability covenants. The regulator will act to both lower and increase unit costs with initiatives designed to stimulate responses from airlines to change their sustainable performance. Early responses to these policy changes can pre-empt some recurring costs.

In this chapter I aimed to detail the major forces acting on airline business models from the grey literature with feasible industry responses. As such this chapter lays the foundations for direct contact with industry leaders. The next chapter (Phase 3) discusses the findings of a primary data collection in the interviews of senior personnel, a group that was not represented here.

Chapter 6 Challenges and opportunities for the European Airline Industry for Industry Stakeholders in the MLP (Phase 3)

6.1 Introduction

This chapter presents the findings of the first part of the primary qualitative analysis (Phase 3, Figure 17) following the 39 interviews with 40 industry members and experts on the challenges and opportunities facing commercial European aviation. The literature review (Chapter 2) has highlighted models and theories of how industries undergo long term transformation, and how companies develop sustainable business models in response to concerns about declining supplies of raw materials and environmental damage. It concluded that the alignment of windows in the MLP enables transformative technologies to be adopted and break through Geels (2018). What is unclear however is how mature industry transformations affect the business models of complex organisation in the areas of economics, energy, social and environmental dimensions and technology (Boons & Lüdecke Freund, 2013) that together determine long-term business performance. The research presented in Chapters 5, 6 and 7 aim to begin to fill in this gap.

In this chapter I unpack in more detail the factors shaping the MLP and industry transition for Europe's airlines as identified by industry experts. More specifically this chapter is concerned with the key research questions of how should airlines address movement in the dimensions of the market, non-market and technology in Europe? What options exist for airlines and what actions might they take? Does innovation in business models have a role in sustainability transitions? Can the forces driving business model innovation in the MLP shape or drive a sustainability transition? What opportunities are there for the alignment of interests to facilitate industry change? Geels (2018) suggests that effective mitigation of climate change will require major changes to existing complex systems involving major disruptions in politics, technology, user practises, infrastructure and importantly for this study, business models. Changes within the landscape may put pressure on the regime creating openings for new technologies, and likewise changes within the regime affect the landscape and the development of new technology (Geels, 2002).

> 'It is the alignment of developments (successful processes within the niche reinforced by changes at regime level and at the level of the socio-technical landscape) which determine if a regime shift will occur.'
> (Kemp et al., 2001:277)

6.2 Findings of the Interview Data using the MLP

This section of the chapter is composed of an analysis of the interview findings presented along the three dimensions of the: i. Socio-Technical Landscape (STL), ii. the Socio-Technical Regime (STR) and iii. the Technological Niche (TN). I aim to draw out agreement and alignment between respondents based on their roles as different industry actors within the MLP. The forces shaping the industry are identified and outcomes and courses of action discussed.

Interview findings were divided into responses from: i. industry senior management ('Internal Airline Actors'), and ii. the regulators, consultants, academics and industry suppliers ('External Stakeholders') in Table 54. I believe that this separation is useful in understanding the different interests and responses of the interview pool. In the analysis I separate responses which are different and highlight where they are the same by comparing the 'External Stakeholders to the 'Internal Actors'. Quotations are selected to emphasise the key points made per interview group.

Table 54: Interview Pool by Internal Airline Actors and External Stakeholders

Category of Interviewee	No. of Interviews Round 1	No. of Interviews Round 2 (persons)	Transcribed Pages of Interview Text
Internal Airline Actors	11	8 (9)	329
External Stakeholders	13	7	370
Total	**24**	**15 (16)**	**699**

In the following text the STOF Model forces are marked in bold as service (**S**), (technology) **T,** organization (**O**)**,** finance (**F**) and the nine perspectives of the

Osterwalder and Pigneur (2009) business model canvas are mentioned where appropriate.

6.3 The Socio-Technical Landscape (STL)

The STL refers to external contexts that normally change slowly. In this study, it relates to European demographics, the increasing pressures of climate change, macroeconomics, fuel prices and their supply, and the organisation of airport and navigation infrastructure and cities. The word 'landscape' implies a level of firmness that is not rapidly shifted, except in crises (Geels, 2002). The STL might change quickly in time of war, disease or economic shocks such as oil price volatility or availability. The landscape puts pressure on the regime such that 'windows of opportunity' open up for 'novelty' and new business opportunities (Genus & Coles, 2008). In this analysis the air transport market sits in the STL. In the questions on the STL many of the interviewees focussed on linking in their arguments with potential consequences. For example, the price of fuel and demographics with airline economic growth; the material context of the industry in the spatial arrangements of cities and access to hubs; and the state intervention in the market and in business models with airline profitability. Interviewees believe that the pressure for action on climate change would increase from the STR into the STL, as would the pressure on oil prices and supplies which tend to be located in politically volatile geographies.

Six major themes emerged in the STL section of the interviews: i. state intervention in the landscape **(F),** ii. hub access **(O),** iii. future market growth **(F),** iv. short journeys and cheap fares **(O),** v. airline survival and differentiation **(S),** and vi. connected networks of transport systems **(O).** English is not the first language of most interviewees and this is reflected in some quotations. The summary findings are presented in Table 55.

Table 55: Main Interview Themes STL 1 of 2

Main Theme Socio-Technical Landscape	Secondary Theme	Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for policy or business models
State intervention and market failure	Current market failure	Cost Structure	F	Market failure leads to low airline profitability through overcapacity, structural cost problems and facilitation of LCCs to grow by indirect subsidy	Market failure leads to low airline profitability. LCCs have not been supported	Allow airline failure with the possible end of national brands & development of global airline groups
	Oligopoly and reduced consumer choice	Key Partners	F	Oligopoly of airlines in Europe with ever fewer carriers	Oligopoly of airlines in Europe with ever fewer carriers	Scrutiny of state participation in airlines and review of failure mechanisms and consumer concerns
		Key Partners	F	-	Allowing global consolidation essential to airline profitability	Review EU legislation on cross border consolidation outside Europe
		Cost Structure	F	Success as airline size dependent	Success as airline size dependent	Regulator scrutiny of further industry mergers and market monopolies and dangers for passenger choice
	Lack of pressure to innovate	Cost Structure	F, T	Duopoly in aircraft and engine manufacture with low innovation pressure (lock-in)	Duopoly in aircraft and engine manufacture with low innovation pressure (lock-in)	Ensuring & creating market access for new entrants. Incentives and penalties for duopolies in aircraft/engine manufacture to innovate.
Major hub access	EU/Global hub competitivity	Key Resources, Value Proposition	O	Scale up investment in major hubs needed to be globally competitive	Small secondary hub growth to continue	Increased connectivity of all hubs to rail/road required and increased infrastructure for growth and new technologies
		Key Resources, Value Proposition	O, T	Concept of 3/4 global hubs in each continent with ME pressure at EU hubs	-	EU hubs to be competitive at a global level with improved and new technology infrastructure required
	Infrastructure pressure at major hubs	Key Activity, Key Partner	O	Future growth will be mostly P2P	Future growth will be mostly P2P	LCCs and Network carriers likely to cooperate at major hubs, LCLH and VLCC models will be P2P. Two new business models likely
		Key Activity	O	Pressure for 24H hub activity to be competitive with other global hubs outside Europe	-	Environmental pressure on major hubs for 24H operations as a bargaining tool
		Key Resources, Value Proposition	O	LCCs move to major hubs means high competition at big 6 EU airports for higher yields	LCCs move to major hubs for higher yields	Pressure to develop hubs to global standard and competition over slots could be used to negotiate green deals
	Ground connectivity to hubs	Value Proposition	O	-	Small hub links to road and rail to be grown to support VLCC models	Secondary hubs to develop connectivity with ground transport, desirability of very low fares airlines?
	Space for new business models	Key Resources, Value Proposition	O	Catchment areas key for LCLH model success	Secondary hub growth will feed a VLCC model	Two new business models in development LCLH and VLCC with implications for low fares
	Oligopoly and reduced consumer choice	Key Resource	O, F	6x6 model - 6 major hubs, 6 major carriers in Europe likely	6x6 model - 6 major hubs, 6 major carriers in Europe likely	Ensuring & creating market access for new entrants implications for passenger choice, higher fares
Future market growth and demographics	Passenger growth in Europe	Revenue Structure	F	Traffic growth slow in Europe, Asia as growth market	Growth slow in Europe. Asia, Africa growth markets for EU airlines	European airlines must hub in non EU passengers with implication for hub renewal. Low fares models become more attractive
		Value Proposition	O	Europe as a middle 'global hub' between US and Asia	-	Major EU hubs key to long-haul profits for (large) carriers with implications for hub infrastructure renewal
		Value Proposition, Sales Channel	F	Lower consumer disposable incomes	Growth at bottom of pyramid	Cheap fares a last growth mechanism emphasising low fares models
		Key Activities	O	Competition for 'the hub' passenger	Most growth to be at new long-haul destinations	Average aircraft size to increase with more long-haul and implications for hub infrastructure
	Price of fuel and regulation determines fares	Cost Structure	F	Passenger growth dependent on cost of energy and regulation	-	Energy and regulatory costs can direct industry transformation

Table 55 continued: Main Interview Themes STL 2 of 2

Main Theme Socio-Technical Landscape	Secondary Theme	Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for policy or business models
Short journeys and cheap fares	Sensitivity of low cost, short sector models to regulation	Value Proposition	O, F	European/global kerosene tax likely affects low cost, short sector models most	European/global kerosene tax likely affects low cost, short sector models most	Sensitivity of short haul services models with potential traffic caps, minimum fares and cost pressure on short flights
	Equalisation of fares ground/air	Cost Structure	F	Additional short haul taxes and traffic caps, minimum fares	Tax complexity and unlevel playing field in Europe, Equalisation of ground and air fares.	Equalise price of short haul air segments with ground travel. Pressure to end short haul services <4 hours door to door. Simplify taxes on airlines
		Cost Structure	F	Equalisation of rail/air/ground transport by tax/VAT/other	Equalisation of rail/air/ground transport	Fuel and emissions taxes to create a level playing field with ground transportation
	Repositioning of existing business models	Revenue Structure	F	Growth of ancillary revenues on value models	Growth of ancillary revenues on value models	Value models to increase tailoring
	Connectivity available to all consumers?	Customer Segment, Customer Relationship	S, F	Polluter pays - leaving out the least well off passenger	Polluter pays - leaving out the least well off passenger	Fewer cheap fares leaves the poorest passengers behind
	Increased requirement for intermodal travel	Value Proposition	O, F	-	Short haul travel by air will be lost to rail/bus on short sectors	Pressure on LCC and VLCC models greatest during industry transformation
Airline survival, differentiation	Oligopoly and reduced consumer choice	Cost Structure	F	Few airlines will survive, scale is vital	Few airlines will survive, scale is vital	Further consolidation has dangers for consumers
		Key Activities	F	Niche airlines will need to be part of a group to capitalise on economies of scale	Airline capital requirements will increase, strong credit rating vital	Large airlines will dominate capital markets, credit rating important
	Changes in consumer behaviour	Value Proposition, Customer Relationship	S	Danger of greenwashing and losing passenger credibility on environmental issues	Airlines scared of changes in green consumer behaviour	Airlines will have to make visible progression on green targets and communicate this. Changes in consumer behaviour drives industry transformation
	Price of fuel and regulation key issue	Revenue Structure	F	Ticket prices dependent on fuel and regulatory costs	-	Use of price of fuel and regulation as a mechanism to direct industry investment
	Space for new business models	Customer Segment, Value Proposition	S	Increased differentiation targeted (4 business models)	Increased differentiation targeted (4 business models)	Four airline business models developing
	Market disruption	Key Partners	O	-	Brexit a disrupter	Increased turbulence in EU market with UK withdrawing from EU and EASA
Connected transport systems	Increased requirement for intermodal travel	Key Activity	S, O	Obligation of the state to provide mobility	Tighter rail-air collaboration	Restrictions on short haul kerosene flying and journeys <4 hours, replaced by rail
		Key Activity	S	More rail hub transport collaboration and transport intermodality. Goals of EU intermodality	EU transport policy with intermodality goals	Significant increases in rail-airport infrastructure provisions required to support intermodality <4 hours
		Key Activity	T	Electric shorthaul aircraft possible 2040 and should fly without penalty	The purpose of flying is transportation not flying	Restrictions, caps on shorthaul kerosene flying and journeys <4 hours unless using e-aircraft
	EU/Global hub connectivity	Key Activity	O	-	Energy density of new fuels may lead to more 'airport hops'	New fuels have implications for reworking airline networks and hubs
	New passenger fares models	Revenue Structure	F	Complex yield/fare sharing management models required for new modality	-	Intermodality needs reworking of fares models for airlines

6.3.1 State Intervention

The secondary themes in this section involved current market failure and the oligopolies of the major carriers and industry manufacturers **(F)** with an effect on the business model cost structure and with key partners.

Internal Airline Actors maintain there are high levels of regulation and intervention in the European market and which is operated as an oligopoly of three large airline groups with a core business as a network carrier, three LCCs plus a few small players. Market failure was evident with governments stepping in to assist some carriers with funding bailouts or bridging loans, and implicit guarantees for some 'national' carriers resulting from their part state ownership or strategic importance to the national economy (ICAO, 2016). Long-term profitability is adversely affected by overcapacity, legacy and structural problems with the cost base, and market interference with national barriers to consolidation - which meant that 'failing players rarely left the game' unless a purchase by another player is accepted by the regulator.

> '*The big guys are trying to get leaner and the basket-cases will, slowly continue to fall out because they are not allowed to keep getting state aid'.*
> (Senior IATA Official, Montreal)

The group consider that the LCCs had grown with indirect support from the state through subsidy and that consolidation mechanisms would have to be enabled to move the industry forward globally and to regain a sustainable level of profitability. From this new baseline industry restructuring could occur and capital reinvestment could increase. These may be comparable to those in the US (Chapter 11), but in Europe this would have to enable cross border stake holdings or complete ownership in a foreign country, and probably mean the end of many 'national brands' and the state participation in airlines. Smaller airlines will likely cease operations or be purchased by the larger groups and horizontal consolidation to continue, accompanied with lower levels of organic airline growth.

The group hold that size will be key to maintain market dominance and keeping unit costs under control, but that a global geographical advantage (such as great circle distances or hub location) may help a few niche carriers such as Icelandair or Finnair survive.

Airline managers opine that the duopoly of large civil aircraft and oligopoly of engine manufacturers is not under great pressure to innovate with order books full for more than a decade. They expected that the new Chinese and Russian aircraft manufacturers would make progress on breaking the Airbus and Boeing oligopoly, but mainly in Asian markets.

External Stakeholders agreed with the critical nature of airline size believing that the bargaining power of larger airlines or groups would enable a coming redistribution of the profits in the value chain of the European industry.

In contrast, the group do not accept that the LCCs in Europe had grown with indirect support from the state through subsidy, but are convinced consolidation mechanisms would have to be facilitated to restore profitability. With this mechanism industry consultants and academics argued that many of the smaller and national brands will cease operations with horizontal consolidation strengthening the cash flow of the remaining players.

> *'Obviously, the low-cost airlines have generally been quite profitable. I think the airlines that are struggling with profitability are the smaller to medium sized, more niche airlines. For example, you've got Monarch which is dependent upon a charter model which has been undermined by the low-cost industry. There's a number of others, mainly based in smaller countries, to be quite honest. I think the likes of IAG, Air France KLM, Lufthansa will gradually sweep up or possibly some of these businesses will go out of business.'*
>
> (Academic and Industry Consultant, UK)

Uniquely, interviewees with technical knowledge believe it is likely that to protect their market position Airbus and Boeing would try to purchase an engine manufacturer to lock-in customers as a supplier of both airframes and engines given the length of the current product life cycle. This structural 'lock-in' might prevent rapid innovation being implemented as new aircraft and engines with airlines.

6.3.2 Access to the Major Hubs

The secondary themes in this section covered the competitiveness of European hubs, infrastructure pressure at the hubs, ground connectivity **(O),** space for new business models and reduced consumer choice **(S)**. These forces affect the key resources and key partners of airline business models.

Internal Airline Actors agreed that access to the major hubs of Europe remain key to the success of the Network Carrier, LCCs and any new business models. The group believe that the LCCs would increasingly seek to gain access to the major hubs leaving behind many of the secondary airports that drove their initial progress. This is principally due to the fact that secondary airport traffic growth is slowing, and greater yields are to be found at the major hubs. This movement by the LCCs implies seeking to connect to other global hubs with new partners and has implications for consumer choice with hubs predominately being occupied by the largest airlines.

Smaller and secondary airports would continue to be used by the LCCs and by a new breed of Very Low-Cost Carrier (VLCC) that will be developed with partners in bus and rail services. Airline managers thought it likely that six major hubs with six airlines would dominate in Europe (termed ´6+6´) - three large network carrier groups and three large LCCs - offering more flights to more destinations but on fewer airlines reducing competition. Any fresh growth will mostly be point-to-point.

> *'There will only be a handful of airlines, three in Asia, three in Europe, three in North America, who will remain, and the others will disappear because they will not be able to operate as efficient as they need because they are lacking the economies of scales.'*
>
> (Senior Director Network Development, Network Airline)

The group believes that the success of the network hubs continues to be dependent on catchment wealth and size, and proximity to the dominant centres of economic activity in Europe, Asia and the USA. There is concern displayed over the lack of global competitiveness of the European hubs with growing competition for global passengers through three or four hubs in the USA, Europe and the Gulf/South East Asia, and a clash over access to the high-volume hubs such as Frankfurt, Heathrow, Paris and Amsterdam likely. In order to remain competitive, there will be increased pressure for the 24-hour operations of European airport hubs, with more runways and increased passenger infrastructure required in Europe. Any new destinations from Europe will likely be the secondary cities in Asia with high catchment populations involved in global supply and manufacturing.

External Stakeholders

The management consultants differed from the rest of this group in that they believe smaller and regional hubs would grow using smaller aircraft to meet point-to-point air traffic demand, linking up with rail services to serve less populated communities. The growth of second tier hubs will be dependent on local economic activity, with Southern Europe vulnerable to a long recession in the near term. The group believe short journeys under four hours would probably be lost to low-cost bus services (comparing to Eurolines and FlixBus), high-speed rail and driverless cars (Hars, 2015). Collaborating with other transport providers offers airlines a way forward to encourage business at these smaller hubs.

`But, the reality is I think we are going to move… growth increasingly is going to be point to point.'
(International Airline Consultant, UK)

6.3.3 Future Market Growth and Demographics

The secondary themes in this section reviewed the potential passenger growth in Europe **(F)** and the implications of the cost of fuel and regulation for air fares **(F).** The responses given challenge the revenue structure, value proposition and cost structure of airline business models.

Internal Airline Actors agree that the market within Europe will show slower growth with an ageing population and lower disposable incomes. This would mean that for the European industry to grow, demand would have to be stimulated by new pricing models and greater service differentiation, or that passengers would have to be transferred to Europe from hubs outside Europe affecting the value proposition. The global centre of air travel will likely move to Asia, but the European market would still be the third largest hub market after the Asia and the USA. Several airline managers believe that Europe is ideally placed to act as a global hub because of its favourable geography by offering shorter travel times across the Atlantic to the USA compared to across the Pacific.

'Growth broadly comes two ways. You expand the bottom of the pyramid by offering lower and lower fares so, technically, bigger aeroplanes, so the A380… yes…and then you look at it by opening up new routes and new routes are going to be from smaller aeroplanes which have greater efficiency and low costs so they have much better trip costs.'
(Airline Industry Consultant, UK)

'*Europe has got a terrible demographic, shrinking and ageing population and so we're sort of looking at stagnation in the European air travel markets.* `
(Senior Official IATA, Geneva)

The group conclude that future growth in the European market and airline fares will be largely dependent on the price of fuel and regulation, with all current demand forecasts by airlines and manufacturers based on the continued use of kerosene.

External Stakeholders agreed Europe would show slower growth but maintained drivers such as local GDP growth were important. This group believe that long-haul air services would be subject to the least competition with constraints on access to the major European hubs and the lack of an effective substitute. In contrast to airline managers, industry consultants believe that the African market is currently lost to the Middle Eastern carriers but with its geographical proximity and high population could be a growth area for European carriers. The Europe to Americas markets remains strong with IAG very dependent on North and South America for its core profits.

> *'I don't think airlines can decouple themselves from emissions on the short term, let's say within a decade or within 15 years. It's simply a matter of technology. It is more probable that, let's say, decrease of emissions will come through a decrease of demand.'*
> (Economic Consultant, Aviation Consultancy, Amsterdam)

6.3.4 Short Journeys and Cheap Fares

The secondary themes in this section involved the sensitivity of low fares models to regulation **(F),** the equalisation of ground and air transport fares **(F),** the strategic positioning of existing business models and passenger connectivity **(S, O).** Responses given to these questions affect principally the value proposition, revenue and cost structure of airline business models with greater customer segmentation and a renewed customer relationship.

Internal Airline Actors maintain that increasing environmental taxes would most adversely affect the very low fares airlines, as their business models are more price sensitive. As such models come under pressure, the poorest consumers may potentially be priced out of flying. The group agreed that there would be fewer fares sold at less than the marginal cost of transport, with the equalisation of rail and air transport likely and equitable. The removal of VAT from rail travel or added to air travel is seen as a mechanism, with the carbon taxes being applied to air travel in Europe from 2020 absent from electrified rail raising the competitive cost of flying. Several managers believed a global kerosene tax as inevitable and that short-haul air travel would become subject to traffic caps.

> *'But I truly believe that if something like that (emissions taxes) comes it will more impact the lower price segment than the higher price segment.'*
> (Senior Director Network Development, Network Airline)

> *'I think if emissions become so high, then these (low fare) business models will be in trouble, for sure.'*
> (Senior IATA Official, Montreal)

External Stakeholders accept the cost of emissions falling on the polluter/passenger as the fairest method of addressing the cost of emissions, despite disadvantaging the least well-off consumers. There is a concern that complexity of the taxation of air travel should be avoided with possible specific taxes for airport departure, kerosene, emissions, stage length, cabin class and VAT adding administrative burdens to airlines and with potential collection difficulties. Taxes should be simple, clear for passengers and hypothecated for industry research and renewal, something surprisingly not mentioned by the airline group.

> *'That I think it is quite likely that we will at least see a taxation on kerosene on a global scale.'*
> (Head of Sustainability, Aircraft Manufacturer)

> *'This has become an argument, that you say OK, it's not only that public transport or train is slower than flying, it's also… most of the time it's more expensive. Yes, so how… in the free democratic society, how can you levelise it.'*
> (Climate Pressure Group and Consultancy, Germany and Switzerland)

Minor themes included an increased airline focus on developing revenues from ancillary services to combat declines in passenger yields and preventing local state support and subsidy to secondary airports.

6.3.5 Airline Survival and Differentiation

The core theme in this section is that demand is likely to stagnate due to increasing environmental taxes and changes in consumer behaviour particularly on short haul demand where cost effective ground transport alternatives will increase and with 'flight shaming' affecting consumer behaviour **(F).** Demand for lower price fares models would rise, resulting in increased differentiation **(S)** affecting the value proposition, revenue and cost structure of airline business models. Customer segmentation and the customer relationship are likely to show more differentiation.

Internal Airline Actors argued that the capital requirements for industry transformation and the continuing pressure on margins would drive more industry consolidation. This is easier within Europe than the consolidation of a European airline with a non-European one, due to protective legislation. Even those national, small and niche airlines that may survive, were seen as having to belong to a larger group where scale advantages could be passed on.

> *'If there are smaller airlines or smaller operators who are tailor-made to, you know, cater for the specific needs of one such segment, they need to be part of a bigger context and because only then you can be able to raise these economies of scale.'*
>
> (Senior Director Network Development, Network Airline)

External Stakeholders are less sceptical about the fall in demand citing historic industry growth curves, but clear that only airlines with strong credit ratings will survive industry transition due to rising capital and operational costs. Stimulating demand requires lower fares and new services with consumer behaviour likely to change with greater options in short sector travel modality. The group also mentioned Brexit as a disruptive factor for the European industry, both for aircraft and parts manufacturers in the UK and with the value of sterling having implications for air travel demand to and from the large UK market.

> *'They are (airlines) really scared that the consumer behaviours will change next time'.*
> (Press Officer and Climate Consultancy Spokesman, Switzerland)

> *'For the low-cost carriers the price of the fare is critical to developing their market and I have the impression that this is why they resist so much a number of actions, such as sustainable fuel. The good thing is that they are new so they are equipped with new aircraft, so their level of… current level of efficiency, fuel efficiency, is excellent and then the transition to other means make it difficult.'*
> (Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

6.3.6 Connected Transport Systems

The secondary themes in this section referred to increased intermodal transport **(S, O),** hub connectivity **(O)** and new passenger fares models **(S).** The forces arising from this theme affect the key activities and the revenue structure of airlines.

Internal Airline Actors conclude that the likely future restrictions on short haul services flown with fossil fuels will require the integration of air and rail terminals to supply the long-haul feed traffic at major hubs (Roman & Martin, 2014; Albalate et al., 2015). With state obligations to provide for mobility, railway stations would need to be integrated into airports before short-haul air services linking hubs could be reduced. Electrified rail services offer national emissions advantages over air travel over shorter segments. Price equalisation with rail seems a likely development with many interviewees seeing the end of very cheap fares and less short haul flying as inevitable given EU transport goals in intermodality. Several interviewees thought it likely that an electric/hybrid may replace some kerosene fuelled aircraft ‘short hop’ services by 2040.

> *‘Politics is obliged to keep the social mobility and also the local mobility of the people. So, they kind of have to in some ways, they have to provide infrastructure reach like autobahn or railway.’*
> (Head of Maintenance Planning, LCC)

> *‘I think there will be a stronger and more seamless collaboration between the different players. This topic, inter-modality, is a hot topic, 100% sure, from a passenger seamless travel perspective, from an emissions perspective, political perspective.’*
> (Senior Director Corporate Development, European Network Carrier)

Improved passenger yield and profit management models need to be developed to manage more integrated and complex transport models. New techniques in data management and analysis enable the profit management of individual customers with continuous pricing, revenue/profit per m^2 and journey passenger contribution concepts discussed.

External Stakeholders added unique comments relating to the problems of middle and long-haul services noting the carbon inefficiency of carrying large volumes of fuel around the globe, predicting more ‘refuelling hopping’ due to the lower energy density of renewable fuels, and with slower flying (impacting timetables and networks) which reduces aircraft emissions and damaging contrails (Ezard, 2006). The ‘energy density’ of renewable fuels however may soon exceed that of fossil fuels, as the density of currently extracted fossil fuels falling according to one expert.

