Is Aviation Finance Part of the Asset Class Infrastructure?

Master's Thesis

Zurich University of Applied Sciences
ZHAW

School of Management and Law
Department Banking, Finance, Insurance

Master of Science Banking and Finance

Author:
Melanie Erny

10-275-097

Supervisor:
Dr. Holger Hohgardt

Co-Supervisor:
Brian Olvany

Written at the School of Management and Law, Zurich University of Applied Sciences Zurich, 15 June 2018

Declaration of Authorship

"I hereby declare that this thesis is my own work, that it has been created by me without the help of others, using only the sources referenced, and that I will not supply any copies of this thesis to any third parties without written permission by the head of this degree program."

Last name/first name of student (in block letters)

Erny Melanie

Student's signature

Management Summary

The continuously increasing demand for air travel increases funding needs for aircraft. Institutional investors, being exposed to a sustained low yield environment, increasingly pay attention to these needs. Institutional investors' increasing demand for aviation finance requires classification of the asset class. Classification of an asset is practically relevant as it serves investors in making capital allocation decisions, improving portfolio efficiency and monitoring assets accordingly. Aviation finance shows similar characteristics, physically and economically, to infrastructure. This suggests classifying aviation finance as part of the asset class infrastructure. Infrastructure is a heterogeneous asset, which requires a detailed analysis of its subcategories and investment types.

This thesis analyzes aviation finance and infrastructure with its subcategories and investment types. It assesses whether aviation finance is part of the asset class infrastructure and if it is part of any subcategory and investment type of infrastructure. Economic infrastructure consists of the subcategories transport, energy and utilities, and communications. Investment types of