’Yes, I think this is one avenue (intermodality) and it’s especially a possible one in Europe where we have a dense rail network. Some airlines already do that. KLM had co-chairs with the Dutch Rail and I think maybe Lufthansa has it with the German rail.’
(Economic Consultant, Aviation Consultancy, Amsterdam)

‘I mean flying is not the purpose of flying for the purpose of flying. Where do I want to go? From point A to point B in the most efficient and safe manner. This will develop, I think.’
(Senior Director Environmental Affairs, Aircraft Manufacturer)

’Bundling, I am having a glimpse at another study or paper of the European Union, saying that the target of the European Union is door-to-door transportation is possible between two European countries within four hours.’
(Independent Aviation Consultant, UK)

Summarising from Table 55 the greatest strains on business models from the STL come in the form of financial and operational forces acting on the value proposition, key activities and the cost structure of airline business models. Innovation in the business model to accommodate these tensions can support a sustainability transition by changing the elements of the interlinking of business processes to focus on customer requirements, and the operational and cost aspects of renewable energy technologies.

6.4 The Socio-Technical Regime (STR)

The STR covers the tangible systems, the intangible rules, shared cognitive assumptions, regulations and standards which structure but do not determine action. The STR is ‘dynamically more stable’ but more malleable to change than the STL (Genus & Coles, 2008). STRs develop over long periods between regime elements and also as a response to exogenous landscape pressures and niche-innovations (Kemp et al., 2001; Kemp & Pontoglio, 2011; Geels, 2011).

Geels (2002) and Genus & Coles (2008) note seven distinct elements within the STR: current technology, user preferences, culture and practices, symbolic meaning of technology, infrastructure, industry structure and policy and techno-scientific knowledge. In this study, the STR includes aviation law and traffic rights, the regulation of carbon and other greenhouse gas emissions, airline safety and passenger choices and rights. These elements are regulated by national bodies, the EU and the global body ICAO, plus IATA and ATAG the industry representatives. The STR includes environmental pressure groups. Experts referred to the essential steps that must be taken to make progress on the world stage which are currently impeded by conflicting commercial and national interests.

Five distinct topics emerged from the STR part of the interview questioning and the role of the state: i. global aviation regulation **(F, O),** ii. European aviation regulation **(F, O),** iii. airline emissions and decarbonisation **(F)**, iv. air transport infrastructure **(O),** and, v. funding industry transformation **(F).**

An overriding theme is that state 'energy policy' would determine airline strategy and the cost of kerosene plus industry taxes will determine airline fares and the development path of the industry. The summary findings are presented in Table 56.

Table 56: Main Interview Themes STR 1 of 2

Main Theme Socio-Technical Regime	Secondary Theme	Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for policy or business models
Global aviation regulation	License to grow (or operate)	Key Partners	O	Bilateral agreements the biggest issue - through WTO and to include international shipping	-	Tie global traffic agreements to industry decarbonisation plan
		Key Partners, Key Activities	O, F	Global roadmap needed, self regulation will not work. Holding the rules 'enables license to grow' for airlines	Global transformation roadmap needed	Industry ‘license to grow’ if industry holds agreements on green roadmap
	Extend definition of decarbonisation	Key Partners	O	Supply chain innovation to be incorporated into airline carbon targets	-	Extend definition of carbon targets into supply chain
	Agreement drag, delay	Key Partners	O	Multiple carbon jurisdictions as a worst case scenario, US key player	Regional agreement pressure needed to prevent ‘agreement drag’	Global agreement ideal with multiple jurisdictions agreements to be avoided. Regional agreement pressures may assist
		Key Partners	O	Late decarbonisation as industry strategy, focus on biggest polluters first	Late decarbonisation as delaying industry strategy not acceptable	Industry green roadmap key to allowing industry growth
European aviation regulation	EU/Global hub competitivity	Key Partners	O	Airports as national infrastructure with state to rebuild	-	Airports as national infrastructure and should be rebuilt under a green deal
	Level playing field	Key Partners	F	Multiple carbon jurisdictions as a worst case scenario, US key player	Local pressure maintained to gain global agreements	Global agreement ideal with multiple jurisdictions agreements to be avoided. Regional agreement pressures may assist
		Key Partners	F	EU to act on illegal subsidy, EU Skies, monopolies, consolidation, Middle East competition, offshore tax leasing	EU as a major driver of a regional/global agreement and to push regulatory convergence	Regulator as a key driver of fair and efficient competition
	Regulator driving industry	Key Partners	O	EU as key safety, security, environment and clean energy driver	EU to manage cross border traffic, safety, security	Regulator as a key driver of security, safety and environmental legislation
		Key Partners	O	Regulator to implement Single EU Sky and SESAR	-	Regulator as a key driver of security, safety and environmental legislation
		Value Proposition, Customer Relationship	S	Airlines to promote the public good, benefits to economy and societal obligations	Promote the public good and island/remote economies dependent on airlines	Regulator to recognise the positive contribution made to the economy by the airline industry and lifeline for some communities

Table 56: Main Interview Themes STR 2 of 2

Main Theme Socio-Technical Regime	Secondary Theme	Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for policy or business models
Emissions and decarbonisation	Kerosene+ or Renewable Fuel Escalator	Cost Structure	F	Upward pressure on oil prices essential through taxes or quotas	Upward pressure on oil prices essential through taxes even if lower pax demand	Regulatory policy must include increased cost of fossil fuel energy or quotas
	Agreement drag, delay	Key Activities	O	Aviation cannot be a first mover with safety and lack of alternatives, airlines will lobby for late decarbonisation. Carbon sinking as a bridge to decarbonised industry. Education of the regulator	Airlines will lobby for late decarbonisation, simplicity in taxation necessary	Late decarbonisation should only be accepted with firm commitments to targets and carbon compensation mechanisms
	Hypothecation of industry taxes	Cost Structure	T, F	Decarbonisation facilitated by hypothecation giving credibility for passengers and industry with investments in the Technological Niche preferred by airlines	State and private investments in engine and fuel technologies linked to hypothecation and investments in the Technological Niche	State and private industry partnership drive investment into the Technological Niche with state funds and hypothecated industry taxes
	Early standard setting, open platforms and multiple certification centres	Key Partners	T, O	-	Early open industry standard setting essential and multiple certification centres needed	Early open industry standard setting essential and multiple certification centres needed
	Failure of voluntary regulation	Key Partners, Cost Structure	O, F	Scepticism of effectiveness of global agreements	-	Enforcement of global agreements with penalties
Air transport infrastructure	EU/Global hub competitivity	Key Partners	O	Airport infrastructure not competitive with other global hubs and pax numbers cannot grow gifting traffic to non EU hubs	-	Major European hubs needed to be remodernised to be globally competitive as part of a green deal with airlines
		Key Activities	O	Potential pilot, mechanics and aircraft parts shortages noted, legacy systems and agreements	Legacy systems and agreements	Support for supply chain with EU certified skills and parts, greater public investment. Infrastructure levies or part ownership proposed
		Key Activities	O, T	Pressure for 24H airport operations in EU	-	New technology and noise an increasing issue for EU regulator
	Who pays for infrastructure renewal?	Key Partners	F, T	Taxpayer/state is responsible for infrastructure renewal	State is responsible for infrastructure renewal but passengers will pay through fares and taxes	State is responsible for infrastructure renewal – balance between taxpayer and passenger
	Parallel running of old/new technologies	Key Partners	T	Fuel and new infrastructure must be available globally	Fuel and new infrastructure must be available globally	Dual fuel infrastructure must be available globally
Funding industry transformation	Hypothecation of industry taxes	Revenue Structure	F	Taxpayer will pay for industry transformation through taxes and higher air fares - hypothecation	Taxation of passengers at airports and in fares to pay for transformation	Taxpayers and passengers to pay for industry transformation with higher fares and user charges
	State supports Technological Niche	Cost Structure	F	State support of used aircraft prices enables faster asset turnover	-	Taxation to support asset prices during industry transformation
		Key Partners	T, F	State as a primer for reinvestment in Technological Niche	Risk sharing models with retention of state interest in new technology	State to provide seed capital for reinvestment through grants to Universities and Research Centres with retention of commercial interest

6.4.1 Global Aviation Regulation

The secondary themes in this section are the 'license to grow' **(F, O)**, the international agreement on the definition of decarbonisation and 'agreement drag' **(O)**. These themes act directly on the key partners and the key activities of airline businesses.

Internal Airline Actors affirm an enforced global roadmap of charges and incentives is needed for the industry, and with it the end to national and regional (EU) emissions legislation. Airlines will not regulate themselves or push for any kerosene or carbon taxes with self-regulation of the industry too problematic. The group welcome state direction due to the number of parties involved with several mentioning that the regulation of airlines and shipping should be brought into the World Trade Organisation (WTO) portfolio. This would be important for the agreement of reciprocal air traffic rights and equitable treatment with sea transport.

> *`I think the biggest regulatory issue will be are we able to replace the system of the modern 3,500 bilateral agreements worldwide with a system, which establishes a level playing field globally. Introducing or including the airline industry into the WTO, this is probably the biggest challenge. ´*
> (Former Chief Executive Officer, two European Network Carriers)

Without a global roadmap, long term planning is difficult and company resources would be tied-up in legal activities around fair competition with multiple regulators. A single set of global rules is necessary to begin effective industry transformation with the WTO, ICAO and IATA seen as the forums for generating agreements. Several interviewees noted that the US was now not expected to take the lead global agreement solutions.

Airline managers were convinced that adhering to a progressive environmental timetable should be the price of avoiding 'regulator excess' in airline operations - their 'license to grow'. The group concur that the state is responsible for the provision of new infrastructures, and to initiate and manage the first stages of technological transfer. Pressure from consumers and environmental groups for airlines to 'go green' is emerging as a board issue, with concerns over 'greenwashing' in airline responses highlighted.

> *`There are plenty people out there who want to say there is a solution what we need to do is to restrict the growth of an aviation. I think it is quite important to the industry and its 'license to grow' for some tools of a solution to be developed. `*
>
> (Senior Official IATA, Geneva)

There is a consensus that airlines would seek legislative approval to decarbonise later than other industries considered more carbon polluting, such as coal-fired power and animal agriculture. This strategy would take the form of a delayed timetable of carbon offsetting due to the technological problems of replacing kerosene for long-haul travel. Airlines note that reduction of greenhouse gas emissions throughout the supply chain should be included in CORSIA, as efforts to use cabin service renewables, reduce animal-based foods and electrify airport transits currently went unrecognised.

External Stakeholders believed that regional (EU) rules had their place if no global agreement could be found to prevent 'agreement drag', citing that regional action on emissions in Europe had promoted the move towards finding a global solution through ICAO. Thus, they did not exclude the use of regional agreements if a global agreement could not be held, and did not agree that other industries should decarbonise first.

6.4.2 European Aviation Regulation

The secondary themes mentioned in this section are global hub connectivity **(O),** the 'level playing field' **(F)** and the regulator driving industry coordination **(F, O).** Again, operational forces affect mainly the activities with key partners and to a lesser extent the value proposition and customer relationship in economic and societal benefits.

Internal Airline Actors see the state as having a vital role in the regulation of monopolies and airline consolidation, safety and air transport security, and the governance of (in)direct subsidy and taxes as part of maintaining a level playing field. The current global subsidies for coal and oil are estimated at USD 5.3 trillion p.a. (Sovacool, 2017) which should be reassigned to renewables. Airline managers raised the issue of bailout legislation of former state-owned carriers and the activities of leasing companies. Often operating through international tax havens, leasing companies were seen as distorting competition by lowering the entry barriers through price dumping.

> *`As an economist, I would say the government should only intervene when the market is failing. Therefore clearly, we needed to pay attention in government regulation, and safety and security, probably in environment and those things probably also in developing clean energy sources. Because capital markets fail in properly financing both in the proficient of infrastructure which is I mean I argue the airports in many instances you know should be seen as a public good or in a gateway rather than put in to the necessarily put it in to the private sector. I think the government is going to get in a role to making sure that there is an efficient infrastructure in the air as well I think with 'European Skies´.*
>
> (Senior Official IATA, Geneva)

The group were concerned about regulating fair access to the European market with some Middle Eastern carriers purchasing minority interests in European airlines to move passengers to their Gulf hubs. They believed there was limited regulator recognition of the airline contribution to the economy, providing communication, jobs, social inclusion and even in avoiding international conflicts. Local EU emissions legislation is believed be counterproductive to a reaching global agreement.

External Stakeholders agree with the airline group but consultants with special experience of charter airlines noted that some tourist and island economies in the

Mediterranean dependent on airline flights for the much of their economic activity would require special treatment.

> *`Well, if you look at the global picture then the EU then I think I have said that just last week in a panel it's remarkable what Europe has accomplished in terms of regulatory frameworks of creating an internal market which includes cross-border traffic with a regulatory convergence, with mechanisms not only to define the law but also to apply and enforce. Of course, the whole thing still has inefficiencies, but it hasn't happened anywhere else and it is still a model…I was in Montreal, as I mentioned, and African states say how can you do this? I think we should do it. The ASEAN states look at that, the South American countries want to know how to do this. `*
> (European Commission EC Aviation Lawyer, Brussels)

6.4.3 Emissions and Carbon Lock-in

The secondary themes that drew prominence in this section are a 'fuel escalator' mechanism, voluntary regulation, 'agreement drag', the hypothecation of taxes with early industry standard setting **(F)** and multiple certification centres **(T).** Themes related to emissions drive changes in airline key activities, key partners and the cost structure of airline business models.

Internal Airline Actors concurred that with no breakthrough technology on the horizon, incremental change with carbon offsetting and compensation are the medium-term bridge to a low(er) carbon industry. The pressure on airlines is seen as increasing with many describing carbon as a boardroom issue at 'tipping point' in 2019. Several individuals see a danger in the fact that if 'fuel plus carbon' prices fell, then no action would be taken on industry transformation (Atmosfair, 2018), and that continued upward pressure on total energy costs (something I term the 'kerosene+ escalator') is necessary for action. Airlines rejected the idea of new layers of complexity in taxes, while at the same time seek increasing industry investments from the state for new fuels and aircraft types.

‘Any kind of drop in the fuel price would take the pressure off to develop something.’
(Senior IATA Official, Geneva)

’Can global agreements work? I don’t know, is the answer to that one! There’s no enforcement.’
(Senior Official IATA, Montreal)

‘Even if somebody would come up and say that’s a very brilliant idea, I don’t see how you can do that (the kerosene+ escalator).’
(Aviation Lawyer and EU Regulator, Brussels)

Lobbying for late decarbonisation is a prominent theme with ‘agreement drag’ delaying effective decarbonisation. The education of the regulator is seen as important due to a lack of technical understanding of the problems involved.

‘They’ll lobby for late decarbonisation, airlines, but you think it will be private industry providing new infrastructure, airports. It will be a combination of both because one drives the other.’
(Head of Fleet Technical Services & Deputy Technical Director, LCC)

Airline mergers are linked to the increased capital requirements of decarbonisation, with less cash rich companies being left behind to struggle with industry transformation. Airline managers do not accept that a programme of capital allowances or loans is an appropriate use of state funds to speed up asset turnover given state withdrawal from airline ownership in the last thirty years, preferring direct investments in the TN.

External Stakeholders agree that incremental offsetting is the near-term solution to industry transformation floating the concept of the ‘renewable fuel escalator’ driving decarbonisation. This proposal is made by an industry supplier with experience of the acceptance of the concept in the Californian and Norwegian aviation markets. In this proposal, the regulator would need to create a market in alternative fuels, which would then be mandated in increasing percentage blends with kerosene over decades to complete decarbonisation by 2050-2060. Since emissions data is already collected for CORSIA it is not an additional burden. The proposal was made that renewable fuels should be rationed for airline use, given that alternative fuels exist for ground transportation and for power generation.

> *'It doesn't make any sense, you have taxes on all energy sources, you have taxes on all kind of products and services, why is kerosene tax free?'*
> (Press Officer and Climate Consultancy Spokesman, Switzerland)

> *'I mean that's the job of the politicians, to have this long-term vision but somehow they have… if they want to convert it into action now, they also have to do some explanations, why it has to happen now.'*
> (Aviation Lawyer and Regulator, EU Parliament, Brussels)

> *'They shouldn't impose price of kerosene increase; I think would be a mistake. They should impose a mandate biofuel content of fuel content. This will in turn be a price increase of kerosene and this will incentivise, I think, the airlines to develop it. My view would be for the states to put some mandates, some incentives, not to kill airlines, and I think the pressure should be in the fuel manufacturers. I think there is a big problem here. The Exxon, BP, Shell, Total, and I may miss a few others, but those guys on earth are by their DNA used to extremely high profit margins, compared to the rest of the industry.'*
> (Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

Other important themes were the early setting of global technical standards after industry consultation, and for the 'fast tracked' certification of new technology. Multiple certification centres were proposed for the USA, Europe, Middle East and Asia, with the current system dominated by the USA and to a lesser extent Europe.

6.4.4 Air Transport Infrastructure

The secondary themes that stood out in this section are the competitiveness of the European hubs **(O),** funding infrastructure renewal **(F)** and running parallel infrastructure **(O)** driving business model changes in key activities and with key partners.

Internal Airline Actors see the state as the provider for the renewal of old infrastructure. This includes airport hubs, passenger, cargo and renewable fuel infrastructure, air traffic control and the SESAR navigation and CleanSky2 initiatives. Airline managers were concerned that European infrastructure is in a weak competitive position with major hubs in Asia and the Gulf, and that Europe would be unable to handle the projected numbers of aircraft movements and passengers. This situation could be partly relieved by 24-hour airport operations to take full use of the geographical advantage of Europe in global travel networks with the environmental problems this would bring. A failure to offer first class facilities in Europe may increase the use of the less popular secondary airports or deliver passengers to non-European competitor hubs.

> *`..because what we will see is that people from Asia, business people and leisure people they have to wish to travel to Europe and if we do not have the necessary infrastructure for aviation then we will get problems. And if we take a look at Europe today, then you will see the most of the big airports have problems to grow. If you take a look at the great market in Europe Germany, France and England I don't see the necessary steps to provide the infrastructure. `*
>
> (Chief Executive Officer, European Network Carrier)

> *`The European industry and then people who fly to Europe will be disadvantaged. Others, let's say, who fly on the border, let's say fly out of Cairo, or Istanbul, or Kiev or… there will be a significant advantage. I don't see the necessary steps to provide the infrastructure. `*
>
> (Senior Official IATA, Montreal)

Experts maintained the inadequacy of European airspace and airport infrastructure, the availability of aircraft parts, renewable fuel, and some specialist staff skills such as pilots and mechanics will adversely affect market growth in Europe. The group emphasised the importance of dual fuel infrastructure being located at all major global hubs otherwise return flights could not be operated.

A proposal for infrastructure levies to be charged for adverse weather damage to airports is rejected as it cannot be directly attributable to air transport. Major repair costs have occurred following hurricane and flood damage in the US with these being borne by the general pool of taxation. If weather damage to air transport infrastructure increases this may prove problematic for highly indebted states. Interviewees agree that industry renewal would ultimately be borne by consumer in the higher prices of air fares.

External Stakeholders agreed the state is the provider and for the renewal of legacy and dual infrastructure through the taxation of passengers, fuel, airlines and airports. There is a difference in emphasis in that the group expected the airline industry to pay for infrastructure through a variety of levies on activities, and the airline group did not make this point.

6.4.5 Funding Industry Transformation

The secondary themes that were prominent in this section are the hypothecation of industry taxes and state support of the TN **(F),** affecting airline business models in the revenue and cost structure and with key partners.

Internal Airline Actors see the state is seen as responsible for leading industry transformation through the provision of financial support and not from private industry in the first instance. Incentives such as residual value asset guarantees, with taxes and user charges are seen as most appropriate (Aircraft Value News, 2006). This approach is adopted due to the fact that airlines are not able to fund the transfer from their own resources. Airline managers regard any taxes levied on the industry should be used for industry R&D and programs to facilitate industry and energy transformation (hypothecation).

> *`Probably the taxpayer's money; there is a lot of investment or a lot of subsidisation of this industry to push them over the start-up hurdles that they have, a lot of money that they need to invest and you need to be calm and needs a certain amount of time to get their money back.'*
> (Head of Environmental Affairs, European Network Carrier)

State support necessary for seed capital for the development of new fuels, battery technology and engine technology by all interviewees. Developments in battery technology mean they could be used to power aircraft cabin activities such as lighting, communications, heating, in-flight entertainment and catering by 2035. The SESAR consortium which is in operation as a public-private consortium to offer direct navigation services is seen as moving unsatisfactorily slowly to achieve its goals of a single European airspace.

External Stakeholders agreed the state is responsible for the renewal of industry operations through centrally provided funds with taxes on airline tickets and on infrastructure use.

> *'The cost of renewal ...I think that it has to be put on to air tickets, eventually.'*
> (Press Officer and Climate Consultancy Spokesman, Switzerland)

The state was needed to prime R&D investment to the point that new technology becomes commercially viable whereupon private capital would step in to supply products for direct commercial use. This risk sharing approach involves funds being provided to public bodies, research institutes and universities at a high-risk stage to encourage private sector funding in a second stage. The state taking equity shares or patent rights in new technology providers is seen as appropriate recompense.

> *`The general economic philosophy, which I would subscribe to is the further away from the market you are that it is very early-stage R&D, the more there is a role for government. The closer to the market you get, it really should be left to the private sector; I think that is a very good rule. `*
> (University Academic and Senior Economic Adviser, UK)

Summarising from Table 56, the greatest stresses on business models from the STR are driven by operational and financial forces with key partners in the regulator and in infrastructure provision. Innovation in the airline business model to accommodate these new tensions can support a sustainability transition by increasing airline skills in negotiation and by supporting the key partner relationships across all business operations.

6.5 The Technological Niche (TN)

TNs are the spaces where radical innovations in an industry are nurtured and developed. These niches are protected and insulated from the process of market selection in the STR, and they act as incubators for radical novelties (Schot, 1998). Radically new technologies need such protection because they often initially emerge as 'hopeful monstrosities' (Mokyr, 1990). They usually have low technical performance, are often cumbersome and expensive needing high levels of development before maturity and potential commercial application. TNs also include the articulation of vision and meaning, customer preferences the recruitment of new actors and resources to increase momentum and design to meet market demand and user preferences (Geels, 2011).

> ’A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures.’
> (Rip et al., 1998:340)

Learning takes place in the niche which becomes linked through co-construction and with their evolution they pressure the STR for 'windows of opportunity' to become established (Genus & Coles, 2008). Niches may exist in the R&D functions of private industry, or public Research Institutes, Universities, Government Agencies and the Military. Technological transformations occur in one of two ways (Geels, 2002), either as the evolution as a process of variation, selection and retention; or as evolution as a process of unfolding and reconfiguration. In both cases a dominant design is established which pushes into the STR where it is retained.

Geels et al. (2010) show that technological transitions focus on how multiple innovations are experimented with, are combined and reconfigured and the governance of such structures, while Turnheim & Geels (2012) show that industry transitions are most effectively accomplished at destabilising crisis points. A sustained rise in the price of oil, paying for environmental despoliation or the Coronavirus may be such crises for airlines. A reaction might be compared to the aircraft noise issue that the industry faced in the 1990s, which was addressed by ICAO in 2001, 2006, and 2017 resulting in substantial improvements (Rivers, 2019; IATA, 2019).

Interviewees unanimously believe that it is state actors who should be responsible for the seed capital and funding for the shift away from oil in the TN. The interviews relating to the TN revealed five main groups of ideas as second level nodes: i. the risk of investment in new technology **(F)**, ii. speed of technology transfer **(O),** iii. developments in industry technology **(T),** iv. industry knowledge transfer **(T)** and, v. new financing models for investments **(F).** The summary findings are presented in Table 57.

Table 57: Main Interview Themes   TN 1 of 2

Main Theme Technological Niche	Secondary Theme	Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for policy or business models
Risk of investment in new technology	Derisking investment in new technology	Key Partners	T	Low risk and incremental investment patterns adopted by airlines and manufacturers as they both benefit with low oil prices	Low risk and incremental investment patterns adopted by airlines and manufacturers with full order books	Policy incentives and support for derisking technology investment and transfer
		Key Partners	T	State to provide seed capital and bear risk with private sector	State to provide seed capital and bear risk with private sector	Taxpayer to bear some initial risks of investments in new technology. State golden share or patent rights to recover investment cost
		Key Partners	T	Technology risk sharing models sought by airlines	State to provide seed capital and bear risk with the private sector	Risk sharing models with state sought by industry
	Hypothecation of industry taxes	Cost Structure	F	Hypothecation of taxes required for technology related investments	Hypothecation of taxes required for technology related investments	Hypothecation of taxes seems essential - also seen with voluntary compensation schemes where pax choose fuel over carbon compensation
	Competitive advantage to those airlines with cash	Key Resources	F	Only cash rich airlines can/will take a risk on e-aircraft as oil has always been the industry fuel	Only cash rich airlines can/will take a risk on e-aircraft as oil has always been the industry fuel	Large/cash rich airlines with inherent advantage in industry transformation
		Key Activities	T	Digitalisation of aircraft and passenger data provides opportunities to save costs, raise yields	-	Competitive advantage to those players who can implement this technology
	Parallel running of old/new technologies	Key Partners	T	New ground infrastructure must also be available with parallel running for decades	Parallel development of technology - Commercial risk of stopping old technology and investing resources in new technology is some years away (2050)	Policy incentives and support for technology investment and transfer
Speed of technology transfer	Kerosene+ or Renewable Fuel Escalator model	Key Activities	T	Most likely new fuels halophytes and synthetics in increasing kerosene/renewable fuel mixes	Most likely new fuels halophytes and synthetics in increasing kerosene/renewable fuel mixes	Drop-in hydrocarbon fuels facilitate industry transformation with quick certification
		Cost Structure	F	Progressive kerosene taxes or quotas needed to speed industry transformation process	No incentive to change existing profitability of major oligopolies in airlines, aircraft/engine manufacturing	A progressive system of rising kerosene taxes/quotas required to drive transformation incentives
	Oligopoly and reduced consumer choice	Customer Relationship	F	Increased capital requirements needed for faster asset turnover	Increased capital requirements needed for faster asset turnover	New financing models for increased asset turnover favour cash rich airlines
	Renewable fuel market needs scale and support	Key Partners	T, F	Carbon sinking as bridge to scale up of renewable fuels	Kerosene taxes need to increase incentives to scale up new fuels	Carbon sinking with incentives to transfer technology as bridge. Prioritise remaining kerosene/oil for air travel with increasing oil/renewable mixes
	Long lives of existing technology	Key Activities	O	Existing aircraft types will be used to 2050 especially on long-haul	Existing aircraft types will be used to 2050 especially on long-haul	A progressive system of rising taxes required to drive transformation incentives. Priortise kerosene for long-haul air travel
	Early standard setting, open platforms and multiple certification centres	Key Partners	T	Shorter technology certification times required	Shorter technology certification times required	Multiple and global centres to shorten certification times (US, Europe, Asia)

Table 57: Main Interview Themes TN 2 of 2

Main Theme Technological Niche	Secondary Theme	Business Model Perspective as per Osterwalder & Pigneur	Business Model pressure in Bouwman STOF Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for policy or business models
Developments in Industry, Aircraft, Engine and Fuel Technology	Customer Data and IT security	Sales Channel	S	Protection of customer data key to yields on value business models and to avoid skimming	Encroachment of Google, Amazon, Facebook into travel services	Higher IT security or strategic partnering. Airlines lacking skills.
	Drop-in technologies speed transformation	Key Activities	T	-	Lighter aircraft and composites viable for new aircraft models	Fuel and emissions cost savings possible if technology can be certified
		Key Activities	T	Retrofittable modifications as drop-in	Retrofittable modifications as drop-in	Shorten effective aircraft life cycle through retrofittable modifications
		Key Activities	O	Drop in hydrocarbon fuels most likely and scaleable, incremental technology, not competing with food chain	Drop in hydrocarbon fuels most likely and scaleable, incremental technology, not competing with food chain	Prioritisation of new fuels for airline industry as ground transport has alternatives. Scale the key issue
		Key Partners	T	Certifying the fuel (not engines) saves much development time	Certifying the fuel (not engines) saves much development time. Fuel investment more attractive investment than high risk aircraft/engines so existing technologies favoured. Scale is the issue	Fuel certification and scale key to quicker industry transformation. Scale is the key issue
		Key Partners	T	Battery technology to power cockpit and cabin operations likely by 2040	-	Battery technology reduces (fossil) fuel consumption during industry transformation with lower emissions costs
	Special treatment for airline industry	Key Activities	O, T	Prioritise renewable fuel for airlines with a 30 year transfer window	Prioritise renewable fuels and mixes for airlines where no substitute fuel available	Prioritisation of new fuels for airline industry as ground transport has alternatives
	Parallel running of old/new technologies	Key Activities	O	Electric aviation by 2040-45 for services on short haul that can't be done by rail as they require less fuel. Long-haul flights remain with hydrocarbon fuels	Passengers may be sceptical of e-aircraft	Parallel running of new technology may ease passenger fears. State support of e-aviation for short haul sectors by penalising kerosene on short distances
	Avoiding future monopolies, access to new technology	Key Partners	O	Multiple fuel providers and approaches/technologies needed to avoid monopoly and increase fuel security	Multiple fuel providers and approaches/technologies needed to avoid monopoly and increase fuel security	Regulator to ensure no monopolies develop in new fuel technologies
		Key Partners	F	Fewer aircraft and engine types might increase the monopoly power of manufacturers	-	Regulator to control monopolies for effective industry transformation
Knowledge transfer and generation	Antitrust and competition law as lock-in	Key Partners	O	Commercial and antitrust considerations prevents industry cooperation	Commercial and antitrust considerations prevents industry cooperation	Relax antitrust legislation in regard to decarbonisation technology
	Early standard setting, open platforms and multiple certification centres	Key Partners	T	Increased speed of knowledge transfer	Industry hyperlinking to be promoted	Free information exchange and platforms to encourage information transfer
	Learning from low carbon short haul operations	Key Activities	O	Transferability of learning from shorthaul operations	E-aircraft shorthaul experience informs new long-haul operations	Short haul as a learning ground for implementing long-haul technologies
Financing Innovation	New financing models for the industry	Key Partners	F	Finance feed forward models proposed	Finance feed forward models proposed	Necessity for industry to be attractive to investors or they will abandon industry, bringing returns forward for investors and researchers
	Derisking investment in new technology	Key Partners	F	Risk sharing models with airlines, state, airports and manufacturers needed over the long term	Seed capital needed from state with state having golden share or patent. Scale the issue	Risk sharing investment models with state retaining interest in patents or golden shareholding
	Hypothecation of industry taxes	Cost Structure	F	Hypothecation of taxes as a funding stream for infrastructure	Passengers will pay for industry transformation through taxes and charges	Hypothecation of taxes for industry renewal as additional financing stream

6.5.1 The Risk of Investment in New Technologies

The secondary themes that stood out in this section were, de-risking new technology **(T)**, hypothecation of industry taxes **(F),** the competitive advantage of cash rich airlines **(F)** and parallel running of new technologies **(O).** Pressures from technology affect airline business models in their cost structure and their activities with key partners.

Internal Airline Actors see the high failure risk of new investments as discouraging investment and maintaining the path of incremental improvement in existing technology when 'step changes' in new technologies are what is needed. Cash rich airlines are able and more prepared to take a risk on new technologies than those struggling, giving advantages larger established players. The question of who pays for initial investments is a divided amongst the interview group, with some industry managers feeling seed capital for research and development should come from the state to universities and public bodies, and others believing the private sector could finance development. Airline officials believe industry taxes on fuel and infrastructure should be hypothecated for technology development. Parallel running of new and old technology would be required for decades.

> *'We will partner because we are not the patent people, we are not the scientists. We are the people with ideas, we come up with that and then we will develop the idea, but we get the first move advantage, and say well if I'm not going to protect the patent, I'm going to get the first mover advantage.'*
> (Chief Financial Officer, European Network Carrier)

External Stakeholders affirm investment seed capital for R&D should come from the state to universities and public bodies and others believing the private sector could finance development. Incremental and parallel development of new technologies reduces the risk of the pursuit of a technological dead end by academic institutions, but in the end, manufacturers will pay for their own R&D once a technology breakthrough can be commercialised.

'Well, I think we are getting to the point where you can imagine in the sort of 2050 timeframe to keep meeting the improvement required; we are likely to see…new aircraft concepts, new propulsion concepts, will start to become viable. If we want to continue on this path of reducing emissions and that poses quite an interesting dilemma in terms of how much more you invest in current technology, and when do you introduce it to get the maximum benefit.´

(Senior Programme Engineer, Engine Manufacturer, UK)

This group conclude that it is difficult to allocate hypothecated taxes to industry transformation believing funds would come from both hypothecation and central government pools. Most commented that in the end the customer would pay for new technology through fares and taxes.

6.5.2 The Speed of Technology Transfer

The secondary themes that stood out in this section are a fuel escalator mechanism **(F, O),** support of a renewable fuel market with increased capital investment requirements **(F),** the long life of existing technology and early standard setting and certification **(T).** The speed of the introduction of technology will impact on the cost structure, on key activities with key partners of business models.

Internal Airline Actors acknowledged that the oil available to industry cannot be burned without damaging climate effects, and that renewable hydrocarbon mixes offer the optimum energy density fuel for airlines (McGlade & Ekins, 2015; Carbon Tracker, 2013, 2014). The speed at which technology is being developed needs to be increased, and that each generation of sustainable fuels will probably need accompanying higher kerosene and emissions costs or there would be little incentive to develop them. Several airline managers felt a major chance to develop alternative fuels was lost during the last oil spike at USD 147 per barrel, when it is clear airlines could survive such fuel prices but then engaged in fares wars as oil prices fell post peak. Airline interviewees deem kerosene should be prioritised for long-haul services where it cannot currently be replaced, having the benefit of reducing volatility in price as short haul demand falls.

> *'You need to prioritise biofuel to aviation sector compared to road sector. Road sector has tons of solutions, using biofuel to the roads I think would be a mistake and this should go from the governmental policies.'*
> (Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

Aircraft life cycles of 20-25 years in operation inhibit fleet renewal, and mean that new radical aircraft types would not be available before 2050, prompting interviewees to posit that retrofittable technology offered a route to shorter development cycles and lower capital costs, citing examples from aerospace and the US Air Force. From design to sale, aircraft life cycles now approach 50 years. The speed of technology transfer expresses itself in the market as shorter product life cycles and reduced certification times for new aircraft, engines and fuels. Interviewees believe airlines would be using kerosene until 2040 or 2050 with increasing use of biofuel mixes and they regarded carbon sinking/offsetting as the bridge to a carbon neutral industry.

> *'I think it (the industry transformation) will take 20 to 30 years.'*
> (Chief Executive Officer, European Network Carrier)

> *'And I think this is a good idea because a there is a lot of possibility of offsetting. I think this is one of the best approaches to solve the problem. Airline digitalisation will be the major airline investment category to 2040 (not combustion technology)'.*
> (Chief Executive Officer, European Network Carrier)

External Stakeholders too acknowledged that oil cannot be used indefinitely, agreeing that the speed at which technology is being developed needs to be increased and that each generation of sustainable and renewable fuels will accompany higher kerosene and emissions costs or there would be little incentive to develop them. Current aircraft and engine life cycles mean incentives need to be given to manufacturers to develop breakthrough technologies and with shorter certification times.

> *'There's obviously a certain risk, and if you have only two guys in a market… The 737 is already a little bit weaker in performance than the A320 Family Neo, but it's not as bad that it doesn't have a market, so neither of the two really have an incentive to change this bread-and-butter business that they have with the short haul aircrafts, the narrow body aircraft.'*
> (Partner Transport Management Consultancy, Germany)

Interviewees are reluctant to commit themselves to timelines on industry transformation (Akerman, 2005), but a few offered pointers which are detailed in Appendix 12.5.

6.5.3 Developments in Industry, Aircraft, Engine and Fuel Technology

Discussions in this section focussed on new passenger fares models **(S),** IT security, drop-in technologies **(T)**, special financial treatment for the airline industry **(F),** parallel running of technologies **(O)** and avoiding monopolies in new technology **(F),** all affecting key activities and with key partners in airline business models. The ability to manage customer data will affect the sales channel.

Internal Airline Actors maintain electric or gas/electric hybrid aviation is possible on short haul services with a timescale of approximately 20-30 years if accompanied improvements in battery weight and technology due to the lower energy requirements of short segments. Initially, such flights would only accommodate 50-100 passengers in services that could not be provided by rail, such as to remote areas or over water. Learning from this new short haul technology will later be applied to long-haul services. It is likely that batteries could be employed for cabin operations reducing the demand for inflight kerosene that is currently used to power cabin services by 2035. The high weight and 'grey energy' involved in battery production and disposal is mentioned as a not insurmountable problem given the rapidity of developments in this technology. One official is convinced pilotless aircraft will be used on cargo flights by 2040 and if successful, a single pilot on passenger flights proposed thereafter. This would face the resistance of pilot unions. Those with technical knowledge believe given certification problems, there would probably be fewer aircraft types and possibly the return of turboprops on short haul due to their higher fuel (but lower noise) efficiency.

> '*But the other question, maybe, is should aviation be one of the first movers because there are so many restrictions and so many safety issues as well. Or, should we take the energy and put them into villages and cities.'*
> (Senior Director Environmental Affairs, Network Carrier)
>
> *'Electric aircraft will serve the short haul market. They won't serve the long-haul market.'*
> (Senior Official IATA, Geneva)
>
> *'I would say the commercial aircraft, a regional aircraft but really a passenger aircraft scale, not a small business jet, could become electric in 2040-2045.' 'A hybrid electric by 2035-40, yes, it can start happening because you have the surface of the wings, so for aircraft that they are… you can compensate if you have like solar panels on wings, let's say, and you fly during the day, it's an ideal place.'*
> (Senior Official IATA, Montreal)

The group are convinced that shortening the effective aircraft life cycle to reduce emissions through retrofittable modifications is possible. Winglet retrofits have shown their value in this category with these business cases being decided on positive investment potential. Retrofittable modifications should be effectively 'drop in' with certification times the major barrier.

There was agreement that oil will be the major fuel source until 2050 in increasing mixes with latest generation biofuels (see Appendix 12.2). One airline manager believing 10% of kerosene could be substituted by renewables in 2040. Multiple fuel providers and multiple technologies are to be encouraged to prevent further oligopolies, ensure scale volume and fuel security. There should be a focus on production of biofuels or synthetic fuels from feedstocks that do not compete with the food chain and have limited environmental externalities - such as halophytes, desert-based plants (4th generation biofuels) and synthetics from industrial and household waste or hydrogen, water and CO2 (King et al., 2009, Marxer et al., 2017).

> *'I would say there might be a chance if you go into synthetic fuel, synthetic alternative fuel, which now with the ETH has been some developments that you can produce it on a regular environment and its scalable.'*
> (Senior Director Corporate Development, European Network Carrier)

The specification and certification of new fuels is established and is comparable with aviation grade kerosene to enable blending in increasing proportions. Although not currently cost competitive with kerosene, renewable fuels could be cost competitive with increased scale and an appropriate tax policy within years.

> *'If you certify the fuel rather than the engines then you have cut years out of the process.'*
> (Head of Business Development, LCC)

Airline managers understood that the ownership and monetising of passenger and operational data that comes from airline systems will become increasingly important, having the potential direct passenger yields and offer significant savings in maintenance and repair times while adding to the design data for future generations of technologies.

External Stakeholders agree that oil will be used until 2050 in increasing kerosene/renewable mixes. Those with technical knowledge maintain third and fourth generation drop-in biofuels probably from algal sources, and synthetics offered the best opportunity to replace kerosene - offering no competition with the food chain, low freshwater usage and the ability to remove burn impurities during production (see Appendix 12.2). Propulsion experts from engine and aircraft manufacturers are convinced that a long-haul geared fan type engine is needed to improve the fuel consumption on long distance services.

> *'It's going to be hydrocarbons, it's going to be the kind of propulsion we have now, maybe the aeroplanes too. Some of the questions in your thing, maybe the aeroplanes will look different, maybe, but it's going to be jets and it's going to be hydrocarbons.'*
> (Head of Growth and Investment Sustainable Fuels, Fuel Manufacturer)

Suppliers propose retrofittable modifications and composites would be used to lower aircraft weight and that the technical improvement in unit fuel consumption through aerodynamics, new materials, reduced weight and improved engine burn technology of approximately 1-2% p.a. could continue for another 25 to 30 years. Total aircraft emissions would not fall if airline growth exceeded this figure.

> *'I mean the development in aircraft technology will also be make aircraft lighter. That means the percentage between aluminium or metal and composite material will go more and more through composite material we have seen already the Dreamliner it's a very high percentage it a composite aircraft and it's made aircraft lighter and on top of that more durable because there is no corrosion.'*
> (Airline Industry Regulator, Switzerland)

> '*Yes, this is something doable (lifecycle reduction through retrofittable modifications). Technically, it's doable. There have been re-engineering projects in the past, so this is nothing new. And if you look at what happened with after the world financial crisis, you might remember that car manufacturers were actually propped up a bit through all sorts of*

programmes where people could retire their old cars so that the car manufacturers could sell them new ones. So, similar solutions can work in our industry as well.'
(Economic Consultant, Aviation Consultancy, Amsterdam)

There is a greater emphasis by the group on patent protection for commercial companies and greater recognition of the volumes of fuels needed to replace kerosene. The sceptics of electric aviation opined that most efforts should be spent on certifying and developing new fuels (incremental innovation) rather than developing new radical electric aircraft types (Rolls Royce, 2018) and electric fan engines (Rolls Royce, 2020), due to the risk of failure and the immediacy of the problem to be solved. Long-haul flights currently consume an estimated 70% of global kerosene supply and short haul 30%. Hydrocarbons from a wide variety of feedstocks were to be encouraged with concerns of renewable fuel security issues due to high sunlight requirements for synthetics and biomass, and thus mainly tropical sourcing. Specifically mentioned is the prioritisation of the limited quantities of renewables for aviation due to the lack of alternatives for air transport.

'These biofuels we're talking about, I think they fit well into what we call the incremental improvement in technology. Essentially, you're still keeping some form of an internal combustion engine. You just say that the fuel you are combusting is more eco-friendly. If that avenue works out, then I think the private sector will move towards that direction.'
(Senior Economic Consultant, Aviation Consultancy, Amsterdam)

6.5.4 Knowledge Generation and Transfer

The secondary themes that stood out in this section are anti-trust legislation **(T),** early industry standards and certification **(T),** and learning from short haul operations as a basis for action on long-haul services **(O),** affecting the key activities and the key partners of airline business models.

Internal Airline Actors group mentioned that free and open knowledge transfer and cooperation in aircraft and fuel technology is being inhibited by anti-trust and commercial considerations. Relaxing this legislation would be productive for expeditious innovation. The learning gained from low carbon short haul operations is seen as essential for introducing effective long-haul operations. Early certification of fuel and aviation technology to a globally agreed industry standard is essential to quickly spread best practise.

> On global industry certification. *'Oh, that's a good question. I just don't know, but in some point in time this centre will be at least also in Asia, not only in the US but not for the next years. So, it's too US dominated.'*
>
> (Chief Financial Officer, European Network Carrier)

> Kerosene isn't really replaceable on long-haul for the next 30/40 years is it? *'Certainly not and if we… we will get no chance to go to a long-haul replacement on the kerosene if we can't accumulate experience on different types of energy on short. '*
>
> (Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

External Stakeholders noted that airlines and manufacturers were locked-in to incremental innovation and recertification, and only those with 'big pockets' could afford to investigate radically different solutions. Hyperlinking is inhibited by anti-trust and competitive legislation that needs amending in certain circumstances.

'It's not a coincidence that Boeing and Airbus keep flogging their narrow body designs instead of coming up with a clean sheet design. It's just simply lower risk to improve something incrementally. And if you look back at the history of OEMs many of them went bankrupt when they started with a clean sheet design and then later realised that the demand is not as big as they had originally hoped.'

(Economic Consultant, Aviation Consultancy, Amsterdam)

'When we want to talk to others (manufacturers) I have lawyers on my back saying watch out, anti-trust. The level of exchange we would like maybe is hampered by with anti-trust laws.'

(Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

An electric or gas/electric hybrid aircraft if successful would by-pass incremental innovation for the first time in the industry post war and since the replacement of the turboprop. Fuel experts note that there is an inherent conflict between aircraft and engine manufacturers in developing new technologies, since each group competes for the profits of the other with the end user.

6.5.5 Financing Models for Industry Transition

The secondary themes discussed in this section were new financing models for the industry, de-risking investment and hypothecation of taxes **(F)** affecting the key partners and cost structure of airline business models.

Internal Airline Actors responses relate mainly to incentives that needed to be provided by the state and aircraft and engine manufacturers to share the cost and risk of asset replacement and not to leave this with airlines. Long-term relationships with multiple partners are seen as essential and need to be deepened to ensure industry transformation. Feed forward models where the cash flow is brought forward to technology providers to fund research is seen as improving current investment plans. Aircraft and engine manufacturers might conceive new funding models with airlines and the state to improve the cash receipt profile. This introduces an element of cost, risk sharing and close co-operation into airline business models.

> *'However, unless they become very confident and clear with financing models, the likes of Rolls Royce, or Airbus, or Boeing for that matter, it's going to be difficult for airlines.'*
> (Head of Fleet Technical Services & Deputy Technical Director, LCC)

> *'The state moved out of aviation many years ago. There's hardly any sector that's left other than navigation that the state have got a stake in and even the navigation is almost gone now. I just cannot see the state coming back into play there. It will be very much the private sector again.'*
> (Head of Business Development, LCC)

> *'I think if policy is heading towards, you know, net zero emissions by that point which means the industry's got to look a bit more at that and I think the solution, you know, the only way that it's going to get there is with sufficient quantities of sustainable fuel. There'll be policy constraints and there'll be consumer pressure as we're seeing, and I'd be very surprised if that didn't lead to, you know, dramatic stepping up of investment in and development of sustainable fuels.'*
> (Senior IATA Official, Geneva)

External Stakeholders uniquely commented that airlines and aviation had to be attractive for future investors to secure industry renewal. Unbroken and increasing investment is the major concern from the group with such streams of funds likely from passengers, airport users and the state.

> *'If we just let it go, suddenly we will hear the nice and interesting message that because we are not progressing on climate change all investors are advised to dis-invest. We have to have convincing routes to be attractive for investors. ´*
> (Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

> *'I think there will… whether it's a new… yes, financing model. It's not… for them it's not just Boeing or Airbus. It's us all together with the airports and the airlines and for that I think.'*
> (Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

A fuel expert confirms renewable fuels are attractive for private and state investors and is independent of 'oil money' with scale the central issue. The group concurred on the necessity of a major programme of state investment in new aircraft engine and fuel technologies with a 'golden share' or patent again mentioned for the state to recover initial public investments.

Summarising from Table 57 the greatest stresses on business models from the TN come in the form of technological, operational and financial forces acting on airline key activities and with key partners. Innovation in the airline business model to accommodate these tensions can support a sustainability transition by adjusting interlinking business processes with key partners and with the regulator.

6.6 Inconsistent Findings

A lack of relevant technology-based knowledge amongst some interviewees gave rise to different views on a timescale for industry transformation or an unwillingness to state an opinion. Overall, airline managers generally expected more financial support from the state and a lower passenger burden than the external stakeholders, and were more cautious in their approach to industry change.

6.7 Summary of the Interview Findings

An analysis of interview responses on the expected shifts in the MLP suggest that airline business models will be affected as summarised in Table 58. This table shows the greatest pressures on airlines from the MLP arise from the STL, with the STR and TN exerting similar levels of activity. Financial and organisational/operational forces on airlines are highlighted, with technological pressures indicating an increasing complexity with requirements for augmenting company skills in these disciplines.

I make the claim that through an MLP and STOF analysis mapping the forces impinging on organisations, responsive changes to business models can offer a contribution to meet the challenges of low carbon transitions by designing in long term sustainable processes as core business activities. In this way a contribution to the theory of the role of business model innovation in supporting a sustainability transition is made.

Table 58: Heat Map of STOF Forces Arising from the MLP Derived from Interviews

STOF Forces/MLP Level	STL	STR	TN	Total
Service	5	1	1	**7**
Technology	3	6	14	**23**
Organisation/Operations	15	14	7	**36**
Finance	19	10	9	**38**
Total	**42**	**31**	**31**	**104**

Table 55 indicates that financial and operational forces from the STL will impact on the value proposition, key activities and the cost structure of airline business models. Innovation in the value to chain to differentiate and fragment the service offers to passengers is displayed. The susceptibility of short-haul services to the costs of regulation was a focus and with the pressure on the major European hubs likely resulting in more complex revenue sharing models with partners. The simplification and reduction in the cost base through service and volume aggregation and by adopting new technologies to mitigate tougher regulation is highlighted.

Table 56 highlights the fragility of airlines on operational and financial pressures from regulatory partners in the STR. Such key partners will determine the industry 'license to grow' by linking to a progressive emissions framework including a 'fuel escalator' mechanism and by using infrastructure renewal as a bargaining tool. Requiring airlines to mandate to use an incremental renewable fuel quota per decade, or the use of a rising price-based mechanism making oil sourced fuels unattractive, would be a major step towards industry decarbonisation, something CORSIA does not confront. Key activities for airline businesses will be lobbying with partners and the agreement of a decarbonisation roadmap.

Table 57 details the key dependence airline have on technological forces from key partners in de-risking, developing and the timely introduction of sustainable industrial science. Key resources for airlines in industry transformation will be liquid funds for investment and the key activities of developing skills in managing multiple technologies are displayed.

The next chapter discusses the information drawn from the interviews with specific regard to proposals for refocusing airlines on four business models and with business model innovation supporting a sustainability transition in the industry.

Chapter 7 Challenges and opportunities for the European Airline Industry for Business Models (Phase 4)

7.1 Introduction

This chapter presents the findings of the second part of the qualitative analysis (Phase 4, Figure 17) following the interviews with industry members and experts on the challenges and opportunities facing the European aviation sector. The chapter aims to identify how mature industry transformations affect the business models of a complex organisation in the areas of economics, energy, social and environmental dimensions and technology (Boons & Lüdecke Freund, 2013) which together determine long-term performance. The research phase builds on the information presented in Chapters 4, 5 and 6 (Phases 1, 2, 3 respectively). Specifically, this chapter is concerned with the key research questions of how do airlines address sustainability STOF pressures in the MLP and how does this impact on future airline business models in Europe? How is sustainable value created?

7.2 Findings of the interview data in regard to Airline Business Models

As in the previous chapter the findings are again divided into responses from: i. industry senior management ('Internal Airline Actors'), and ii. the regulators, consultants, academics and industry suppliers ('External Stakeholders') shown in Table 54. This separation is useful in understanding the different interests and responses of the interview pool and in highlighting responses which are different or the same from each group. Quotations in each section of analysis and are selected to emphasise the key points made per interview group or to highlight majority opinion. For the interview pool information please see Table 23.

7.3 Developing Sustainable Value in Airline Business Models

The purpose of the analysis is to understand how the sustainability pressures in the MLP affect the repositioning of existing and the development of new airline business models. To that end, respondents were asked to outline what they believed to be the most likely set of generic business models emerging in the European airline sector. This information is combined with that in Chapters 5 and 6 to portray potential sustainable value creation which crystallises in business model types.

To assist analysis a series of 'trigger words' were identified by virtue of their frequency. The use of this approach to manage data was justified in Chapter 3. These words were used as nodes in NVIVO to filter out the characteristics of four business models developing or differentiating in the market. The findings and the broad features of the business models shown in Table 59 and Table 60. Drawing on the interview analysis made in NVIVO and using the Osterwalder and Pigneur (2004, 2009 and 2010) nine perspective business model canvas, interview points made and transcribed to NVIVO were allocated to proposed business models. In the opinion of the interviewees, four models are the most likely to survive in the market given the increasing burdens of technology and legislation that lie ahead. Comparing the findings with the St Gallen Business Model Navigator (Gassmann, Frankenberger & Csik, 2014) reveals that the four business models fall into three distinct classifications or generic types (Table 59). The Very Low-Cost Carrier (VLCC) and Low Cost Long-haul (LCLH) models fall into the category 'frugal or 'no-frills. The Low Cost Carriers (LCC) can be placed in the category 'pay per use' and the 'new' Network carrier falls into the category 'mass customisation and leveraging customer data'. An extended version of Table 59 is to be found in Appendix 12.9.

The responses discussing business models were divided into three main groups, i. the two established business models in the Network Carrier and LCC, ii. the VLCC and, iii. the LCLH. The views of the airline management group and the external stakeholders are aligned by similar theme and shown in Table 60.

Table 59: Summary of Sustainable Value Creation in Four Airline Business Models

Business Model/Feature	Very Low Cost Carrier (VLCC) P2P	Value Carrier Short-haul (LCC) P2P	Low Cost Long-haul Carrier (LCLH) P2P	New Network Carrier
Nomenclature after 'The St Gallen Business Model Navigator'	No frills or frugal	Pay per use	No frills or frugal	Mass customisation, leverage customer data
Key Partners	Secondary airports, providers of capital, road, rail	Secondary airports and major hubs, international aviation bodies	Major hubs, providers of capital	Airline alliances, major hubs, international aviation bodies
Key Operational Activities	Short-haul p2p, high density seating	Short-haul p2p	Long-haul p2p, high density seating	Network hub model with cargo a major element
Key Resources	Service contracts	Yield management, passenger database	Service contracts	Profit management systems, skilled staff, passenger database
Value Proposition	Creating demand through price	Serving existing demand	Creating demand through price	Meeting complex travel needs
Customer Relationship	Short term	Seeking long term	Short term	Seeking long term
Sales Channels	One, direct to customer	Few	One, direct to customer	Many, agents involved
Customer Segments	Cost sensitive, leisure	Value sensitive, business traffic	Cost sensitive, leisure	Value sensitive, higher disposable incomes, business
Cost Structure	Simple	Complex	Simple	Very complex
Revenue Streams	Few	Several, class based pricing	Few, some inflight	Many, dynamic or continuous pricing

Table 60: Main Interview Themes Value Driven Business Models 1 of 2

Business Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for Sustainable Business Models
Mosaic/a la Carte, (Network based group) with value focus	Network type business models will survive and converge, overlap customer offer on shorthaul	'New Network' carrier groups will operate a portfolio approach	New Network' models will reposition as value carriers
	Dynamic pricing key to maintaining yields. Protecting passenger data key	Dynamic pricing key to maintaining yields with more travel tailoring/pricing	New fares and yield management models support tailored travel. IT security highlighted
	Clear logic to both P2P and Network flights	Clear logic to both P2P and Network flights	Network models will survive
	Long term decline of business traffic post 2008	End of first class products with rise of 'premium economy'	Product and service convergence in value models likely to end most first class products
	LCCs will feed Network Carriers at major hubs, possibly a merger and more consolidation	-	Cooperation of two value models at major hubs
	Business model convergence/interchangeability between LCCs and Network Carriers on shorthaul offerings	Business model convergence/interchangeability between LCCs and Network Carriers on shorthaul offerings	Cooperation of two value models at major hubs
	Only two business models have been developed Network and LCC and seen to succeed	Hybrid models will likely fail but hybrid groups could succeed	Operation of a distinct business model key to success
	Strategic mistakes will be more costly	-	Slower, more cautious and low risk approach to strategic decisions
Pay as you go Hopper (P2P) with value focus	LCC business models will survive and converge with Network Groups, overlap customer offer on shorthaul		LCC models will position as value carriers
	Clear logic to P2P flights	Clear logic to P2P flights	LCC models will survive
	Long term decline of business traffic post 2008	More ´pay as you go´ offers add differentiation and value	Product and service convergence in value models likely to end most premium products with pay as you go options
	LCCs will feed Network Carriers at major hubs, possibly a merger and more consolidation	-	Cooperation of two value models at major hubs
	Business model convergence/interchangeability between LCCs and Network Carriers on shorthaul offerings	Business model convergence/interchangeability between LCCs and Network Carriers on shorthaul offerings	Cooperation of two value models at major hubs
	Strategic mistakes will be more costly	-	Slower, more cautious and low risk approach to strategic decisions

Table 60: continued: Main Interview Themes Cost Driven Business Models 2 of 2

Business Model	Internal Airline Actors	External (non-airline) Stakeholders	Implications for Sustainable Business Models
Frugal Hopper(P2P), with cost focus	VLCC fares models are more sensitive to environmental taxes	VLCC fares models are more sensitive to environmental taxes	Scepticism of VLCC model by some?
	New startups will be 'pure play'	High cost focus of new startups	The simplest cost effective business models necessary to engage market due to lack of scale
	There is value in a 'white label' tube operator model	Separation of operator from customer interface gives you a virtual airline (Flixbus, Eurolines of the air)	VLCC models as a virtual airline
	Space in the market for a VLCC business model due demographics and lower disposable incomes	Growth will come at the bottom of the pyramid	Decline in business class traffic, growth in lower yield leisure and VFR traffic supports VLCC models
	As LCCs move to major hubs VLCCs will step into secondary airports	As LCCs move to major hubs VLCCs will step into secondary airports	Movement of LCCs to 'value' models enables VLCC business models
	-	New aircraft types and 'thin seats' with lower operating costs and higher seat densities makes these new models fly	Future aircraft/cabin types offer better yields and lower operating costs making new business models viable
	Passenger growth will increasingly be point to point	Passenger growth will increasingly be point to point for both big and small cities	Primary and secondary hub traffic requires increased integrated rail/road infrastructure for growth
Frugal Red Eye (P2P) with cost focus	Very low cost fares models sensitive to environmental taxes. long-haul airlines need a cargo contribution to be profitable	Very low cost fares models more sensitive to environmental taxes	Scepticism of LCLH model by some?
	New startups will be 'pure play'	-	The simplest cost effective business models necessary to engage market due to lack of scale
	Space in the market for a LCLH business model due demographics and lower disposable incomes. Low cost models moving to long-haul to meet leisure traffic	Growth will come at the bottom of the pyramid	Decline in business class traffic, growth in lower yield leisure traffic
	Passenger growth will increasingly be point to point	Passenger growth will increasingly be point to point for both big and small cities	Primary and secondary hub traffic requires increased rail/road infrastructure for growth
	LCLH models need a large catchment area and major hub access to succeed	LCLH models need a large catchment area and major hub access to succeed	Large catchment area and major hub access essential to this business model
	LCLH models already exist in economy cabins of the A380	-	End of large aircraft models gives LCLH models more chance to succeed
	-	New aircraft types with lower operating costs makes these new LCLH models fly	Future aircraft types offer lower operating costs making new LCLH business models viable

7.4 Existing Market Players and their Business Models

The major secondary themes in this section are the repositioning of the Network and LCC models, business model convergence and increasing risk attached to strategic decisions.

> *'I would say that they will be structured very similarly to the way they are now. How long has the airline industry been going? Probably since the '20s and '30s. It is operated on a… there have only been two real models that have developed. The network model and the low-cost airline model on a point-to-point basis but for short haul'.*
>
> (University Professor and Airline Industry Consultant, UK)

Internal Airline Actors concur that the two current business models currently operating in Europe would survive and dominate the market but move closer towards each other on short-haul services, with several airline officials believing Network and LCC models and former competitors could cooperate at the major hubs. Voices in this group believe that the growing similarities between the existing business models would mean that there would be increased space in the market for VLCC and LCLH business models.

> *'New start-ups will the first years be a pure play; then they will … and we will, let's say, come from the other side and meet in the middle (business model convergence), in a way, like we do as today already with Eurowings, for example'.*
>
> (Chief Financial Officer, European Network Carrier)

The group believes the two current major business models in operation would show increasing convergence on the short-haul product and service offering in a 'pay as you go' type business model. For the short haul operators' offerings, I term this **'Pay as you go Hopper'**. Several airline managers believe that after a LCC and Network Carrier collaboration, that there might be the consolidation or merger of a network carrier with a LCC in Europe.

'I would guess they (business models) are coming closer together. I would not say they are becoming identical but there will be some overlap. We see it already with the European low-cost carriers also the US low-cost carriers introducing elements of loyalty programs, business-oriented features like lounges, preferred boarding also pricing structures, corporate agreements etc., this is a whole complexity which is developing but also then the treat to attract this kind of clientele to be honest. And this means there will be some overlap. We see on the other side many of the established carriers trying to basically move into more low-cost similar structure for air business so I could imagine that at some point in time maybe for the big hub carriers there is a low-cost style even feeder service even provided long haul services remaining part of the all established. `

(Former Chief Executive Officer, two European Network Carriers)

'I think it is not a question of the business model because at the end of the process I think both will survive, low-cost carriers and network carriers. I think that will come as well (LCCs feeding Network carriers). The most clever solution will be us buying EasyJet`.

(Chief Financial Officer, European Network Carrier)

The introduction of 'dynamic or continuous pricing' models are seen as extremely important by airline managers in maintaining or improving yields on premium or 'value' products. This increasing personalisation of service travel innovation I term **'a la Carte or Mosaic'**. Airline management strongly believe airlines would need to protect their customer databases from the advances of third parties such Google, Amazon and Facebook in the next decades which would attempt to sell travel services and thus engage in margin skimming. Two senior airline officials suggested working with such companies as pre-emptive action. Several interviewees from the group mentioned that strategic mistakes will be increasingly costly resulting in a more cautious and incremental approach in decision-making and strategic planning.

`I think this is one of this is not only a technological problem but for how to keep the direct access to the customers. And at the end of day if you do not ensure that we are still the ones who has the access to the customer data, then we have problems, as we are only an airline who brings passengers from A to B providing the transport but not the entire offer. So, I think we have one of the key technological question is ensuring that we are the one who are able to have the access to the customers into the distribution centre. `
(Chief Executive Officer, European Network Carrier)

External Stakeholders also agree the two major current major business models in operation would continue in some form, and most with increasing convergence on the short haul product and service offering. The industry consultants believe that in order to differentiate themselves on the long-haul product, network carriers would have to improve their service offering with more complex travel services moving towards individual passenger profit management rather than the yield management of single seats. The continued introduction of a 'premium economy' offering by the network carriers on long-haul services was regarded as best practise due to the high yield per square meter that could be generated. It was believed that the introduction of more 'premium economy' would in many cases be accompanied by the end of 'first class', which was seen as uncompetitive given the high standards already achieved by many carriers in 'business class' and the general decline in business traffic since the financial crisis of 2008. Post Coronavirus this development seems more likely with a slowdown in business traffic and more leisure traffic evident (Cirium, 2020).

'So, you are looking at how things have to change and what we are seeing is a portfolio approach and we saw the portfolio approach probably most developed with Singapore (Airlines)'.
(Airline Industry Consultant, UK)

The group opined that any businesses that are 'stuck in the middle' will not survive with more pronounced division of the market likely in providing comprehensive travel services (value) or alternatively low price. Hybrid business models such as Air

Berlin and Norwegian Air Shuttle encountered severe financial difficulties, but hybrid groups operating multiple businesses may well do so because they might offer the opportunity to separate and lower group risk. The separation of business models into companies as distinct operational entities seems essential for success. Industry and management consultants in particular believe that there are several valueless airlines in Europe, which must restructure in the next years or face closure.

> *'…but I am very black and white. This is what I believe the winners on the long-haul market in service innovators and no frillers on the short haul market will be the point to point no frillers, clearly positioning in the airlines.'*
> (University Professor and Airline Industry Consultant, Switzerland)

7.5 Very Low-Cost Carrier Business Models, the 'Frugal Hopper'

The major secondary themes in this section are the sensitivity of low-cost models to environmental charges, the simplicity of new business models, creating and meeting new demand for leisure traffic and new technology and infrastructure facilitating business models.

Internal Airline Actors exhibit general agreement on whether other business models might evolve to take up gaps in the market caused by the convergence of the product and service offerings of the LCCs and Network Carriers. One Chief Executive Officer and one Chief Commercial Officer of a European network carrier believe that a VLCC could take the place of the established LCCs based at secondary airports as the latter seek to increase operations from the major airport hubs. The current LCCs would be positioning themselves into becoming 'value carriers' and the new VLCCs as the 'true low fares' airlines. I term the latter business model type the **'Frugal Hopper'**. Such models are sensitive to environmental costs and would have to have the simplest and lowest cost structures.

'I see a new logic of models coming who owns the customer where would the customer go to if he wants to go from A to B, and this is where the value chain will be. Maybe there is going to be a new business model from a sheer operating platform, a white label. Just a tube flying from A to B.`
(Chief Commercial Officer, European Network Carrier)

External Stakeholders

Management Consultants think that a VLCC could take the place of the established LCCs place at secondary airports as the latter seek to increase operations from the major airport hubs. On three occasions, low-cost bus services such as Eurolines and FlixBus were mentioned as a potential business model template for this. In the case of FlixBus, bus services are run in cooperation with regional bus companies from all over Europe. Local partners are responsible for the day-to-day running of routes, while FlixBus is in charge of the regulation required to operate a long-distance network. FlixBus' head office handles all bus network planning, marketing, pricing models, quality control and customer service. The business model has been highly scalable and has enabled the company to grow successfully and quickly, albeit at the criticism of the social dumping of the workforce (ETF, 2019) ironically something Ryanair has also been accused of (Dumoulin, 2014; Epeusite, 2016). Such business models focus on low prices and on flexible low-cost service contracts, rather than asset ownership.

'You have an aircraft operator that is tasked with operating the aircraft as cheaply as possible, or at the lowest possible cost; buying aircraft cheaply, hiring crew, doing everything absolutely high safety standards but at the lowest possible cost – and then you have virtual airlines that own the customer interface, that have the brand and the website, and they switch between operators.`
(Partner Management Consultancy, Germany)

’I would argue that we see a continued convergence on short-haul towards a low cost - how do I put it - a low-cost operating model and a value orientated model. So, something like Ryanair getting more premium and some carriers like Eurolines getting more… reducing their costs and getting less premium.`
(Partner Management Consultancy, Germany)

The development of the Skyrider 3.0 ‘aircraft seat’ from Avio Interiors might enable such VLCC models within the European industry increasing seat density by approximately 20% on the popular Airbus A320 family models, differentiating themselves from short haul value carriers with additional services, larger seats and greater legroom.

7.6 Low-Cost Long-haul Business Models, the ‘Frugal Red Eye’

The major secondary themes in this section are sensitivity of taxes to low-cost models, the simplicity of new business models, creating and meeting new demand, and new technology and infrastructure facilitating business models.

Internal Airline Actors disagree on whether other business models might evolve to take up gaps in the market caused by the convergence of the major operators in Europe. A senior IATA official and two Management Board members of a European network carrier believe that LCLH could be made to work in large catchment areas and if well-funded. I term this business model type the **‘Frugal Red Eye’**. Interviewees agreed there was a sufficient demand for long-haul low fares from major hubs, but some experts across all groups argued that the existing network carriers could meet the demand with low fares in the future growth of their long-haul fleets.

’But will the current (models) remain, yes, low cost will expand to long haul and we still need network carriers I think so. Because certainly don’t we need to have a flight from Bologna to New York. From that logic yes, I believe both models will work. `
(Chief Commercial Officer, European Network Carrier)

'LEVEL, yes, a strange name…and in a total defensive move against Norwegian so like 'don't come onto our turf, we're going to match you; I've got more money than you and less debt'. So, yes, it may well be that the low cost long haul does finally succeed.'
(Senior IATA Official, Switzerland)

The scepticism from some airline managers about the success of LCLH resulted from the fact that some carriers already offer cheap seats on popular long-haul destinations and that a 10-12% cargo contribution was essential. However, recent trends in the large aircraft long-haul market such as the cancellation of the Airbus A380 production (Katz & Kammel, 2019) might mean that cheap seats will reduce in number. Believers stated that simplicity, low-cost demand and the growth of leisure traffic (Cirium, 2020) are important factors in their success.

External Stakeholders concurred there was a sufficient demand for simple long-haul low fares from major hubs with two Management Consultants believing that LCLH could be made to work in large catchment areas and if well-funded. In the opinion of these interviewees the opportunity for fledgling carriers to acquire the new aircraft types with much lower operating costs such as the Boeing 787 for long-haul services, makes such models increasingly feasible. There is additionally a growing sector of passengers prepared to travel without frills in the leisure segment (Albers et al., 2020; Cirium, 2020).

'Yes, it will be successful Low Cost Long-haul. In the end, it is not black and white, you will have a growth in point-to-point connections, and in a transparent, perfect market, point-to-point connections focus on big cities, but also between smaller cities, but big cities will get more point-to-point connections. In these big cities, you can start connecting between point-to-point flights, and also connect to long haul flights, so there's logic to point-to-point connections but also a logic to having transfer flights, and this is why both models will exist in future. `
(Senior Management Consultant Transportation, Germany)

7.7 Conclusion: Four Business Model Types

The interview findings indicate that customer preferences are seen to be driving the air transport market towards four broad business model types over the next decades. This finding is justified in this section.

Internal Airline Actors

The proposal that four broad airline business models will develop in the next decades is the conclusion of the research here. Four generic types of business model, does not exclude that within these types there could be market/geographic tailoring adjustments for the two value driven models. There was universal agreement that network carriers must develop more personalised services to remain competitive and that existing low-cost carriers would seek to move to major hubs due to limited market growth opportunities in their existing models. A gap would then be left for the 'Frugal Hopper' to fill a need at the bottom of the market using new aircraft types and new financing models along the lines of low-cost bus companies in Europe. 'Frugal Red Eye' models were accepted as a viable business model by many, but as a niche and single class product operating in a large catchment area, and on high traffic and mainly tourist routes. This repositioning and fragmentation of the Network and LCC business models is a key finding.

> '*The four models seem perfectly logical to me.'*
> (Principal, Aviation Consultancy, London)

To succeed the 'Frugal Red Eye' will use the benefits of lower operating costs of new aircraft types and seek unique inspiration from novel hotel chains and caterers (Franke, 2007, Moreira et al., 2017). The sceptical voices in this group felt that replacing a cargo contribution of 10-12% was a key factor in making it successful. One airline manager working for a LCC suggested the cargo area of a wide body aircraft could be redesigned as on board lounge replacing a similar ground facility to improve turnaround times and the profitability on LCLH flights, with ´on-ground but in-flight´ entertainment proposed as a differentiator.

The airline managers generally believe that some national brands would continue to survive having an advantage in capturing ‘home market’ traffic. This group opine that all low-cost business models would come under increasing stress from environmental taxes, rail and environmentally conscious consumers. Ancillary revenues would be increasingly important in keeping this segment profitable. While most accepted the success of ‘Frugal Hopper’ models, their viability would always be under threat from the level of regulation and taxes.

> *‘Yes, basically, the four business models that you have identified, I fully agree with them. Everything you’ve said so far I kind of concur to them.’*
> (Senior Economic Consultant, Aviation Consultancy, Amsterdam)

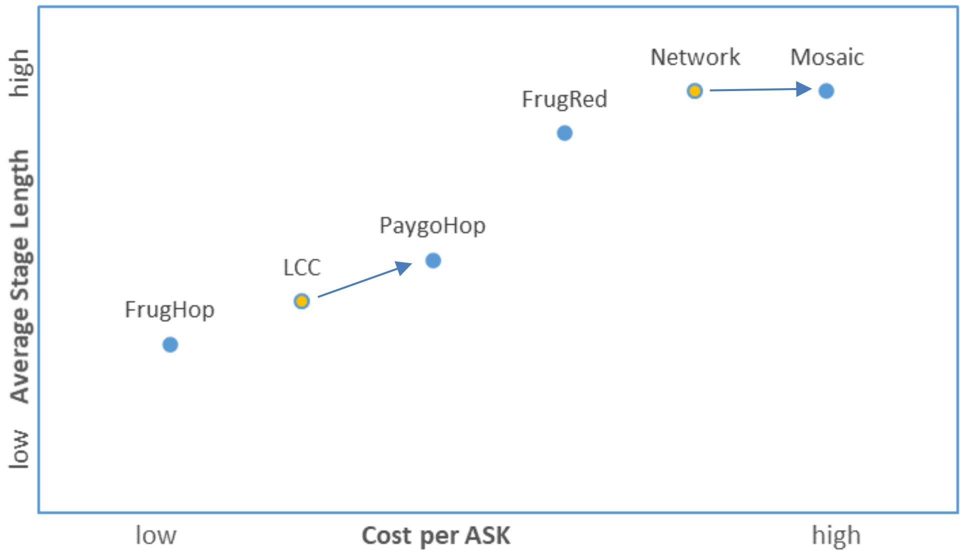
External Stakeholders are generally in agreement with the airline group but with a more positive approach to the ‘Frugal Red Eye’ model. The group concur that the model could succeed as a single class, higher seat density product, to volume traffic destinations with tight cost control and attractive inflight services and entertainment. Asset management is seen as a key skill by this group, with asset utilisation and asset financing believed core to the success of all business models but particularly those with very low fares. The external stakeholders admit that national airline brands would only be retained where they added marketing value for the customer, such as in capturing the demand in a local market.

> *‘The greatest growth of flying has become from low cost and penetration of the income pyramid for those who were less able or unable to travel before, but it’s been made available to them because of airlines - in some cases their ability to charge low fares, but in others a necessity that they need to charge lower fares to get the traffic.’*
> (Industry Consultant, UK)

7.8 The Analysis of the Interviews with regard to Airline Business Models in Europe

The four business model types are seen as offering a clear differentiation and value in an over supplied market with two models offering customisation and passenger choice and two focusing purely on price. 'Value carriers' would seek improved passenger and profit management with ancillary services and revenues, and the 'cost-based models' would seek operational and passenger service simplification.

In Figure 22 the four business model types are positioned in terms of 'unit cost and stage' length and in Figure 23 'service offer and unit fare'.



Key to Figure 22:

FrugHop	Frugal Hopper
LCC	Low-Cost Carrier (previous positioning)
PaygoHop	Pay as you go Hopper (new positioning)
FrugRed	Frugal Red Eye
Network	Network Carrier (previous positioning)
Mosaic	Mosaic/a la Carte (new positioning)

Figure 22: Schematic Model of Stage Length against Unit Operating Cost

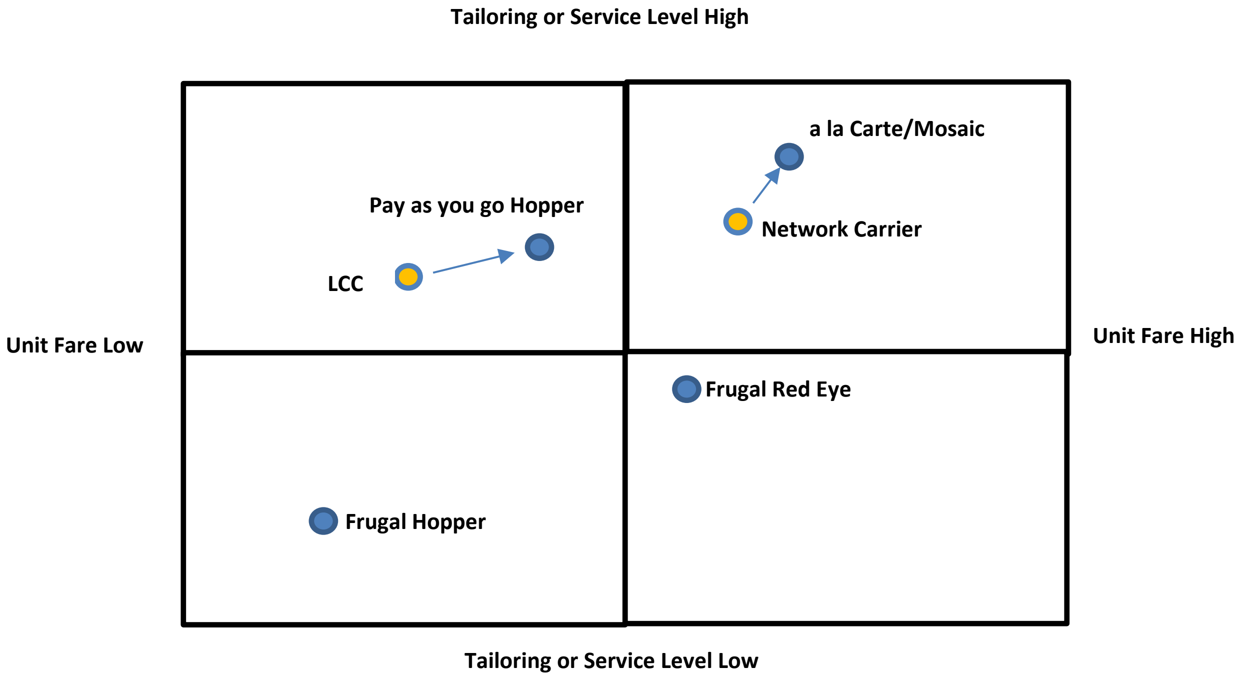


Figure 23: Schematic Model of Unit Fare (Price) vs Level of Service

7.9 Inconsistent Findings

The main inconsistent message from the second round of interviews is that although the 'frugal' models were accepted as developing a foothold in the market, it is these precisely these two models that seemed to be the most vulnerable to the coming wave of environmental penalties. Unless the margins of these two frugal models are at least as high as the two value business models then they might struggle to develop a foothold. The scale of fuel and environmental costs will likely decide their future. One consultant opined that although low carbon tickets will be attractive to a new type of passenger, it was the horizon of the cost base that was key.

> *'My expectation is that low cost, very cheap low-cost carriers will disappear in states where they have pretty high environmental taxes because, competition reason.'*
>
> (Senior Director, Environmental Affairs, Network Carrier)

> *‘Sustainability, I don’t think anybody at the moment have an idea properly how it’s going to impact them in terms of cost’.*
>
> (Head of Fleet Technical Services & Deputy Technical Director, Low-Cost Carrier)

> *’I don’t see a direct connection between protecting the environment and the business model of an airline’.*
>
> (Economic Consultant, Aviation Consultancy, Amsterdam)

> *‘For the low-cost carriers the price of the fare is critical to developing their market and I have the impression that this is why they resist so much a number of actions, such as sustainable fuel. The good thing is that they are new so they are equipped with new aircraft, so their level of… current level of efficiency, fuel efficiency, is excellent and then the transition to other means make it difficult.’*
>
> (Head of Sustainability Initiatives and Environmental Affairs, Aircraft Manufacturer)

The findings were also complicated by the fact that some industry officials believe that cheap seats already exist within the existing operations of both LCCs and Network carriers through differential pricing. For example, reduced conditions of travel on short sectors (with no food, no baggage allowance or ticket change facility) already allow cheap short haul sectors, and there are cheap seats available on the largest long-haul aircraft between major international hubs, albeit the A380 being phased out by some carriers. Thus, for some there was no gap seen in the market for new business models to grow. The literature and interviewees were not able to pinpoint ´novel´ business models for cross border travel, where industry regulation and key resource access dominate operational possibilities.

7.10 Summary Concerning Airline Business Models

Geels (2018) makes the case that the MLP model is a suitable model to examine change to a low carbon world by including elements absent from other frameworks such as Christensen´s (et al.) (1992, 2016). This is because it includes levels of complexity and nuance that others do not, specifically, linked innovation processes, regulatory influence, co-operation amongst partners across the levels of the model, business strategy, and social, cultural and political acceptance.

A feature of the STL is that airline managers have control over their business model even if they have to surrender to shifts in macro-economics, regulation and technology. In 'efficiency' centred business models, leaders face two essential trade-offs - minimising costs or maximising seat yields at a given level of complexity. The convergence of the ´Pay as you go Hopper´ and the ´Mosaic´ models on short haul services maximising value, leaves room for the 'Frugal Hopper' totally focussed on cost. New efficient aircraft types, the withdrawal of the very largest aircraft types by European ´Mosaic´ carriers and their repositioning in more personalised travel, facilitate the rise of 'Frugal Red Eye' models. Even if scale economics are denied to start-ups, they could stimulate new demand in a flagging European market as their competitors move to personalised service.

Four broad airline models are seen as operating in Europe in the next decades, two servicing a price sensitive customer, and two focused on a value-based model with layers of choice in products and services. Within these four model types it is possible specific market or geographic adjustments might be economically viable, but the cost of adding complexity needs to be covered by the airfare, and is therefore most likely in the larger ´value´ models.

The operation and choice of business model can support a sustainability transition by adjusting to passenger demands, environmental strictures from the regulator and in new combustion technologies. Airline managers believe the leveraging and protection of customer data was core for the success of the ´value-based´ models. Lock-in mechanisms hinder legacy carriers who will find it difficult to remain cost competitive with the unencumbered. Legacy investments in existing carbon-based technology dominate the European industry and legal commitments such as contracts with the state, suppliers, IT and airline staff may take many years to ‘see out’ before meaningful revision, giving ´frugal models´ a greater potential foothold.

System transitions in ground transportation have already delivered new transactions in car sharing, car leasing/rental models, car-pooling, passenger bus models and taxi models such as Uber and Lyft. There has been increasing cooperation in the interlinking of air, bus, tram and train timetables giving intermodal travel options over shorter distances (Ongkittikul & Geerlings, 2006). Developments in information and communication technologies have reduced the need for air travel especially for business and have improved all aspects of traffic management. Self-driving cars, trucks and ‘intelligent transport systems’ are now on the horizon with a realistic implementation timetable on European roads within twenty years (Hars, 2015; Hörl et al., 2016). It is now time for airlines address the sustainability issues facing the industry and make innovative changes to their business models by adopting more rigorous positioning and embracing new activities in ´sustainable value creation´.

The next chapter draws together the information from Phases 1, 2, 3 and 4 (Figure 17) aiming to draw industry recommendations in a process of triangulation.

Chapter 8 Discussion: Toward a more Sustainable Airline Industry: a Conceptual Model for Industry Transformation

8.1 Introduction

This penultimate chapter discusses the future of the airline industry in Europe building on the academic literature and the findings of this research project. The discussion seeks to place the findings of the study within the context of existing knowledge and understanding.

Firstly, I review the aims and objectives of the thesis and discuss whether these were broadly met. Secondly, I survey the results of the research through triangulation, while highlighting my empirical, theoretical and practical contributions to knowledge and practice in relation to airline industry transformation. I also reflect on the general lessons for other industries transitioning from hydrocarbons. Thirdly, the limitations and delimitations of the study are discussed before concluding.

8.2 Reviewing the Aim and Objectives of the Study

The aim of the thesis was: *´To examine the role of business model innovation in supporting a sustainability transition in the European airline sector.*

To achieve this aim, Chapter 1 outlined five research objectives that provided the basis for five specific research questions (Table 61). In Chapter 2 the literature review discussed change frameworks and business models and sought to link the MLP and STOF models to the business model canvas to create novel and appropriate tools to examine industry transformation. This is a new way of linking two significant models to a third and provides a framework for investigating the effect of changes in the MLP through the STOF forces on business models. The research methodology was summarised in Chapter 3. In Chapter 4, the recent performance of twenty airlines in Europe was analysed in a major quantitative study and multiple regression models were constructed that identified the key parameters affecting airline financial results and how they might be levered for success thus meeting objective one. In Chapters

4, 5 and 6, the challenges and forces facing the industry were identified through a grey literature review and a series of interviews with industry experts meeting objectives two and three. A process of market fragmentation towards four major business model types was identified, and proposals were made for a more sustainable airline industry in Europe to overcome barriers to industry transformation meeting objective four. This chapter reflects on how sustainability transitions occur, meeting objective five.

Table 61: Review of Thesis Objectives

Research Objective / Research Question	Key results/findings	Goal met?
1. To carry out a historic quantitative study of the performance of Europe's airlines. *What financial and non-financial factors have been key in European airline survival since 2000?*	• For all sampled airlines: Unit Cost of Labour, Yield as RRPK, Passenger Numbers (scale), Journey length, Member of a global alliance, Reinvestment in the capital base • For Network Carriers: Unit cost of labour, Free cash flow, Yield as RRPK, Net Debt/EBITA (credit rating), Passenger numbers(scale), Journey length (long), Cargo tonnage • For Low-Cost Carriers: Unit Cost of fuel, Debt/Equity ratio, Employee/fleet size ratio, Passenger numbers (scale), Journey length (short), Flights/destinations ratio, Reinvestment in capital base	Yes
2. To conduct qualitative research to understand key stakeholder perspectives on the major challenges facing the European airline industry to 2030. These concern an industry at the interface of market, regulator and technology. *What sustainability challenges face the industry?*	• Lower passenger demand within Europe but growth towards the East • Increased requirements for fresh capital investment with weak and volatile industry margins • Development and scale for renewable fuels, replacement of existing combustion technologies • Gaining a global agreement that effectively reduces/ends GHG emissions from aviation • De-risking developments in technology, increasing speed to market adoption • Pressure on short sector travel from road, rail, regulator • Poor competitive position of European infrastructure, with dual infrastructures needed • Passenger need for safety, security, fragmented and tailored travel, fares transparency and equity • Maintaining investor and passenger confidence essential	Yes
3. To use ideas from the literature on industry transformation and sustainable business models together with the analysis of a qualitative data set to arrive at recommendations for a more sustainable European airline industry. *How will airlines negotiate the transition to a low carbon world through business model innovation?*	• Business models react to changes in the STN and TN, airlines can only confer, advise and lobby • Airlines are technology end-users, re-modelling mechanisms weakly reflect this aspect • Business models are not transformative solutions to a sustainability transition in aviation • Business models can lock-in incremental change, prevent backtracking and agreement drag • Critical mass in the adoption of new technology in a business model enhances a system solution • Airline business model innovation requires system change with other partners	Yes
4. To identify the barriers to a successful transformation of Europe's airline industry and provide possible pathways to overcome them. *What barriers exist and how might they be overcome?*	• Clear regulatory pathway increases information for planning and investor confidence • The regulator to implement a fuel escalator mechanism to provide incentives to transition • Technology de-risking can be overcome with multiple partners with agreed and open standards • The public funding needed can be protected with a golden share for the taxpayer • Regulator needs to set industry standards early and increase global certification centres	Yes
5. To use the findings of the study to reflect on the efficacy of the concept of 'sustainability transitions' and 'sustainable business models' and to provide portable, durable learning for other industries, particularly hydrocarbon users. *What are the key insights for sustainability transitions in general?*	• Global industries need global agreements • The regulator is key in driving change in a globally regulated industry • De-risking investment, technology coordination means neoliberal solutions unlikely • Preventing monopoly technology provision is a legitimate regulator role • Where complex technology is instrumental in change, business models are only incidental • Company business model innovation assists system transition	Yes

8.3 Contributions of this Thesis

In the following sections I outline the empirical, theoretical and practical contributions (Corley & Gioia, 2011) of my thesis from my research on an industry that is mature, globally integrated and highly regulated, and therefore unlikely to undergo radical and quick readjustments. Even so, my research is also of practical benefit because the recommendations made for airlines, regulators and technology suppliers offer a pathway to a more sustainable industry.

8.3.1 The Empirical Contribution

In Chapter 4 and summarised in Table 61 objective 1, I make an empirical contribution in the form of a multi factor study on the European airline industry during a period of several industry crises from 2000-2019. This research in this thesis is unique in that it includes a comprehensive set of 50 independent variables for 20 airlines over a period of 20 years and within a single continent. Six multiple regression models are presented that reflect the performance of the whole group of airlines, network carriers and LCCs included in the sample. The results provide a comprehensive overview the key financial and non-financial factors that have shaped European airlines' financial performance over the past two decades. While knowledge of the past is no guide to the future, the findings contribute to our understanding of the different airline characteristics that have been responsible for the financial evolution of this industry. The empirical contribution is original because factors that affect all European airlines are isolated, plus the factors that affect two distinct business models are identified. Uniquely the empirical contribution is drawn from data including six industry crises pointing the way for airlines to prevail during future industry turning points and including negotiating a problematic industry transition.

At the same time, the study adds value for industry professionals and academics involved in energy and sustainability transitions more generally. The work of Foxon (2011), Gorissen et al. (2016) & Hernandez-Chea et al. (2021) focuses on evolving technologies, a multiplicity of potential options the early phases of industry transitions having limitations in addressing the issue of diffusion from the TN (Roberts

& Geels, 2019). In contrast, this study aims to structure a two-step, three model process for business model ´mapping´ for sustainability transitions with direction from the STR at the core due to the highly regulated nature of the industry, through identifying four STOF forces arising and driving business model change and from all three levels of the MLP.

8.3.1.1 Triangulation of the Data Sources - The Role of Business Model Innovation

Based on the research undertaken, in this section reviews the empirical contribution of this thesis by comparing findings from the different methods employed in this thesis with a specific focus on the value of business model innovation in supporting a sustainability transition in the European airline industry (Table 62). This is also done in preparation for a practical contribution for policy for industry transformation presented thereafter in Figure 25.

The quantitative study in Chapter 4 indicated a number of factors have been important in airline success and survival, notably for all the airlines analysed, low labour costs, yield management, company size and capital reinvestment. There is statistical evidence of an optimal (but different) stage length for both Network and LCC models for maximising operational efficiency.

For Network carriers, a cargo operation and the management of the credit rating are highlighted. LCC models seem more sensitive to the cost of fuel, the high operational productivity of their networks and debt financing. Should these factors continue to be significant in coming decades the ability to refresh the capital base and attract funding seem increasingly essential to company survival in an industry undergoing a partly involuntary reinvestment programme with a challenging goal of meeting the European and global regulators emissions targets (Fageda & Teixido, 2022).

Increasing yields through service differentiation, high operational efficiency with low labour costs delivers the decisive difference in generating operating cash flow for the ´value centred models´. It will be difficult to attract skilled labour and at the same time maintain low unit labour costs, but artificial intelligence, automating some tasks and transferring others to passengers are potential solutions. If total energy cost is the regulator´s tool of choice for transformation, then airlines will constantly focus on the most efficient energy networks with the lowest emissions costs. The economic benefit of capital reinvestment for the company is made clear over the medium and long term, even if the short-term benefit is less so - the risk profile of technology adoption is moved towards the present. To meet climate goals, at its most extreme energy policy might involve some types of energy allocation or rationing. Thus, the value proposition and skilful financial and investment management stand out as two business model tasks airlines will need to command.

In Chapter 5 the Grey Literature indicated that movements in the MLP will likely cause changes to the value proposition, with airlines cooperating with partners in ground transport and with a greater variety of passenger service offers. Airlines operating over the shortest sectors will be under the greatest pressure from rising fuel costs and ground travel alternatives. In the run up to implementing new technologies, incremental innovation will dominate, but post 2040 the introduction and limitations of new technologies will affect airline networks. However, this effect is difficult to predict as the technology is not standardised or certified. Until then, the key activities of airlines will be sound financial management and a regular review of the need to reinterpret business models amongst the airline executive. Skills in developing joint activities with more interdependent partners will be increasingly important. Key resources will be dominated by the access and control of major hubs, connectivity and passenger sales channels. Customers will seek security, safety and customised service, with the value focussed airlines developing more complex and shared revenue streams. Another key point is that airlines will react to changes in the market and pressures in technology but will not lead them.

In summary, the quantitative study in Chapter 4 highlighted that unit cost control, operational efficiency and capital reinvestment maximise the recurring operating cash flow in virtuous circles. The efficient use of energy is instrumental in optimising all three parameters. The secondary data and grey literature review in Chapter 5 revealed greater emphasis on the passenger value proposition, and the problems of incorporating complex untried new technologies into airline business models and regular BM scrutiny. Managing increasingly risky decisions during transition will demand greater internal knowledge and heightened cooperation with partners.

In the qualitative studies in Chapters 6 and 7, the interviews with key industry personnel focussed on a fragmenting value proposition and more closely detailed customer segments. The closeness of the customer relationship will be determined by a higher defined focus on yield. Greater integrated partner activities within the industry and outside it, mainly with suppliers, rail and the regulator were highlighted. Core activities involve building new skills portfolios, financial and reinvestment management. Fair regulation and a globally competitive infrastructure are sought by airlines with a likely price finding itself in the timing and cost of regulation. Open platforms, early standard setting and de-risking investments in technology are crucial to the transformation process but are not possible to easily reflect within business models. The impact of the regulator will be felt in the speed of increase in the cost base and in operational restrictions on airline business models, mainly on short haul.

In the qualitative studies four business main models emerged. This does not mean that other business models are excluded from niche markets or geographies, but it is indicated by the research that the majority of European air traffic will be served by these models. A fragmentation and repositioning of the business models are marked. This phenomenon is also noted in a study of 42 global airlines by Urban et al. (2018) which identified an industry fragmentation into seven business model types with two LCCs, one hybrid and four Network Carriers (including single, multi-hub and differing service levels).

An original feature of this study is the triangulation summarised in Table 62 shows a level of convergence in the development of themes for airline business models with implications for other carbon intensive businesses. The customer value proposition becomes more differentiated as customer segments fragment and yield management becomes acute. Technology providers and ground transportation become increasingly important partners for airlines, but the articulation of this relationship within the business model is unresolved. Key activities for airlines remain strong financial and reinvestment management plus optimising efficient (carbon) operations. Key resources will focus on hub management and steering the customer relationship. The cost structure will continue to focus on labour and fuel, but with the cost of regulation increasingly crucial. The difficulty in modelling the impacts of technology and to a lesser extent regulation within the business model framework is the upshot.

Table 62: Triangulation of Primary and Secondary Research on Business Models

Business Model component (Osterwalder & Pigneur, 2009)	Quantitative Study Chapter4	Grey Literature Chapter 5	Qualitative Study 1 Chapter 6	Qualitative Study 2 Chapter 7
Value Proposition	some differentiation	increasingly differentiated	increasingly differentiated	1. Mosaic Carrier 2.Pay as you go Hopper 3.Frugal Hopper 4.Frugal Red Eye
Customer Segment	lower fragmentation	more fragmented	more fragmented	more fragmented
Key Partner(s)	not covered	technology, suppliers, regulator, ground transport	technology, suppliers, regulator, ground transport	technology, suppliers, regulator, ground transport
Key Activities	balance sheet management, reinvestment, optimise operations	balance sheet management, reinvestment, optimise operations	reinvestment, optimise operations	optimise operations
Key Resources	liquid funds	liquid funds, major hub, skilled staff	major hub, skilled staff	major hub
Customer Relationship	not covered	yield dependent	yield dependent	yield dependent
Sales Channel	not covered	direct, control	direct, control	direct, control
Revenue Structure	passenger yield, cargo	tailored passenger yields, cargo, ancillary revenues	tailored passenger yields, cargo, ancillary revenues	tailored passenger yields
Cost Structure	fuel, labour key	fuel, labour, regulation key	fuel, labour, regulation key	fuel, labour, regulation key

8.3.2 A Theoretical Contribution

As per Table 61 and objectives 2-4, this thesis was grounded in a combination of three theoretical models from the academic literature to explore their validity for explaining the potential role of business model innovation in driving a sustainability transition in the airline sector based on a sequential and repeatable two-stage process. This novel framework was developed (Figure 16) to help make sense of, and assess, the respective roles and contributions of internal and external driving forces impacting on individual airlines and the sector as a whole. The intention was to capture and integrate insights from different literatures on how and why industries change over time in the context of sustainability. Specifically, it was designed to address a lack of research on the role that business model innovation plays in shaping sustainability transitions. Through my research I assess the STOF forces arising from the MLP impacting on the business models, and assess their respective limitations in supporting a sustainability transition. I conclude with a research agenda to help shape future research in this area.

8.3.2.1 The Role of Business Model Innovation in Supporting an Industry Transition

My thesis contributes to literatures on the role of business model innovation in driving sustainability transitions by highlighting the crucial role carbon-intensive technology plays in some industries that cannot be easily replaced. Specifically, the research here indeed indicates that BMI mechanisms do not sufficiently address the effect of technology on business models, therefore making business model innovation a necessary but insufficient precondition for a wider sustainability transition in such sectors. Whereas the MLP and the STOF models capture the role of technology more successfully, models and frameworks for innovating business models are primarily concerned with aspects of value creation and value capture that are relatively technology-neutral (or agnostic). While research on BMI has extensively studied the role of digital technologies in enabling industry change (Martinelli et al., 2021), the research suggests that for industries constrained or locked-in to carbon-intensive technology platforms, innovation in business models cannot sufficiently respond to the demands from other aspects of the business environment as characterised by MLP and STOF models. As such, this thesis contributes to our knowledge and literature on business model innovation by identifying its critical shortcomings in contexts characterised by high levels of carbon-dependency. Thus, the thesis challenges a generic perspective that business model innovation can sufficiently and generally support sustainability transitions without recognition of the technological fundamentals.

In the case of airlines, the complex effect of technology on operations and finances cannot be recast in the redesign process as they do not design the technology they operate. This is perhaps more acute in industries undergoing a critical technology transition and moving from an existing business model to a new one with a series of incremental positions all requiring an increased level of passenger acceptance. The focus of a business model matrix is weighted towards the customer and in company processes. It cannot articulate the flow through effect of technology and the regulator adequately, and more so if the effects of both are currently unpredictable and when technology transition is decisive. The shift towards four and more passenger focussed business models has been sense checked with industry experts, but as one management consultant noted, ´´I cannot see a link between an airline business model and sustainability´´. The effect of the regulator is most distinctly seen in the energy cost base and in potential operational restrictions on networks. For airlines there will clearly be increases in the cost of energy, and in the simultaneous operation of both kerosene-based combustion and renewable energy technologies.

My conclusions are that changing a business model will not guarantee the financial sustainability of an airline or the industry. For airlines the purpose of changing a business model is in response to shifts in customer demand to maintain or improve company profitability/cash flow. One part of profitability is determined by the cost of energy and operations, but reworking a business model to include new technologies cannot guarantee that airlines meet their climate change obligations or sufficiently evidence progress towards a decarbonised industry. Airlines will take the most financially advantageous course in the coming years, as they have traditionally done, and the actions of the regulator and developments in technology will likely determine how much that aligns with a (net) zero emissions industry. Perhaps the key message is that the underlying regulation of the cost of energy and emissions will direct the speed of industry transformation. Energy can be used as a policy instrument; it is experienced by the company in its performance.

While airlines can embrace developments in emissions regulation and technology that really underly an industry transition, adapting a business model is a response to MLP shifts and STOF forces, rather than a driver of industry transition. What changing a business model can achieve, is to ´lock-in´ network and technology changes in the way airlines operate by accepting a more demanding regulatory environment and by adopting new aerospace technologies when possible. Cementing-in by reconfiguration of incremental improvements and creating virtuous circles is an element in preventing drag and backtracking, and increases percolation through the sustainable energy system (Hernandez-Chea et al., 2021). It is clear from the research that the regulator and providers of technology will be the major movers in industry transition, and that airlines will respond to energy renewal by implementing improving technologies as cogwheels aligning with the latest regulatory requirements. For airlines, adopting new technology is part of supporting a virtuous circle in an ´industry transformation system´ in which they play the last part as end user. The business model concept holds a modest role in the transition of the system. I represent Figure 16 from Chapter 2 as Figure 24 to explain the conclusions.

Business models are clearly linked to technological innovation, but yet are still separate from it. What a well-structured business model can do is reconcile and monetise the link between technology and firm performance (Baden-Fuller & Haefliger, 2013), but airlines do not control the relevant technology. Restructuring an industry is best served through business model innovation (Nidumolu et al., 2009; Kavadias et al., 2016; Christensen et al., 2016). New business models are enabled by new technologies by creating new value, operational or cost propositions (Magretta, 2002; Baden-Fuller & Haefliger, 2013; Hienerth et al., 2011). If company performance improvements will be increasingly dependent on both technological innovation and business model innovation, then the traditional S-curves used in technology management (Fisher & Pry, 1971; Christensen, 1992) will need to be reviewed for their respective contributions to organisational performance (Baden-Fuller & Haefliger, 2013).

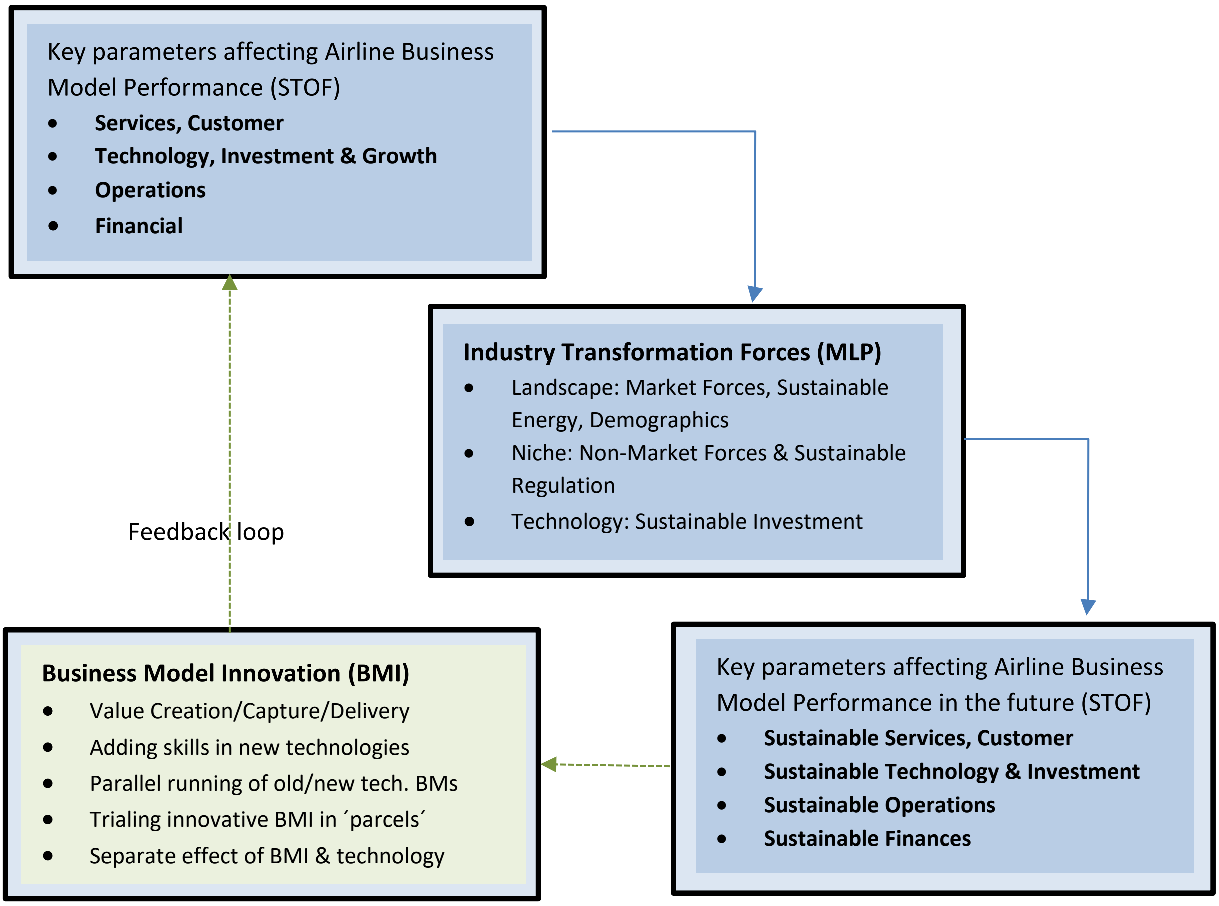


Figure 24: Conceptual Model for Understanding Airline Business Model Innovation by Linking the Multi-Level Perspective and STOF models (revised)

Source: Author, adapted from Bouwman et al. (2008)

Colfer & Baldwin (2010), Sosa et al. (2004) and Sosa et al. (2007) have shown how the alignment of organisations with newly adopted technologies in a process they call ´organisational mirroring´ improves operational performance and reduces unit costs. This is a question I raise as relevant for the airline industry, in that it is yet not understood how much airline business models will have to adapt to the new technologies that await them, and how far in advance of the delivery of useable technology that airlines must begin to adapt their business models. Brusoni et al. (2006) and Baldwin & Clark (2006) have shown that the evolution of knowledge intercedes in organisational and technological development, and makes organisation design open ended as a company evolves into new space. Baldwin & Clarke (2006) and Aversa et al. (2015) emphasise the importance of introducing planned ´modularity´ in managing this ambiguity. This means managing complexity in organisational units which can accommodate uncertainty, and enables the parallel running of old and new technologies. My findings suggest that adopting such a strategy would be potentially valuable for airlines, since business model changes can leverage improved performance, but the profusion of transition uncertainty that prevails in the industry prevents its near to medium term fulfilment.

Given the risk and unpredictability of adopting new technologies within civil aviation, the implementation of new technologies within a company division or smaller group subsidiary and adopting established risk management procedures might prove a useful strategy for airlines to adopt. Given so few providers of ´new combustion´ airline technologies, such risks are increased compared to the existing machinery. Tohanean et al. (2020) has proposed this in the heavy engineering industry. Caryannis et al. (2015), Lindgardt et al. (2009), Christensen (1997), and Schneider & Spieth (2014), use the term ´strategic entrepreneurship´ to describe business model innovation when established organisations use their skills and resources to develop new entities coexisting with existing businesses to test new technologies. Given the high levels of investment required and the uncertainty of future operational performance, a proposed and logical path whereby airlines can address technological change is to build in an organisational innovation ´parcel´ responsible for maintaining flexibility and ambidexterity, and implement new combustion technologies within this separate autonomous unit for maximum organisational learning. Such organisational learning has been discussed by O'Reilly & Tushman (2004), Caryannis et al. (2015), Aspara et al. (2009), Pohle & Chapman (2006), Carayannis et al. (2000)

and Carayannis (2008). Using ongoing feedback, experimentation and economic analysis can identify the most promising technology, business processes and models to pursue and integrate with partners (Girotra & Netessine, 2013; Hofmann & Jaeger-Erben, 2019). Discrete operational units offer organisations the flexibility to more rapidly adapt cross organisation, cross functional and partner activities in adjusting business model design to maximise performance.

Foss & Saebi (2017) discuss that business model research has been broadly in three main directions: in changing businesses, developing new businesses and measuring business outcomes. The research suggests that the complexity, functioning and measure of the change expected for airlines can only be completely understood by taking a modular approach within a discrete organisational unit or ´parcel´ and where new technologies and performance outcomes in relation to the natural, economic and social capital of sustainability can be measured (Breuer & Lüdeke-Freund, 2014), and without the opacity of mixing multiple technologies. Within a smaller entity some scale advantages may be lost, but the opportunity to understand the effects of new technology on finance, the environment and on stakeholders is markedly improved. If airlines are to deliver optimum sustainable performance and meet their industry goals such insight is vital. The ´parcel´ model advantages identified in Table 63 might be a place to begin.

To avoid excessive network disruption such units would initially likely be operated as ´short haul point to point´ businesses. Interview feedback indicates that short haul learning in new combustion, engine and aircraft hull technologies will be vital for later future long-haul operations. The separation of new combustion technologies into separate operational business units would identify the benefits of using new technologies (S-curve) plus a new technology business model, and enable comparison with conventional technologies.

Table 63: Features of a New Technology Airline Unit Compared to Mixed Operations

Business Model component (Osterwalder & Pigneur, 2009)	Features of new technology standalone airline unit or ´parcel´	Features of mixed technology airline operations
Value Proposition	Using new combustion technologies, green airline	Established reliable old combustion technology
Customer Segment	Environmentally conscious, young	Less environmentally aware, sceptical of new technologies
Key Partner(s)	New technology suppliers, new maintenance providers dual airport infrastructures	Many and complex
Key Activities	P2P operations, higher operational fallout likely, greater organisational flexibility	Network or P2P operations, lower operational fallout, lower operational flexibility
Key Resources	Highly skilled personnel in new technologies, separate AOC reduces group operational carryover	Skills in existing and technologies, Group AOC potentially increases group operational risks
Customer Relationship	Close, repeat business	Close and distant
Sales Channel	Probably direct	Some direct, use of agents
Revenue Structure	More transparent fares with lower burden of emissions taxes on fares	Fares pooling. Less transparent fares with higher burden of emissions taxes on fares
Cost Structure	Transparent to new technologies, higher unit costs initially, radical technology cost improvements later, higher cost of own AOC	Greater economies of scale, lower unit cost, incremental cost improvements tailing off, lower cost of group AOC

Having a separate Air Operators Certificate (AOC) for any ´sustainable point to point unit´ might have advantages in reducing the risk of an airworthiness technology failure (which is increased with radical and new technologies) carrying over to a mixed operation. An AOC demands assurances concerning qualified personnel and ongoing training, liquid funds and insurances, quality systems and legal representation and importantly adequate ground infrastructure support in airport operations and maintenance (Skybrary, 2022). A separate AOC will certainly increase unit production costs.

Positioning a new operational unit as a more ´sustainable carrier´ might well have a snowball effect encouraging environmentally aware consumers to use such services while tacitly accepting the operational risks that it might bring, certainly in their early phases. The separation of new combustion technologies into separate business units might also have advantages in the transparency of air fares. New combustion technologies are likely to enjoy lower emissions penalties than older technologies, and especially if an escalator mechanism is adopted by the regulator. Discrete operations offer the opportunity to avoid the fares pooling of a mixed technology organisation, by separately identifying the benefits of reduced taxes for passengers and passing these on directly in ticket prices. Study evidence shows that airline demand elasticity in developed countries is lower indicating that European consumers are less price sensitive than in developing countries (Intervistas, 2007). Intervistas (2007) notes heavily served sectors are less elastic and that longer sectors are more price sensitive. Three studies (Gillen et al., 2007; Doganis, 2006; Intervistas, 2007) indicate income global elasticity of demand at between 1.14 and 2.5, confirming the global position of air transport as a luxury good. Developed markets and those highly served by LCCs show lower price elasticity. Thus, the developed European market with a level of price inelasticity maybe be an ideal launch market for such organisational units and if more fragmented business models adapt to cater for changing customer requirements.

My conclusions are that unless new businesses design emergent business models with new technologies and with sustainability as a core value, then adjusting business models in mature industries to accommodate moves towards sustainability is only tinkering around the edges. Such findings chime somewhat with Bolton & Hannon (2016), indicating that fledgling organisation business models show more promise over other options. This means that the business model concept has value in a sustainability transition, and that incorporating new technologies into a complex business model ´reconfigures´ incremental change toward sustainability and creates industry critical mass. In complex and global businesses, designing sustainable business models for a sustainable industry will involve more interacting parameters than those that can be comprehended in a mixed operation. There are too many sequential alignments from multiple partners that must take place for industry effective results. Understanding complex sustainable industry transitions involves reducing and isolating these parameters to understand them fully, plus probably the support of complex programmable solutions, multiple scenario planning and that may be market specific. The volume of systems data being produced from new generation technologies in engines and aircraft, together with artificial intelligence, can assist with the adjustments in these business model processes.

8.3.2.2 Cooperation of the Pay as you go Hopper and Mosaic Carriers at Major Hubs.

´Parcel´ model approaches to the problems of understanding of technologically driven changes to business models might encourage cooperation and specialisation in BMI. The grey literature and interviews with senior officials in the industry in Chapters 5, 6, and 7 proposed that the repositioned Pay as you go Hopper (PAYGH) could conceivably cooperate with the repositioned Mosaic carrier at major hubs to improve the margins of both players (Jarach, 2004; Müller & Vorbach, 2015). Such an operation would have both advantages and disadvantages for both airlines, and cause fresh problems for the regulator. A common adoption of this practise would result in many airlines conducting a ´point to point ´ business model, an inherently more efficient operating grid. In such an arrangement both companies would likely lose their independence to act freely to develop their own networks.

> *'The optimum size then for an aircraft if what we've always thought with the last… A320, Boeing 737.'*
> (Senior Official IATA, Montreal)

While such an activity would likely improve the margins of both partners it would create an interdependence and the attention of the regulator. The short haul operation of network carriers has usually been the poorest performing part of a network. This is because the timely wave operation that network carriers operate to fill their own profitable long-haul services is inherently inefficient, and offers much lower productivity than a comparable short haul low-cost cousin with a higher asset utilisation. However, short haul asset utilisation declines as sector length increases beyond an optimum, as does profitability. By combining the core skills of both types of business model profitability and asset utilisation might be maximised for both partners. The service standards of the two models would also likely match the targeted customer segments. But, such a situation would only function if the core skills of both were not hampered. The PAYGHs should not operate with changes to accommodate the Mosaic carrier long-haul operations, since their profitable operations depend on volume and frequency, and not on a long-haul network timetable. Thus, continual aircraft waves delivering passengers for long-haul operations would result in the waiting of some long-haul passengers at the major hubs. Such an operation is termed ´a rolling hub´.

PAYGH carriers might also expect the adverse industrial reaction of flight and cabin crew unions who generally suffer inferior pay and conditions over their Mosaic carrier colleagues. A merger between a PAYGH and a Mosaic carrier would likely create scale to reduce unit costs and unit fuel consumption (Ryerson & Kim, 2014), but the differential between employment contracts would remain until renegotiation with potential industrial relations strife. Additionally, the attention of the regulator would likely be raised given the dominance of a large company a major hub with implications for competition and potentially higher fares (Bieger & Wittmer, 2011). A summary of these points is made in Table 64.

Other considerations to be noted are that the Mosaic carrier would enjoy cheaper feeder traffic and a greater simplicity in operations by operating fewer aircraft types with associated cost and administrative benefits. The latter enabling an increased focus on new long-haul technologies which in the short and medium term are likely to be ´drop-in´ through SAFs. Such a cooperative arrangement might be less attractive for PAYGHs as their business model would bear most of the risk of substitution by ground transportation, and the disproportionate burden of new taxes on short-haul services. PAYGH models would also bear all the operational risk of the earlier entry of ehybrid and hydrogen powered technologies over the shorter sectors.

Table 64: Ad/Disadvantages of Value Business Model Cooperation at Major Hubs

STOF Force	Advantage Mosaic Carrier	Advantage Pay as you go Hopper	Disadvantage Mosaic Carrier	Disadvantage Pay as you go Hopper
Service	Service product convergence on short-haul	Service product convergence on short-haul	Cost of complexity of non-standard service	Cost of complexity of non-standard service
Technological	Fewer aircraft types with less complexity	Remain with few aircraft types		Bear risk of new the ehybrid and H2 aircraft types
Operational	Simpler operational focus long-haul	Operational focus on short-haul in waves maximising efficiencies	Disruption of crew unions for a combined operation	Crew unions seek comparable conditions to partners
Operational		Move to higher yield core EU hubs		Lose dominance over secondary airports
Operational	Block LCLH models at key hubs		Lose control over own network, increased interdependence	Lose control over own network, increased interdependence
Operational			Potential longer passenger waits at major hubs	Possible damage to short-haul productivity.
Financial	Cost effective short-haul feed	Lower direct competition increases passenger numbers/margin	Bear risk of premium and frequent flyer taxes	Bear risk of short-haul emissions taxes
Financial	Size leverage in negotiations	Size leverage in negotiations	Regulator requests hub slots	Regulator requests hub slots
Financial	No threat of rail substitutes		Increased complexity of rail/air/road partnerships	Bear threat of rail substitutes

It is likely the regulator will request that both partners give up key airport hub slots if such a cooperation were allowed to enable the entry of start-ups and LCLH models and to prevent monopoly pricing. Such cooperative models then might limit their own potential growth.

8.3.2.3 Limitations of the MLP, STOF and Business Model Innovation Construct

The following section critically analyses the concepts used in the thesis, particularly with regard to their use in achieving sustainability transitions. The benefits of linking three conceptual models together are that they provide a direct link between the forces generated by the industry transition (MLP) to the forces on the organisation (STOF) and then to elements of the company business model canvas (Osterwalder & Pigneur, 2009). Thus, the creation of sustainable value might be addressed in repeatable, logical and workable two-stage process (MLP to STOF to Business Model Innovation). Such a methodology maybe of value wherever the MLP is regarded as a suitable framework for analysing industry transition, and I believe when the regulator has a dominant role (Geels, 2018; Roberts & Geels, 2019). The STOF forces from the MLP represent stresses on the traditional divisions of a company, and pressures on the business model promote the redesign and interlinking of existing business processes whether internally and with partners. A more complex business model framework can reflect a more complex business model, but even this might not capture sufficient complexity. The simplicity of my model is an attractive proposition, but may not be broadly applicable.

The MLP model does not link the airline end user (of technology) directly to the developments in technology. The MLP implies that technology innovation and commercial development in the TN enters the STR and through a process of selection become adopted in the STL. This bypasses the collaboration between the end user in the airline and the technology developers who certainly interact to exchange real-world experiences in developing successive and improved generations of products. In the airline industry, developments in new technologies do not emerge in isolation in the niche they are modified in the landscape before purchase, adoption and operational service. Airline cash resources, management willingness and the risk profile of decision makers will determine the rate of the development and market acceptance of new technology. Complex internal and external trade-offs are involved. The early airline adopters of new technology in aircraft and engines have repeatedly suffered from the high risks of entry into service, often resulting in operational disruption (or worse), even if there were some initial price discounts. In which case the real competitive advantage in introducing new technology is not clear in the short term. Notable recent industry cases include the Boeing B787 (Carrillo et al., 2016), Boeing 737MAX (FAA, 2019) and Bombardier C Series/Airbus A220 (Hollinger, 2020), and this was with the adoption of incremental improvements using existing combustion technologies. Breakthrough technologies in aerodynamics and combustion will inevitably involve greater risk plus burdensome parallel back-up solutions.

The timing and sequencing of these complex, risky decisions will determine the future of individual companies and the industry. There is an implicit assumption made that the actors in all three dimensions of the MLP are equipped with the knowledge, skills, information, resources and the political ability to make positive and advantageous decisions at each stage in the industry transition process, and that adverse or vested interests do not prevail at any stage. The skill of the regulator was brought into question in the grey literature and during interview. It is also likely that the largest airlines with the greatest resources will have the most skilled decision-making personnel, and interviews with key officials suggest significant risk here, particularly to the smaller players.

The STOF model links well to the MLP reflecting the forces acting on the company. Criticisms of the STOF model are, that while linking well to the MLP, it too links awkwardly to the business model in the aspect of technology. A weak link from technology to business models is seen through the impact on key operational processes and in the cost structure. The multiple outcomes of the adoption of new and complex technologies on existing systems and airline organisations are too difficult to predict, even if mitigated by mixed and parallel running with old technologies, and even if the most skilled personnel are involved in decision making. Additionally, the choice of technology from a series of available technology options and generations over time, the risk of early adoption and their onward effects on operations, finance and passenger services are too difficult to manifest within business models. In such a situation, the use of a ´parcel´ approach can offer organisational learning here. The effect of the regulator transfers through the STOF model and is seen in the aspects of finance costs, key partners and in key operational activities.

In Osterwalder & Pigneur´s (2009) nine-point version, the main concern is that the consequences of technology on business models are insufficiently reflected. The BMI assumes a high level of certainty about the effects of the choice of company strategy on the components of the organisation. What cannot be captured with confidence is the outcome of the sequential series of actions by parties that must occur as new technologies are adopted and simultaneously with multiple partners, including passengers. Partners are often oligopoly or monopoly technology or service providers with little room for smaller and medium size airlines to manoeuvre. A business model innovation skeleton is also unsuitable for businesses operating in multiple geographies with adjustments for a dependence on local airport operations across an airline network. It struggles to cover the complexity of companies both working with, and against some competitors in different markets and in different disciplines, for example in direct competition in one market, but also in cooperation in a limited geographical codeshare, in a global alliance, in airport terminal sharing (or not) and in cooperation with competitors in a lobbying group (Boddewyn & Brewer, 1994; Shaffer et al., 2000).

I believe an MLP/STOF/BMI construct has potential as useable framework for sustainable business transformations for simpler, nationally regulated companies with a higher level of revenue and cost stability and entrenched new technology solutions - or companies designed as start-ups. It is not ideal for a complex global unpredictable industry with multiple partners facing an additional set of ambiguous parameters and undergoing a decades long sustainability transition. Fast moving environments with multiple competitors, the regulator and airports as partners, plus the standardisation, development and the adoption of new technologies are not suitable for the use of this framework. For the airline industry, the open-ended design of a business model ´parcel´ with a focus on passengers, key technologies, research and operational partners, and with a higher level of intelligent support might prove instructive. An autonomous operating unit open to evolving with new certified technologies could offer the greatest chance of clearly understanding a successful sustainable technology solution for the industry.

8.3.3 Practical Implications for Aviation Policy and Airline Management

Proponents of the MLP argue that an alignment in the three dimensions of the model create a window of opportunity that enables industry transition (Geels, 2018). This is a predictive capability in that without alignment and a clear sequencing it is difficult for technological innovations to be widely adopted. This point is especially important for a global multi location industry operating using a global infrastructure platform and using globally agreed technology platforms and industry standards. An industry that needs to be globally regulated in terms of greenhouse gas emissions, makes this alignment more complex.

Although airlines can lobby for legislation and for financial support during crises, they are largely unable to influence the progress and development of new technology since they are end users, but it is clear that airlines are consulted during the design process by manufacturers. For practical purposes, this leaves airlines in the position of, i. increasing and targeting their lobbying and working with industry partners and, ii. in a constant re-evaluation of the business model and the energy efficiency of their operations.

Providers of technology will only deliver incremental improvements in existing technologies without some de-risking of the commercial environment. Technology providers will thus, i. adopt low risk investment behaviour or risk sharing and, ii. seek investment security through the promotion and adoption of industry standards and platforms.

The regulator, situated between technology providers and airlines needs to settle a global regulatory solution and timetable with airlines, and only when this is achieved, can they incentivise and support a market in alternative aerospace technologies. I present my research derived agenda as a practical and policy contribution for industry transformation in Figure 25. The figure indicates the recommended major activities at each level of the MLP over a short-, medium- and long-term timescale.

In the framework proposed in Figure 25, the focus of airlines in the STL should be in the near term to positively manage the movement in changing passenger attitudes and consumer practises (Dichter et al., 2020), together with presenting a positive opportunity to investors. In the medium-term activities are likely to focus on facilitating industry transformation and competition by managing the regulatory relationship, and beginning to develop new business models and networks with partners (highlighted in green). In the longer-term the continual review of performance will lead airlines to adjust their BMI activities at regular intervals during transition.

In the STR in Figure 25, the focus of the regulator should be initially to lead activities on, structuring industry transformation, developing industry standards, managing fair competition and ensuring continuing confidence amongst the public and investors. Different models of capitalism in Europe will direct windows of opportunity likely leading to a staggered industry transition (Lane & Wood, 2009; Wood & Wright, 2014; Barry & Nienhauser, 2010). In the medium term the regulators central focus should be on implementing a ´fuel escalator´ type mechanism and driving investment into technology development in the TN. Requiring airlines to mandate to use (say) an incremental 20% renewable fuel per decade or equivalent, would be effective in completing industry decarbonisation over approximately 50 years - in comparison to CORSIA which has no limit or cap on emissions. This is a ´pull´ type mechanism. Alternatively, an escalating price-based ´push´ type mechanism (including kerosene and carbon taxes) would make oil sourced fuels increasingly unattractive and encourage the switch to renewables. Without such a mechanism I believe significant progress towards industry decarbonisation will not be achieved. CORSIA has no mechanism that ensures a year-on-year increase in the effective price of kerosene or that its use is phased out. Over the longer term the regulator´s focus should be in sequencing industry transition with a review and updating of the regulatory pathway.

In the TN in Figure 25, the focus for the providers of technology should in the short term be, on building investments in intellectual property and reducing investment risk. Medium-term activities should centre around research priorities and building industrial scale for airline use. Over the long-term, activities should focus on ensuring energy security and an ongoing review of research priorities.

Objective	**Industry Agreement**	**Regulatory Agreement**	**Tip balance of risk to reward**
Timescale / MLP Perspective	**Socio Technical Landscape - Airlines**	**Socio Technical Regime - Regulator, Airlines**	**TN - Technology Supplier, Regulator**
Short Term Actions (0-5 years)	A1. Ensuring passenger and investor confidence in airlines	B1. Structure industry transformation and competition	C1. Building investment in Intellectual Property and system innovation
	A2. Changing consumer practises	B2. UNFCCC/ICAO fora lead agreement and coordinate regulators	C2. Sharing investment risk and reward
		B3. Define global industry standards, specification	C3. Open source solutions, industry standards, accept regulatory pathway
		B4. Ensure passenger and investor confidence with unbroken investment in the industry	
Medium Term Actions (5-10 years)	A3. Facilitate industry transformation and competition through agreement	B5. Implement 'fuel escalator´ mechamsim and build renewable fuel market and infrastructure	C4. Set research priorities, increase speed to market and spread knowledge
	A4. IATA industry forum generates industry unity on energy, roadmaps	B6. Drive incentives for new technology, penalties for old technology, compliance timetables	C5. Building scale
	A5. Large airlines lead policy process with small exemptions for some players	B7. Communication to public and investors	C6. Develop new financing models with risk sharing
	A6. Managing the competitor and regulator relationship		C7. Blending adjacent systems and technologies
	A7. Building new Business Models and transport networks		
Long Term Actions (over 10 years)	A8. Review progress and update business model activities	B8. Sequencing industry transition processes, supporting hubs and infrastructure	C8. Ensure energy security with multiple suppliers and technologies
		B9. Review progress and update regulatory pathway	C9. Review progress and update research development pathway

Figure 25: Policy and Agenda Framework for Airline Industry Transformation

8.3.4 Transferable Recommendations for Practise and Policy

Findings from this thesis suggest there may be general lessons that might be applied to other industries that are subject to potential 'carbon lock-in'. I have grouped these into three major categories: i. technology transfer, ii. gaining global agreements and iii. the role of business models in sustainability transitions (objective 5, Table 61).

8.3.4.1 Technology Transfer for Industry Transformation

Access to new technologies unencumbered by private commercial interests is necessary for widespread technology transfer and the development of industry standards and certification. Technology transfer should be facilitated by the state to the point of commercial viability, or it is unlikely that any industry transformation will occur since the commercial risk is likely to be too high. I believe existing anti-trust legislation should be reviewed if it is a barrier to the necessary development of breakthrough technologies with a higher system end value. The state retaining a part equity or patent interest in new technology may provide a source of public income to recover these early and high-risk investments and avoid the necessity to increase corporate debt. Early standard setting, the separation and prioritisation of technology streams seem to facilitate quicker technology development.

Roberts and Geels (2019) maintain neoliberal policies do not generally support complex industry transformation. For these authors, industry transformation requires an interventionist approach with a major role for policymakers in shaping markets, stimulating innovation, launching larger missions, building infrastructure, increased regulation and perhaps part ownership. In the case of this study, airline managers were quite open that without the intervention of the regulator, industry transformation would not occur with any rapidity, nor would be much incentive to alter current practices. In such a case airline decision making is reduced to the most financially advantage course of action and with no regard to environmental goals.

Building knowledge networks in the TN is vital to speed of development of technology and technological transfer. It facilitates the generation of new ideas and assists with the filtering of the successful ones to the next level of development. I believe new models for financing technology developments can reduce risk for the providers of technology. The research indicates such models may involve bringing forward the cash flows from end users, and using multiple partners including a state interest. In the case of partnerships between the state and the commercial aviation industry, Molas-Gallart (1997), King & Nowack (2003) and Eriksson (2010) cite successful strategic collaborations in engineering, aircraft manufacture and in navigation and information technologies.

Multiple global certification centres for new these technologies prevent bottlenecks hindering market adoption. The contribution and adoption of new technology is summarised by Hall & Khan (2003) and only becomes effective if the new technology becomes widely accepted and adopted. The acceptance and the diffusion of technology results from a series of individual decisions by (mainly large) companies to begin to use it. These decisions are the result of a comparison of the uncertain benefits/costs of the new invention, set against projections the status quo. The speed of adoption is dependent on the clarity with which this decision can be viewed and capturing above average profits (McGrath, 2010). The research shows that the regulator should facilitate the transparency of this decision, but it will still require plentiful financial and skills-based resources.

8.3.4.2 Gaining Global Agreements

Global industries require global agreements for fair competition, but global agreements may also be used as a justification not to move from the current position in a regional setting. My research indicates that the pressure of national and local regulation should probably be maintained in the search for any global agreement to prevent ‘agreement drag’. Barrett (2006) notes that the adoption of technology in a setting of ‘anarchic international relations’ as much more problematic than in a single country. Forces that undermine climate change protocols can only be overcome by offering technology with superior and increasing net returns to existing technologies. The approach to treaty design then should be strategic to encourage the adoption of technology through superior returns. This strategic approach to treaty design should for example include the collective financing of R&D, incentives (taxes, quotas or permits) for adopting breakthrough technologies and even if they are not adopted (non-convex) by the market due to 'technology lock-in'. 'Non convex' costing is the term used to describe the event that new technology or practises are not adopted even when the economic rationale is that they should be (Hoel, 1998), so called 'market failure' (Kuttner, 1997).

The state or regulator should provide long term roadmaps to facilitate commercial planning with early standard setting and open information platforms. I believe the facilitation of new markets by the regulator is a legitimate role, as long-term plans by organisations are best made with a higher level of price certainty. Building networks of influence in the STR is vital to speed of industry agreement concerning regulation and timescales. The leaders of change will be the largest organisations with influence (Wills, 2013). Trade organisations are obvious candidates for industry representation with the regulator. There is a real danger however, that industry transformation favours large companies with knowledge, influence, intellectual expertise and strong cash flow and will be used to reduce competition. Small companies and new entrants should be able to compete fairly, with the regulator's job to prevent large players from having dominance, but not to support companies that fail due to poor management.

8.3.4.3 The Role of Business Models in Sustainability Transitions

Two conclusions concerning business models resulted from the study, firstly that where long complex multiple technology transfers are instrumental in change, business model innovation is secondary and a reaction to STOF forces arising from the MLP, they do not drive industry transition. Secondly that company business model innovation assists system transition and is an important part of the whole process. Isolating new technologies in ´parcels´ is the key to understanding their financial and operational contribution in designing new sustainable business models.

8.4 Conclusions

The triangulation of the quantitative and qualitative studies from this thesis indicate that airlines react to changes in the MLP through STOF forces, but it is difficult to easily articulate the timing, scale and innovation of technological change into airline business models. The complexity of the sequencing and partnership activities displays a dependence that is out of airline management´s direct control. Additionally, a series of interim and mixed technology stages means accepting the operational inefficiencies of running possibly several different technology-based models. This does not mean business model innovation is of no value in sustainability transitions, it locks in system change and supports a system industry transition, but it does not drive it. A proposal for the responsibilities and timing of activities of the parties involved in an airline industry transition is a valuable fallout of the study. The final chapter discusses the implications of the thesis findings for air transport in a post COVID world.

Chapter 9 Conclusions

9.1 Introduction

This study contributes to the most important issue facing the global economy this century – a fourth energy transition away from fossil fuels to a low carbon energy-economy. Although airlines are currently a relatively small consumer of fossil fuels in global terms, they will be one of the last industries to decarbonise, and before this occurs, aviation is forecast to experience significant growth. Klauber & Toussie (2019) indicate that emissions from the industry will reach between 3-9% of global emissions by 2050 and the CORSIA targets will not be met. Total European aviation emissions have risen 16% since 2005 (EASA, EEA & Eurocontrol, 2019). The proportion of global greenhouse gases that airlines emit will rise both in absolute terms and as a percentage of global emissions, as other industries decarbonise before them. This concluding chapter summarises the findings, limitations and delimitations of the research and presents a future research agenda in line with the aims in Table 61.

9.2 Summarising the Research Findings

During Phase 3 of this study the question arose 'what is air travel for`? …are airlines part of a connected series of transport offers in a network of road, rail and air transport providers - or do they stand alone divorced from other transport solutions? Because a reduction in carbon emissions is an essential goal of European states, then I believe airlines should become part of a wider network of transportation services that maximises fuel and carbon efficiency and involves a coordinated effort on the part of all mobility services (Figure 25, page 277).

9.2.1 A Quantitative Study of the Performance of Europe's Airlines

The historic quantitative study indicates that critical success factors during the airline industry crises have focussed on financial management, and scale with operational efficiency. There was no indication that service quality or ownership was a barrier to generating the strongest operating cash flow. The fragility of current airline business models was again highlighted by IATA (2020) during the Coronavirus pandemic indicating the smallest and most indebted airlines are the most severely affected. The critical success factors identified signal that the European airline oligopoly will continue and possibly strengthen.

9.2.2 Understanding the Challenges Facing the European Industry

Substantially increased levels of investment in the industry are needed to make the transfer to low carbon operations but many European carriers currently struggle to be operating cash positive. More effective price competition from rail will ensure this state of affairs will persist. Emissions taxes levied on airlines will likely make the immediate situation worse but could prompt an energy transition using the price or mandate mechanisms discussed in Chapter 8. The adoption of new technology by airlines is hindered by long aircraft service lives, long certification times and manufacturers currently focusing on low-risk incremental innovation. The cost of fuel and regulation will be the major determinants of air fares and airline performance (Vespermann & Wittmer, 2011; Romera & Van Asselt, 2015). With the previously agreed baseline for CORSIA having been disrupted by the pandemic, and with the increased debt obligations that results from airline rescue packages, European industry transformation looks an even greater challenge than when I began this study.

9.2.3 Recommendations for a Sustainable Airline Industry

Serious issues face the industry but airlines are not simply at the mercy of changes in the MLP. I believe the management consultants and academics understood this point to a higher degree. The managers at European airlines interviewed do not propose to address the problem of the incorporation of technological innovation or of other indirect competitive threats from other transport modes to their industry with any speed. There is a belief that slow progress can be made in SAF and in aircraft technologies, and carbon sinking/capture will be the bridge to a cleaner industry.

The main option airlines have that is under their control, is to address the design, structure and connectivity of their business model. Whilst this will not transform the industry, it is important in making progress to a carbon neutral industry. The four broad business models outlined in Chapter 7 adopt the approaches long established by Michael Porter (1980). Thus, two business models address consumers interested primarily in the **cost** of their travel, and two for customers prepared **to pay for convenience** by using major hub connectivity, for comfort, additional services or for tailored travel. It is in airlines long term interest to support enthusiastically industry transformation with MLP partners since it will enable them to operate in the most carbon efficient manner and stabilise their operating cash flow. Thus, airlines can address the challenges facing them in two further ways: first, by in engaging with ICAO the global regulator and the EU-ETS the European regulator to agree an industry timetable for a full transfer to renewable fuels through a price or mandate ´escalator´ mechanism; and second, by facilitating industry co-operation to de-risk the investment environment.

9.2.4 Identifying Barriers to Industry Transformation using the MLP

In the STL the weak and volatile financial performance of airlines make it difficult to step up investments in fleet renewal and technological change. It is also likely that the downward pressure on airline margins will be exacerbated by lower levels of travel post Coronavirus to 2024 (IATA, 2020). There is a real risk that the continuing weak performance of the European air transport sector prevents major investment in new technologies and that airlines will focus on a continuing reduction in unit emissions (per RPK) rather than on absolute emissions (Dray et al., 2018). Higher air fares would address both limiting passenger growth and absolute emissions growth. The reality is that at present industry traffic forecasts indicating continual growth are unrealistic without using kerosene. However, the uncertainty surrounding the sourcing and cost of oil-based fuels alongside their associated emissions, will lead airlines to diversify their energy sources for energy security, but how quickly?

In the STR the interview findings suggest that driving airline industry energy transition requires incentives and an open regulatory roadmap for long term strategic planning. It is unlikely that industry transformation can be achieved without a global ‘fuel escalator’ mechanism and the creation of a suitably scaled renewable fuel market. There is evidence that price mechanisms alone may spark upward capacity changes and that fuel mandates might be more useful (Beneish & Moore, 1994).

Uncertainty in the development of regulatory and energy related legislation make planning problematic and lead to airlines to adopt slow, low risk behaviour.

The failure of most European airlines to meet their cost of capital over the longer term increases the pressure on mergers or acquisition. Further industry consolidation in Europe is likely, with only a few airlines are regarded by the major credit rating agencies as investment grade propositions (SCOPE, 2017). Oligopolies have implications for PSOs and consumers. A (temporary) return to part state ownership of airlines might offer a pathway to survive crises and jump investment hurdles.

If fuel and emissions related costs are applied fairly to all transport modes to encourage decarbonisation, short haul air traffic will become less competitive in comparison to high-speed rail or road, with a consequent decline of the shortest air sectors. The public acceptance of cheap short haul fares using kerosene is changing. This clearly has implications for ‘hopper’ type business models. Pressure to meet carbon targets is likely to drive innovation in short haul flying. In the medium-term, long haul air travel does not seem under threat in the same way as there is no alternative, but its cost is likely to increase in real terms to better reflect its carbon consequences. The competitive playing field with other transportation types and the price of energy should be used by the regulator to direct the desired outcomes. System, not sector innovation is key (Markard et al., 2020).

In the TN networks of innovation hubs, the state and new technologies will interact with the STR. A substantial increase in central public funding and shareholding to de-risk R&D is necessary. Renewable fuels will not be available in sufficient quantity for twenty years (Soone, 2020). While current generations of biofuels are not practical long term, they offer an interim solution. Using liquid hydrogen fuel will require the redesign of existing technologies (Janic, 2008; Airbus, 2020). New fuels may not be sufficiently energy dense to maintain existing airline networks, but the price and efficiency balance between fossil and renewable fuels is increasingly tipping towards renewables (Appendix 12.6). All new fuels suffer from scale and infrastructure issues. Fracking and new oil sources are either difficult to extract or unsuitable for aviation use and will be short-lived (Maugeri, 2012; Morgan, 2013; Heinberg, 2014). Airlines will continue to require for the near-term high volumes of superior grade oil.

Technological improvements to current aircraft and engine design will only provide slight relief to the oil requirements of airlines and while welcome, are insufficient to be transformative. Short-haul and regional aircraft fleets will likely be the first to move to new types of aircraft and provide essential learning for long-haul operations. New technologies will likely require substantial central funding but taxpayers could be protected with a shareholding, royalties or patent interest.

9.2.5 Reflecting on Sustainable Industry Transitions

This study demonstrates that the MLP, STOF and business models can be linked to develop insights for companies and their suppliers working within a highly regulated sector. After the study, my belief in theoretical transformative models as useful tools in describing complex interrelated processes and bringing this understanding to a wider audience has increased. This belief was reinforced in Phases 3 and 4 of the study when industry officials indicated their understanding was facilitated by the use of models. Their practical use in designing new sustainable airline business models I see as limited. Studies of business model redesign have delivered established change frameworks and some common content. A contribution to theory from this airline study is that a long, complex multiple technology, multiple partner industry transformation involving a global regulator is that the MLP/STOF/BMI combined model is not a transformative solution. As airlines are end users of technology, BMI incorporating new technologies is part of reaching critical mass in industry transformation. Change is most effectively delivered early in the process of redesign with trialling in a ´parcel´ beneficial to reducing complexity and improving transparency. Interdependent partnerships with a requirement for the iterative development and adoption of multiple technologies demand innovative system solutions and not just at the company level.

The major and perhaps unsurprising conclusion is that a tough regulator will be crucial to airlines operating sustainable business models. At a global level this means binding agreements between ICAO and IATA, since the current goal is that the EU ETS will coexist and dovetail with CORSIA (Grote et al., 2014; Strauss & Abnett, 2020). Without EU support CORSIA is likely to fail given the importance of the European market. Should the future developments to CORSIA be unsuccessful in substantially reducing airline emissions (in Europe) then it seems likely that regulatory pressure from the EU ETS would increase. Without regulatory pressure, progress towards a low carbon industry will be very hard to make. Left to its own, the market will not bring about substantial change. The state as industry partner and as a mover seems essential. Such a transformation is certainly achievable, but not without a rise in the real cost of air transport which will be passed onto passengers. There are also new externalities in insurance and public health costs. Most airline passengers are not currently paying for the 'despoliation costs' of their travel (Barbot et al., 2014) - consequently the era of the cheapest airfares, and the availability of flights on the shortest segments within Europe is likely drawing to a close (Graham & Shaw, 2008; Gössling, 2020; Gössling & Humpe, 2020).

The research indicates that airline leaders accept their wider responsibilities towards the environment but are poorly prepared for the major challenges facing their business. The requirements of listed companies for shareholder-returns, growth, and the career aspirations of airline managers restrict initiating complex, risky and costly activities that address the long term. The search for global agreements, together with lobbying, are partly the instruments of delay. There is, however, a contradiction in holding a position of seeking global agreements, whilst believing they may not succeed because others will take advantage of them. The ongoing pressure of unilateral and regional solutions should be maintained as incentives (Wood et al., 2010).

During the latter stages writing this thesis, a novel pandemic severely affected the airline industry. What the pandemic has shown us is the fragility of the networks that support the global population. Human civilisation means that networks in energy, transport, finance, global health, and food production and supply are all connected. Failure in one part of the chain has a complex interdependency. Economic recovery from this point could delay or speed industry transition depending on the path now chosen. This pandemic will pass, but the issue of climate breakdown will remain - with increasing catastrophes expected as disease, adverse weather events, wildfires, floods, crop failure and mass migration (Klein, 2014; Desmet et al., 2015; WHO, 2018; IPBES, 2020; Woodward and Gal, 2020; Ikram et al., 2020; IPCC, 2021). Existing airline business models will be increasingly fragile, and airlines contribute to the spread of pandemic disease (Morand & Walther, 2020). It is likely that the current pandemic will permanently ground many older aircraft, but it is unlikely that total industry emissions will halt their year-on-year increase. Reducing environmental damage is in airlines own long-term self-interest. This crisis has given us a glimpse of what climate breakdown might look like. Transforming the airline industry is more important to the future of the planetary ecosystem than the pain of more expensive fares.

9.3 Limitations of the Study

The limitations are the controllable parameters. The quantitative research took place focused on the twenty largest airlines in Europe with financial results converted to Euro - thus it is weighted to the performance of the larger scheduled services carriers on a single continent, plus any foreign exchange issues that occurred in this period. Although the data sample could have included unlisted and smaller carriers, the time and cost in acquiring non-publicly available information were prohibitive. There was also a risk of inconsistent data over time periods with many smaller airlines having a short trading history of a few years before ceasing trading, entering private ownership or acquisition by a larger group. A follow up study including the financial results of 2020 and 2021 would include further crisis related data but given the seriousness of the industry downturn might be unrepresentative of long-term industry trends. Given that the quantitative and qualitative data were drawn from a European pool, the findings and conclusions may not be applicable to the airline industry outside of Europe given different patterns of airline ownership, state policy and regulatory frameworks. Some conclusions might be applicable for other highly regulated cross border industries requiring needing close multi partner cooperation and undergoing long sustainability transitions (section 8.3.4).

9.4 Delimitations of the Study

Delimitations are the non-controllable parameters. During the quantitative study some of the sampled airlines did not provide consistent year on year data although improving over time, changed reporting currency, merged, changed ownership, and went through restructuring processes. I accept these inconsistent features as part of the study to get the best available data.

Before the study began, I had a list of over 80 contacts for the qualitative and interview stage of the study. Half of these declined to be interviewed, or failed to return or answer multiple telephone calls or emails. As a result, the study omits some key partners and players. However, those I was able to interview are mainly individuals I have met during thirty years employed in the European airline industry, and fortunately many of these hold senior positions. I have attempted to address sample bias by selecting individuals from different functional disciplines. I am also aware that some interview participants did not speak freely and simply presented the views of the companies for whom they work. Several senior individuals interviewed were in the final years of their airline careers and may have supported the status quo despite the promise of anonymity. There is a 30% proportion of individuals from the Lufthansa Group which may weight the opinions in the interview part of the study. Nonetheless, both the network carrier and LCC business models are represented in the data pool. I failed to gain an interview from IAG or Virgin Atlantic representatives despite very good contacts. Several interviewees who declined interviews in a first round accepted in a second, when I had first data of potential interest. I believe the interview rejections were due to my employment with a competitor, and that if I had been a full-time doctoral student, interview access might have been less problematic.

Suppliers were represented by interviews with Airbus and Boeing in aircraft manufacture, and Rolls Royce in aero engine manufacture. However, their industry colleagues Safran-CFM refused an interview. I was fortunate to obtain interviews with several IATA officials representing the airlines, but ICAO officials representing nation states refused invitations explaining that they do not participate in 'speculative research'.

I was able to interview several regulators, academics and industry consultants who I believe spoke without constraints and were generous with their time often far exceeding my expectations. All interviews were completed before the Coronavirus pandemic and this is reflected in the answers given, particularly concerning future industry developments. The writing up of this thesis was completed during the pandemic and prevented further contact with industry officials several of whom have left their previous roles. It is my view that the pandemic will probably set back the successful implementation of airline industry transition, but that the findings remain valuable because the fundamental challenges facing the industry remain unchanged.

9.5 A Research Agenda and Implications for Future Research

Building on the insights and contributions of this thesis as well as addressing some of its limitations may provide significant opportunities for future research in three major fields. Firstly, in a broad understanding of how business model innovation influences sustainable industry transitions in different industries. Secondly, more specifically in understanding how the business remodelling process assimilates new technologies as a central element in industry transition and; thirdly, understanding the need for intervention by the policy maker as an essential driver in a highly regulated industry sustainable transition, such as the (European) airline industry.

This study indicates that mature, globally regulated industries using complex new technologies will likely have different industry transitions than the more locally focused, less regulated and those less dependent on technology for the operation of their business models. The simplicity of, or the disruptive replacement of an existing business model might enable a quicker and more effective sustainability transition than might be expected in the former, as in this study. A first focus on detailing the complexity of the changes required in terms of natural resources consumed, regulation and technology might be instructive.

Secondly, further research is needed into how to articulate the effect of the operation of mixed technologies in the development of new business models. In many cases at least two new technologies need to be operated and potentially integrated during the transition phase. Understanding the systemwide implications of the resistance encountered in some industries or ´transition nullification´ (Wells & Nieuwenhuis, 2012) could provide valuable learning for other companies and industries in transition. More research needs to be done to understand the impact of technology transfers to business model innovation and the action of relevant agents and partners to contribute to the growth of innovative, competitive and sustainable organisations.

Thirdly, the most effective action of the regulator in funding in the facilitation of technology development. This study has highlighted that without regulator intervention, industry transition cannot be achieved, but with the possibility of a ´low knowledge´ regulator and limited investment funding available, implementing the most time and cost-effective course of action could easily falter. Current research into state support for renewable energy and related technology research in universities, and with commercial R&D laboratories could prove useful for pointers to the most efficient use of consumer and taxpayer funds to support innovation (Bozeman, 2000; Dectera et al., 2007; Schacht, 2010. Mazzucato (2018) has referred to the central role of the policy maker in driving forward industry transition, building coalitions the evaluation of progress and risk sharing as ´mission driven innovation´.

As an extension of this study, further research on future passenger profiles could prove valuable post Coronavirus, as it looks likely that high yield passengers will not return to previous volumes (Larsen et al., 2006; IATA, 2021). A sensitivity analysis of both short haul and long-haul air fares might be modelled based on the latest survey data of passenger acceptance of the level of carbon surcharges and the forecast price of carbon. Estimates puts the average fare increase at an additional 10-30% per passenger (T&E UK, 2021; Curley et al., 2020). However, given the complexity and mathematical modelling involved, such a study would be a significant piece of work and outside the boundaries of this thesis. In a future study the inclusion of more non-financial and technologically orientated metrics might prove beneficial if sufficient quality data, including the crisis years of 2020 and 2021 can be obtained. Including these years would add data on the greatest crisis the industry has faced post war, and further interviews with a group of technical experts completed after firmer developments in aerospace technology would clearly improve the recommendations.

9.6 Postscript

On 24th February 2022, the Russian Army invaded Ukraine. In the following days the global price of oil began to climb towards 130 USD per barrel (Oilprice.com, 9.3.22) due to fears of an embargo. Both Russian and Ukrainian airspace are closed to European airlines, requiring the longer rerouting of much European air traffic. European and international airspace is now closed to Russian airlines (Scar et al., 2022). Dozens of European flights were cancelled. At the time of writing no quick resolution to the war is expected. This latest international crisis has immediate implications for airlines in four ways: firstly, in rising operational costs, particularly fuel and insurance; secondly, in reduced passenger and cargo demand as a global recession threatens; thirdly, in the difficulty in reaching and maintaining international agreements with a major partner (Russia) and; fourthly, in the political use of airspace (Alcock, 2012). In the short term, the events of 2022 could therefore bring a renewed focus on fossil fuel security, in the longer term it could accelerate measures to reduce the global economic dependence on fossil fuels.

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Chapter 12 Appendices

12.1 Table 65: Survey of Metrics Used to Assess Airline Performance

STOF Perspective	Balanced Scorecard Perspective	Metric	Authors
S/F	Customer	RPK and Revenue per RPK (yield)	Guzhva (2008)
S/F	Customer	Profit per passenger	Sandstrom & Toivanen (2002) Barros & Peypoch (2009) Wu & Liao (2014)
S/O	Customer	Seat Load factor	Caves et al. (1983)
S/F	Customer	Sales per Passenger	Lin (2008)
S	Customer	Passenger retention/loyalty	Rostami et al. (2015) Alidade & Ghasemi (2015)
T/O	Internal Process	Punctuality	Yahaya (2009) Cho & Lee (2011)
T/O	R&D/Learning	Growth in aircraft fleet	Lee et al. (2008) Cebeci & Sezerel (2008) Bentes et al. (2012)
T/O	Internal Process	Flights per fleet type	Lin (2008)
O	Customer	Number of Passengers or seats	Zins (2001) Lin & Hong (2006) Barros & Dieke (2007)
O/T	R&D/Learning	Number of employees	Zins (2001) Wang et al. (2004) Barros & Dieke (2007)
O	R&D/Learning	Staff turnover	Dave & Dave (2012) Bhadra (2009)
O	Internal Process	Sector length	Trethaway (1984)
O	Internal Process	Number of Accidents	Chang & Yeh (2001) Lin et al. (2009)
O	Internal Process	Flights per employee	Wang et al. (2004)
O	Internal Process	Passengers per Employee	Zins (2001) Wang et al. (2004) Barros & Dieke (2007)
F	Finance	Current Ratio (Current Assets/Current Liabilities)	Wang (2008) Teker et al. (2016)
F	Finance	Profit (Growth)	Wang (2008) Bruhlhart et al. (2015) Teker et al. (2016)
F/S	Internal Process	Sales per aircraft	Teker et al. (2016)
F/S	Internal Process	Sales per employee	Wu et al. (2009) Shaverdi et al. (2011) Teker et al. (2016)
F/S	R&D/Learning	Profit per Employee	Noori (2015) Bruhlhart et al. (2015)
F	Finance	Return on Investment	Wang (2008) Yahaya (2009) Panicker & Seshadri (2013)
F	Finance	Return on Assets	Dave & Dave (2012)
F/T	Finance	Fixed Asset Base	Lin (2008)
F	Finance	Debt/Equity Ratio	Feng & Wang (2009) Bigliardi & Dormino (2015) Helleloid et al. (2015)

Table 66: Metrics used for Airline Service Quality

Parameter	Key Features	Examples	Authors
Overall Airline Service Quality	Multidimensional models of service quality	• (2 factor) tangible & intangible • (3 factor) service product, service delivery, and service environment • (5 factor) tangibles, reliability, responsiveness, assurance and empathy • (6 factor) price/value, booking experience, flight schedule, airport service, inflight quality, post landing experience	• Gronroos, (1982) • Rust & Oliver, (1994) • Parasuraman et al., (1988) • Tsafarakis et al., 2017
Safety & Security	High safety record	• Safety policy • Demonstrable management commitment to continuous safety improvement • Customer perception of safety	• Cheng & Yeh, (2004) • Liou, Yen, and Tzeng, (2008) and Chen and Chen, (2012) • Tsaur, Chang, & Yen, (2002) • Gilbert & Wong, (2003)
Punctuality /Timeliness	Punctuality with regard to timetable	• Perception of on time performance • Arrival punctuality & baggage performance • Information provision to passengers	• Rhoades and Waguespack (2004) • Mellat-Parast et al. (2015) • Chen (2008)
Facilities	Facilities provided by the airline	• Cleanliness • Quality of physical environment, appearance • Ease of access	• Aksoy et al., (2003) • De Jager et al., (2012) • Wua & Cheng (2013)
Information Communication Technology	1. Competitive IT infrastructure 2. Expectations of service flexibility	• Ease of booking • Ease of check in, boarding • Control of journey process	• Cheng, Chen, & Chang (2008) • Oyewole et al. (2007) • Grotenhuis et al. (2007) • Martínez Caro & Martínez Garcia, (2007)
Price and Sales Promotions	1. Price 2. Price/Value relationship 3. Other economic incentives 4. Customer perceived value	• Price of ticket considering service offering • free ancillary services • Air Miles (Frequent Flyer programme) • Other gifts (free baggage, amenity kits, free transport to/from airport)	• Mason (2001) • Williams (2005) • Martin-Consuegra et al. (2006) • Aksoy et al. (2003) • Ciernes et al. (2008) • Pi & Huang (2011) • Park et al. (2010)
Airline Service Culture	1. organizational practices, manner and values 2. behaviour of organization and employees	• service recovery • gifts, amenity kits • evidence of care and warmth	• Skinner et al., (2011) • Groonros, (2007) • Babbar & Koufteros, (2008) • Shah & Jain, (2015) • Han & Hwang, (2015)

12.2 Table 67: Classification of Generic types of Biofuel

Generation of Biofuel	Generation 1	Generation 2	Generation 3	Generation 4
Source	1. Crops from arable land	1. Industrial and bio-waste 2. Biomass on arable and non-arable land	1. Fresh and salt water algae with high oil content	1. Genetically manipulated algae and halophytes grown at sea 2. Genetically manipulated microbial culture
Compatible with existing Aerospace Technology	yes	yes	yes	probably after small modifications
Carbon Neutral	no (EU to end production by 2030)	partly, some only	yes	yes
Advantages	1. Technology available 2. Proven in airline use	1. No competition with arable land for food crops 2. Technology available	1. No requirement for fresh water or arable land 2. Valuable waste products	1. No requirement for fresh water or arable land 2. Valuable waste products
Disadvantages	1. Competes with food crops for arable land 2. Needs fresh water 3. Scale-up	1. Difficult to extract 2. Expensive, higher risk 3. Needs fresh water 4. Scale-up	1. High up-front investment costs 2. Scale-up 3. Technology still under development	1. High up-front investment costs 2. Scale-up 3. Technology still under development

Sourced from: Henry (2010); Zilberman et al. (2013); Chen & Khanna (2013); Jovanovic et al. (2015); Yuan et al. (2008); Taylor et al. (2008); Tollefson (2008)

12.3 List of Questions asked to Interview Participants in Round 1

The following questions were asked to all the interviewees who received this question sheet in advance of the interview.

Qualitative Analysis Questions - Christopher Wills

Working PhD Thesis title – 'Towards a Sustainable Airline Business Model – addressing the forces impacting on European based Airlines in a low carbon world'

Thank you for consenting to take part today.

I will be recording this conversation and making notes to help with the analysis after the event. I have 15 questions to ask you in the next 45 minutes.

Would you like a copy of the transcript afterwards?

Do I have your permission to quote you, or would you prefer this interview is anonymous and not attributed? Are you speaking as an individual or on behalf of the company?

I will be sending you a consent form to fill in if you could return this to me signed please.

Markets

1. *What do you think are the major causes of the lack of profitability in the European airline industry over the last 15 years? Are current business models fit for purpose?*
2. *What do you see are the main competitive issues facing the industry in the next two decades?*
3. *How do you see the European air transport market developing after 2030?*
4. *How might the lack of historic profits for reinvestment in sustainability, new aircraft and infrastructure be addressed by the industry?*

Technology

5. *What are the key technological problems facing the airline industry in the next two decades?*
6. *What problems for airlines are associated with fuel and emissions prices? How long do you think it will take the industry to transfer to alternative fuels and what*

fuels are most likely to replace oil? What do you see as the practical problems of this?

7. *Who will/should develop and pay for the new technologies for the industry? (Reference: aircraft, engines, fuel, infrastructure, digitalisation)*

Non Market & Public Value

8. *What regulatory pressures face the European airline industry in the next 20 years? How will airlines address them?*
9. *What value does the airline industry offer to the public, the economy, for society and the environment? What value does the industry create (positive externalities)?*
10. *What role should the state play in the airline industry of the future? For example in regulation, assisting with the energy transformation of the industry, infrastructure provision or guaranteeing continued operations if airlines become uneconomic.*
11. *Do you think airlines are obliged to behave responsibly with regard to the problems facing the planet in terms of climate change, addressing finite global resources in terms of raw materials, energy and food. Why/Why not?*

Organisation

12. *How might successful airlines be structured in twenty years?*
13. *Do you envisage more vertical or horizontal integration within the industry to share the industry profits for the benefit of all those in the value chain? How might this be achieved?*
14. *Do you see a role in the future for state/private sector hybrid airline organisations such as Private Public Partnerships or Public Finance Initiatives. What kinds of other mixed models or industry coalitions might be necessary to solve industry problems?*
15. *What types and features of airline business models are likely to be operating in the industry and what information is necessary facilitate new business model design? Reference: Customer segment, value proposition, sales channel, customer*

relationship, revenue stream, cost structure, key resources, key activities, key partnerships

Is there anything you would like to add that you have not stated? May I contact you again to in there is something I am not clear on?

Thank you very much for your time.

Christopher Allen Wills
PhD Student 9611557
Warwick Business School, University of Warwick, UK

12.4 List of Questions asked to Interview Participants in Round 2

The following ten questions were asked to all the interviewees who received this question sheet in advance of the interview.

1. *Are these four business models realistic in your view, feedback, thoughts, information, considerations?*
2. *Can other models exist in niches say Icelandair, Finnair, regional models?*
3. *How do you think the regulator will react to the ongoing very cheap fares from very low cost carriers and the low cost long-haul carriers?*
4. *How do you think the regulator will act coming forward in relation to not meeting industry emissions targets as seems very likely?*
5. *Do you think that airlines/regulator would accept a 'kerosene+ price escalator' in return for financial assistance to adopt new technologies more quickly.*
6. *How can airlines address their carbon emissions and decouple their connectivity from emissions in new ways as the IATA targets 2020 and 2050 will not be met?*
7. *What is the realism of electric aircraft on short haul by 2035-2040 and how far has battery technology got to take this on?*
8. *Are drop in fuels and modular technology part of a life cycle shortening for the industry in the near and medium term?*
9. *Do airlines stand alone or are they part of an integrated transport system and what implications does this have for ownership?*
10. *Can you comment on the recommendations for the industry I have made as attached for feasibility?*

Is there anything you would like to add that you have not stated? May I contact you again to in there is something I am not clear on? Thank you for your time.

Christopher Allen Wills

PhD Student 9611557

Warwick Business School, University of Warwick, UK

12.5 Proposed Timetable for Airline Industry Decarbonisation

aircraft type longhaul																					pilotless cargo aircraft longhaul										
aircraft type longhaul																geared fan engine for longhaul															
aircraft type longhaul											current technology using increasing kerosene biofuel mixes																100% non oil fuels post 2050				
aircraft type longhaul	current technology using kerosene																										100% non oil fuels post 2050				
																										single pilot aircraft shorthaul					
aircraft type shorthaul																					batteries used for internal aircraft power										
aircraft type shorthaul																		introduction shorthaul hybrid aircraft													
aircraft type shorthaul											current technology using increasing kerosene biofuel mixes																100% non oil fuels post 2050				
aircraft type shorthaul	current technology using kerosene																										100% non oil fuels post 2050				
emissions caps and charges ICAO	ICAO Stage 1 CORSIA voluntary (all EU incl.)							ICAO Stage 2 CORSIA with 90% global FTKs included									ICAO replacement global emissions agreement														
emissions caps and charges EU ETS	Phase 4 ETS (31 states)						ETS global review																								
fuel renewable																Scale up of drop-in synthetic fuels															
fuel renewable											Generation 1 & 2 drop-in biofuels										Generation 3 & 4 biofuels, scale-up of halophytes										
fuel oil	continued use of kerosene with other industries decarbonising first																														
Year	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**

Figure 26: Proposed Timeline Airline Industry Transformation to New Technology Fuels and Aircraft 2020 to 2050

12.6 Pre-COVID19 Crisis Airline Fuel, Energy and Emissions Prognoses

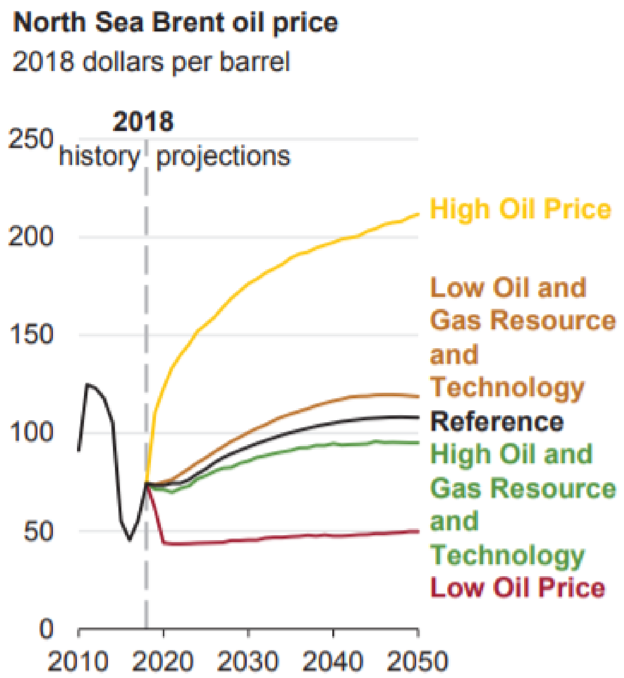


Figure 27: Brent Crude Oil Price Forecast in 2018 USD

Source: EIA (2019:15)

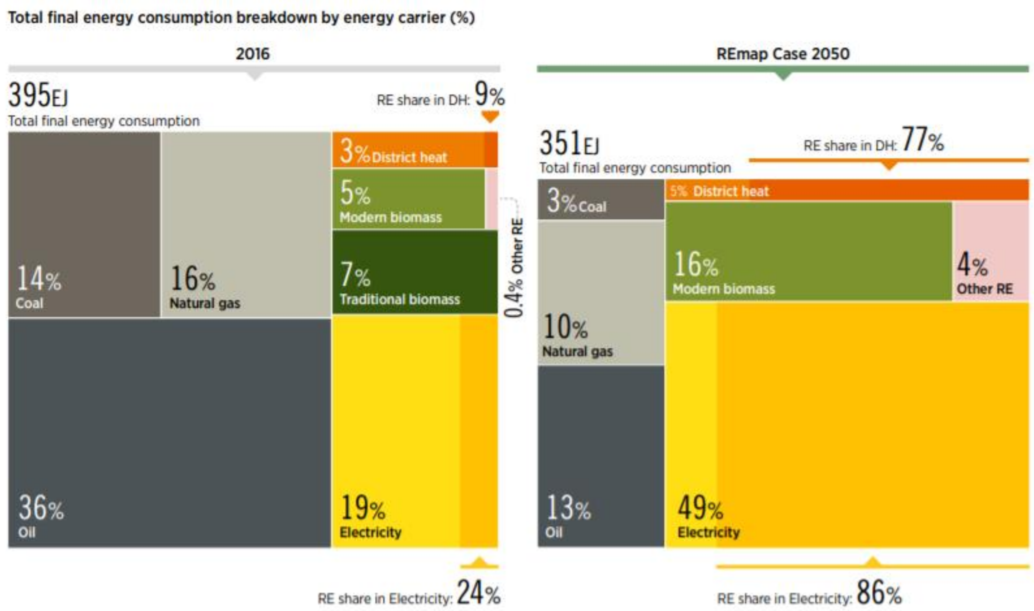
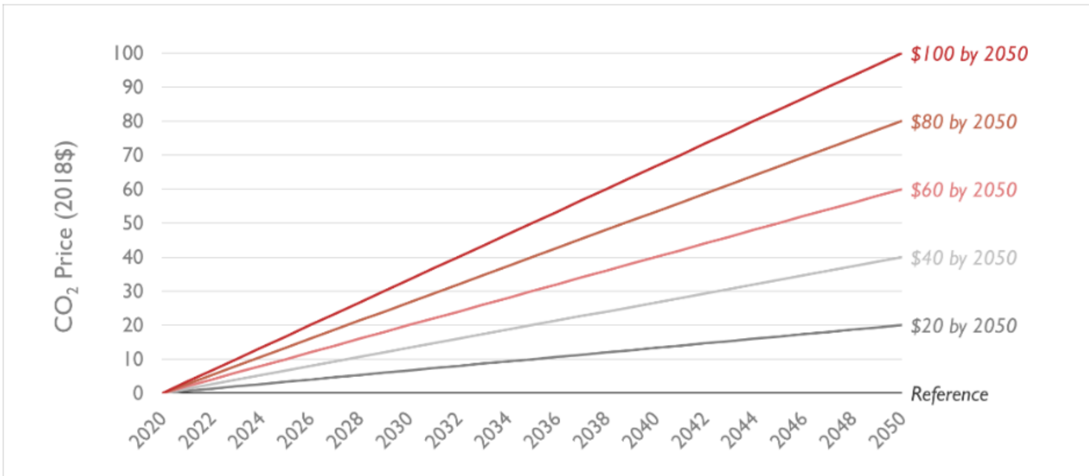


Figure 28: World Energy Consumption by Fuel type 2016 and 2050

Source: IRENA (2019:29)



By 2050, our Reference case (featuring no carbon price) sees 36 percent less fossil generation and 278 percent more renewable generation (2 TWh) compared to estimated 2020 levels. This represents a 331 percent increase in U.S. renewable capacity, driven purely by reasonable renewable cost assumptions, even without a CO_2 price. In our highest-price case, at $100 per short ton, renewable generation is 423 percent higher (3 TWh) than 2020 levels, requiring a 511 percent renewable capacity increase. Coal generation drops steadily across our scenarios—in line with higher and higher CO_2 prices—and is completely phased out by 2050 in every scenario featuring a CO_2 price above $60 per short ton. In our $100 by 2050 scenario, fossil generation in 2050 is 73 percent lower than 2020 levels.

Figure 29: Carbon Forecasts in USD per Tonne of CO2 (one ton of kerosene produces 3.15 tons of CO2).

Source: Peluso/Synapse Energy Consulting (2018:1)

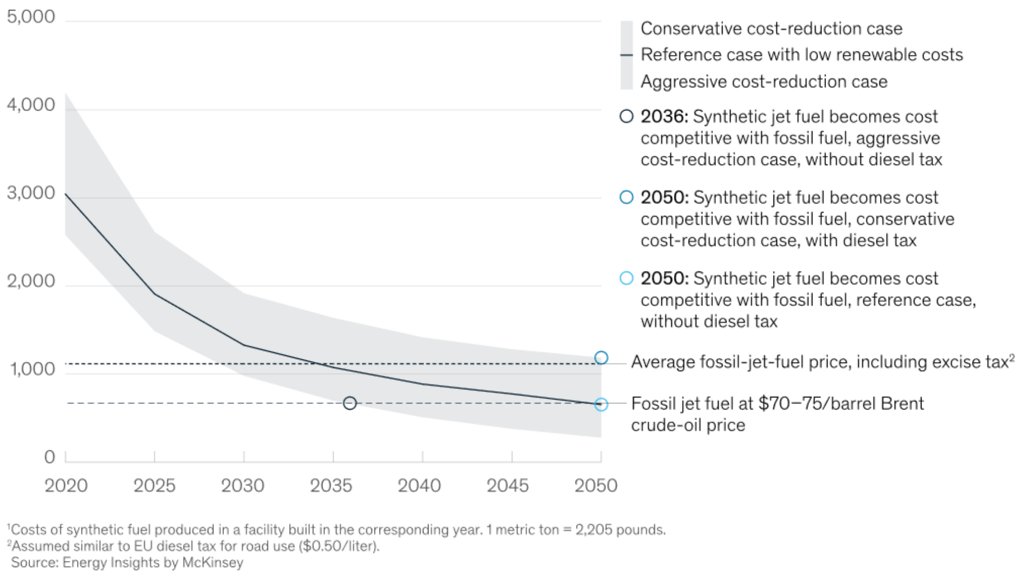


Figure 30: Forecast Cost of Synthetic Jet Fuel Production, $/metric ton

Source: Dichter et al. (2020:8)

12.7 Projected Aircraft Deliveries by Market

Table 68: Aircraft Delivery Market 2038 by Region

Region	Airbus 2019-2038	% of Total	Boeing 2019-2038	% of Total
Africa	1,270	3	1,160	3
Asia Pacific	16,540	42	17,390	39
Central Asia	1,540	4	1,280	3
Europe	7,540	19	8,990	20
Latin America	2,700	7	2,960	7
Middle East	3,240	8	3,130	7
North America	6,380	17	9,130	21
Total Deliveries	**39,210**	**100**	**44,040**	**100**
Total Global Fleet			**50,660**	

Source: Airbus Corporation (2019); Boeing Corporation (2019)

Table 69: Aircraft Delivery by Aircraft type 2038

Region	Airbus 2019-2038	Boeing 2019-2038
Regional	1,550	2,240
Narrow Body	28,930	32,420
Wide Body	7,880	8,340
Freighter	n.a.	1,040
Total	**38,360**	**44,040**

Source: Airbus Corporation (2019); Boeing Corporation (2019)

12.8 Table 70: Testing of the Control Variables with Dependent Variable EBIT

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	330,0329	692,3810	0,4800	0,6342	.
2000	75,3876	115,8734	0,6500	0,5162	3,2023
2001	31,6427	105,8719	0,3000	0,7654	2,6734
2002	100,0140	104,4654	0,9600	0,3397	5,1403
2003	80,3053	97,6101	0,8200	0,4118	5,9330
2004	110,2988	89,2054	1,2400	0,2180	4,9553
2005	105,0838	82,0320	1,2800	0,2019	5,1932
2006	111,7800	74,4248	1,5000	0,1349	5,0854
2007	139,1360	76,3100	1,8200	0,0700	5,7666
2008	77,9755	75,4063	1,0300	0,3025	6,4404
2009	12,0595	69,6199	0,1700	0,8627	5,8301
2010	42,6453	65,9301	0,6500	0,5186	5,2285
2011	52,6356	66,4652	0,7900	0,4295	5,0036
2012	78,4998	67,1992	1,1700	0,2443	5,1147
2013	81,0374	62,9917	1,2900	0,2000	4,4943
2014	84,7013	57,8325	1,4600	0,1448	3,7883
2015	113,3847	52,9435	2,1400	0,0336	3,1748
2016	14,5820	50,1019	0,2900	0,7714	2,8432
2017	11,3317	50,5179	0,2200	0,8228	2,7098
2018	- 22,8941	46,7538	- 0,4900	0,6250	2,3210
Sales	0,9937	0,0279	35,6000	<,0001	1.104,3997
OPEX	- 0,3632	3,1155	- 0,1200	0,9073	12.711.693,0000
Investing Cash Flow t-1	- 0,0006	0,0155	- 0,0400	0,9686	3,7740
Cost of Fuel	- 0,5804	3,1155	- 0,1900	0,8524	622.319,8700
Non Fuel OPEX	- 0,5997	3,1147	- 0,1900	0,8475	8.021.636,4000
Fixed Asset Base	- 0,0267	0,0142	- 1,8700	0,0625	189,8367
Fleet Size year end	- 0,9444	0,6364	- 1,4800	0,1397	272,4289
Pax Mio	9,2796	3,7626	2,4700	0,0146	302,2026
ASK Mio	- 0,0034	0,0036	- 0,9400	0,3486	2.062,6956
RPK Mio	0,0032	0,0043	0,7600	0,4494	1.950,9122
ave.Employees Mio	- 0,0007	0,0037	- 0,1900	0,8489	305,4219
Free Cash Flow	- 0,0177	0,0151	- 1,1700	0,2433	2,1437
>50% State owned	- 13,8940	104,5548	- 0,1300	0,8944	45,8763
Listed	9,3116	94,4522	0,1000	0,9216	37,9613
Private	-	-	.	.	-
LCC	- 61,4427	60,0892	- 1,0200	0,3080	13,2611
Network	-	-	.	.	-
LargeNet/Mixed	82,8916	73,5814	1,1300	0,2615	24,6377
Small Network	-	-	.	.	-
RASK	-18.661,0400	7.256,3360	- 2,5700	0,0110*	502,0000
CASK	-19.478,6400	160.695,5000	- 0,1200	0,9037	276.930,8100
log employees	- 15,1431	118,0880	- 0,1300	0,8981	79,3072
SLF	- 309,3067	846,3374	- 0,3700	0,7152	56,7013
Fuel CASK	26.305,6950	160.856,6000	0,1600	0,8703	10.571,7030
Non Fuel CASK	36.229,4990	160.664,9000	0,2300	0,8219	250.126,8600
RRPK yield	3.456,0710	4.866,3750	0,7100	0,4785	476,9957
Pax/Employees	- 13,8727	160,9765	- 0,0900	0,9314	4,0617
Employees/Fleet	- 0,2486	1,3504	- 0,1800	0,8542	101,9189
Invest/Assetbase	- 74,6630	74,0098	- 1,0100	0,3145	3,0915
Sales/Employees	273,9783	305,8911	0,9000	0,3717	28,7015
Sales/aircraft	0,1546	5,0919	0,0300	0,9758	50,9089
Skytrax	- 46,7367	35,0060	- 1,3400	0,1836	5,8046
Total Liabs Mio	- 0,0066	0,0137	- 0,4900	0,6277	226,4478
Equity Mio	0,0334	0,0156	2,1500	0,0329	24,0747
Labour Costs Mio	- 0,0186	0,0475	- 0,3900	0,6963	236,6585
Ancill. Pax Revenue Mio	- 0,0530	0,0320	- 1,6600	0,0996	14,4236
Cash&Liq y/e	- 0,0007	0,0225	- 0,0300	0,9761	20,4208
Interest bearing Debt Mio	0,0314	0,0098	3,1900	0,0017	19,4137
EBITDA	0,0028	0,0022	1,2500	0,2125	1,4157
Debt/Equity	- 1,3167	0,2867	- 4,5900	<,0001	1,5845
Flights number	- 0,0004	0,0004	- 0,9600	0,3384	209,2396
Unit Labour costs/Employee	- 271,0727	1.025,3160	- 0,2600	0,7918	8,0779
OPEX less Labour and Fuel	-	-	.	.	-
Pax/Flight	- 0,7555	1,2299	- 0,6100	0,5398	20,0884
Ancill. Rev per Pax	- 1,6592	1,7873	- 0,9300	0,3545	11,5113
Network Airports	- 0,2594	0,3344	- 0,7800	0,4390	22,0290
Global Alliance	1,3031	36,2415	0,0400	0,9714	5,7322
Liquidity/Sales	98,9704	97,8082	1,0100	0,3130	4,9057
Net Debt Mio	-	-	.	.	-
NetDebt/EBITDA	0,3217	0,5466	0,5900	0,5569	1,3684
Journey length	0,0665	0,0386	1,7200	0,0866	16,0505
AC Age	4,5848	5,7427	0,8000	0,4257	7,9139
Flights/Destinations	- 0,0616	0,0352	- 1,7500	0,0818	26,7179

12.9 Table 71: Page 1 of 4 Detailed Distinguishing Features of Four Business Models for the European Airline Industry (Osterwalder & Pigneur Framework, 2009)

Parameter	Very Low-Cost Carrier (VLCC) P2P	Value Shorthaul P2P (Hub Feeder)	Value Long-haul P2P	New Network Carrier/Mixed Model
Nomenclature after 'The St Gallen Business Model Navigator'	No frills or frugal	Pay per use	No frills or frugal	Mass Customisation, leveraging customer data
Business Model Description	'Frugal hopper'	'Pay as you go hopper'	'Frugal red eye'	'Mosaic', 'al a Carte'
Key Partners: Operations at Airports	Secondary airports	Secondary airports and major hubs	Major hubs	Major hubs
Key Partners: Industry Manufacturers	Limited direct cooperation with aircraft /engine manufacturers and fuel producers	Close cooperation with aircraft/engine manufacturers and new fuel producers to solve industry issues	Limited direct cooperation with aircraft /engine manufacturers and fuel producers	Close cooperation with aircraft/engine manufacturers and new fuel producers to solve industry issues
Key Partners: External Travel Partners	Cooperation with rail/bus in low density markets	Possible cooperation with long-haul service providers at major hubs	Cooperation with rail/bus/airlines for hub feed	Possible cooperation with value short haul service providers
Key Partners: Knowledge Transfer	Follower not innovator	Seeking inspiration from outside the industry (automotive, rail)	Follower not innovator	Seeking inspiration from outside the industry (automotive, rail)
Key Partners: Sustainability	Not key, accepts industry taxes	Seeking sustainability in Europe through EU/ICAO/IATA/WTO	Not key, accepts industry taxes	Seeking sustainability across the globe though EU/ICAO/IATA/WTO
Key Activities: Ownership, Company size	Privately held, small	Publicly held, listed, large	Privately held, small	Publicly held, listed, large, end of part state ownership
Key Activities: Industry Partnerships	Airlines operate in local isolation	Airlines operate in simple regional cooperative models. Alliance activity possible	Airlines operate in isolation	Airlines operate in complex global cooperation models with subsidiaries and alliance partners
Key Activities: Business Models	Business models designed for city pairs	Business models designed for city pairs, but offer more complex routings	Business models designed for city pairs	Business models designed for more complex routings, tailoring
Key Activities: Aircraft Fleet	Single aircraft type	Single aircraft type	Few aircraft types	Portfolio of businesses with multiple aircraft types
Key Activities: Unit Cost Control	Secondary airports, outsourcing and lower staff costs driving low unit costs	Scale, IT and digitalisation driving change and cost savings	Lower staff costs and outsourcing driving low unit costs	Scale, IT and digitalisation driving change and cost savings, strengthening IT at hubs key to prevent business model failure
Key Activities: Board Incentives	Board remuneration mainly based on financial performance	Pressure for Board remuneration based on financial and non- financial measures	Board remuneration mainly based on financial performance	Pressure for Board remuneration based on financial and non- financial measures
Key Activities: Maintenance, Catering, Ground Services	Outsourcing of major services due small size	Mixed outsourcing and insourcing models (if services can be purchased on the margin)	Outsourcing of major services due small size	Increased insourcing, multiple sourcing, near sourcing, on-shoring combats power of service monopoly providers adds robustness
Key Activities: Company Growth	Organic growth, building scale	Horizontal acquisition and slow organic growth	Organic growth, building scale	Horizontal acquisition and slow organic growth. Vertical integration possible for control

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Parameter	Very Low-Cost Carrier (VLCC) P2P	Value Shorthaul P2P (Hub Feeder)	Value Long-haul P2P	New Network Carrier/Mixed Model
Key Activities: Fleet renewal investments	Smaller scale and lower resources affect product life cycle. More interest rate sensitive as higher debt holding	Increased speed of technological replacement to reduce operating costs, possibly using retrofits. Lower sensitivity to interest rates as stronger cash flow	Smaller scale and lower resources affect product life cycle. More interest rate sensitive as higher debt holding	Increased speed of technological replacement to reduce operating costs, possibly using retrofits. Lower sensitivity to interest rates as stronger cash flow
Key Activities: Key skills required	Cost management a key skill	Value management a key skill	Cost management a key skill	Hub integration as the key skill
Key Activities: Operating Charges	Negotiation on margin pricing. Follower, secondary airports seeking business drives cost base	Addressing passenger compensation and airport security charges globally	Negotiation on margin pricing, follower	Addressing passenger compensation and airport security charges globally
Key Activities: Competitive Advantage	Demand aggregation drives profits	Demand aggregation drives profits	Demand aggregation drives profits	Journey management services drive profits
Key Resources: Fleet Structure	Narrow body with possibly hybrid aircraft. Cost of fuel drives fleet renewal	Narrow body with possibly hybrid aircraft. Cost of fuel drives fleet renewal	Wide and narrow body aircraft using kerosene/biofuel mixes. Cost of fuel drives fleet renewal	Wide and narrow body aircraft using kerosene/biofuel mixes. Cost of fuel drives fleet renewal
Key Resources: Aircraft Fleet	Single aircraft type	Single aircraft type	Few aircraft types	Portfolio of businesses with multiple aircraft types
Key Resources: Customer Data	Open customer data, possibly traded	Protect customer information from third parties to maximise unit revenues	Open customer data, possibly traded	Protect customer information from third parties to maximise unit revenues
Key Resources: Cash Flow	Variablise fixed cost base	Maintain strong cash flow and monitor threats from late booking	Variablise fixed cost base	Maintain strong cash flow and monitor threats from late booking
Key Resources: Employees	Buy in skills from established players	Retention of key skills crucial especially pilots and mechanics lost globally	Buy in skills from established players	Retention of key skills crucial especially pilots and mechanics lost globally
Value Proposition: Industry Partnerships	Less significant	Derisk data sharing with partners, monetise data. Derisk investments in technology	Less significant	Derisk data sharing with partners, monetise data. Derisk investments in technology
Value Proposition: Customer Demand	Create demand with low fares	Fulfil value for money requirements	Create demand with low fares	Serve demand with dedicated travel routings and service
Value Proposition: Investors	New business model higher risk for financiers with higher cost of capital	Established business model lower risk for financiers. Large investments favour large players with strong cash flow. 'Suffers investment drag'	New business model higher risk for financiers with higher cost of capital	Established business model lower risk for financiers. Large investments favour large players with strong cash flow. Suffers 'investment drag'
Value Proposition: Service Level Air / Cabin Complexity	Single class travel	Single class travel but upgraded over VLCC, with pay as you go options	Single class travel	Single class travel in Europe, 2/3/4 class on long-haul, decline of first class, rise of premium economy

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Parameter	Very Low-Cost Carrier (VLCC) P2P	Value Shorthaul P2P (Hub Feeder)	Value Long-haul P2P	New Network Carrier/Mixed Model
Value Proposition: Service Level Ground	No on board and ground services, passenger completes journey transactions	Simple, basic on board and ground services	Simple, basic on board and ground services, passenger completes journey transactions	Simple basic services on short haul, increased onboard and ground services on flights over 10 hours, faster innovation of premium products and services to protect loyalty
Value Proposition: Passenger Fares	Lowest fares possible	Passengers buy to need with unbundled services	Passengers buy to need with unbundled services	Selling innovative mobility packages, with unbundling or microbundling
Value Proposition: Logistics	Point to point short haul services to secondary airports with onward connections	Point to point short haul services from secondary airports and major hubs	Point to point long-haul services from major hubs	Point to point service on short haul from major hubs. No multileg flights on long-haul from major hubs
Value Proposition: Value Curve	Attracting the price driven sector of the market. No loyalty schemes	Attracting the mid market with falling real incomes. Loyalty schemes enhanced	Attracting the mid market with falling real incomes. No loyalty schemes	Decline of first class with sweet revenue spot per sqm in premium economy, attracting older, less tech savvy and wealthier passengers. Loyalty schemes enhanced away from air travel
Value Proposition: Environment	Customers pay for environment and industry change through taxes and fares, with lower taxes on short haul services (due hybrid aircraft)	Customers pay for environment and industry change through taxes and fares, with lower taxes on short haul services (due hybrid aircraft)	Customers pay for environment and industry change through taxes and fares, with higher taxes on long-haul services	Customers pay for environment and industry change through taxes and fares, with higher taxes on long-haul services
Customer Relationship: Fares	Customer relationship based on price	Simple customer management, loyalty programmes	Customer relationship based on price	Complex customer management and targeting, but passengers not to be overloaded, loyalty programmes
Customer Relationship: Brand	Develop and position brand	Strengthen and build dominant brand position	Develop and position brand	Multi-brand groups to be managed while reducing brand portfolio, end of national brands
Customer Relationship: Product and Service Offer	Unbundling as innovation	Unbundling as innovation but more choice	Unbundling as innovation	Service tailoring or micro-bundling as innovation (mosaic of offers)
Sales Channels: Single Passengers	Direct booking to customer, high internet presence	Direct booking to customer. Protection of sales channels key	Direct booking to customer, high internet presence	Direct booking to customer, decreasing power of GDSs, but using more partners to sell increased services. Protection of sales channels key
Sales Channels: Distribution Corporates	Not specifically targeted	Corporate incentives and tie-ins	Not specifically targeted	Corporate incentives and tie-ins
Customer Segment: Passengers	Price driven	Value driven	Price driven	Meeting more complex travel needs. Service and value driven

Table 71: Page 4 of 4

Parameter	Very Low-Cost Carrier (VLCC) P2P	Value Shorthaul P2P (Hub Feeder)	Value Long-haul P2P	New Network Carrier/Mixed Model
Customer Segment: Passengers	Younger traveller and the cost sensitive	Mid market & business traveller	Younger traveller and the cost sensitive	Mid market & business traveller, higher disposable incomes and higher travel needs, passenger prototyping
Customer Segment: Cargo	Not significant	Valuable, but not key	Less significant	Major contribution to results with volume and specialised cargo products and volume services
Cost Structure: Employees	Union free? Danger of social dumping	Move to single employment unions within airlines in EU	Union free? Danger of social dumping	Move to fewer employment unions within airlines in EU
Cost Structure: Seasonality	Holiday seasons drive viability	Profitable all year	Holiday seasons drive viability	Lowering unit costs to eliminate seasonal losses by raising break-even point on short haul
Cost Structure: Organisation	Simple, flat organisation structure	Simple, flat organisation structure with multiple AOCs	Simple, flat organisation structure	Dispersed but complex, networked and matrix organisational structures
Cost Structure: Ful and Emissions	Fuel & emissions and regulation the core of cost strategy - greening as self interest	Fuel & emissions and regulation the core of cost strategy - greening as self interest	Fuel & emissions and regulation the core of cost strategy - greening as self interest	Fuel & emissions and regulation the core of cost strategy - greening as self interest
Cost Structure: Unit Cost reduction	New business start ups	Horizontal consolidation within Europe	New business start ups	Global airline mergers and local horizontal consolidation, some insourcing
Cost Structure: Maintenance, Passenger and Ground Services	Buying services from large providers on the margin	Using volume to leverage unit cost reductions, predictive maintenance. Competitive tendering based on scale	Buying services from large providers on the margin	Return to more (on-shoring) insourcing and automation as key cost and control advantage, predictive maintenance. Competitive tendering based on scale
Cost Structure: Passenger and Ground Services	Push ground services processes and costs onto passengers	Push ground services processes and costs onto passengers	Push ground services processes and costs onto passengers	Push ground services processes and costs onto passengers
Cost Structure: Cabin Service	Minimal, safety only, no IFE, no food or drink on board	Low, safety and limited on board passenger services, no IFE	Low, passenger brings own IFE, buy drinks and meals on board	High, IFE provided, full drink and hot meal services provided in 2/3/4 classes
Revenue Stream: Passenger Fares	Fares wars to continue on commodity product. Yield Management with fuel surcharges key	Fares wars to continue on commodity product. Yield Management with fuel surcharges key	Fares wars to continue on commodity product. Yield Management with fuel surcharges key	More complex and tailored services offered generating higher unit revenues. Profit management of single customers and passenger profiling
Revenue Stream: Other	Revenues mainly from passenger fares to secondary airports and onward travel links	Revenue mainly from passenger fares plus ancillary services, cross sell	Revenues mainly from passenger fares	Revenues mainly from passengers to major hubs but with more complex revenue sharing/generating models with alliance partners, plus ancillary services and cargo operations, upsell and cross sell
Revenue Stream: Cabin	Some Duty Free sales	Some revenue generating IFE and buy food in flight. Duty Free sales	Buy IFE and buy food in flight. Duty Free sales	Some IFE generating revenues. Duty Free sales

ENDS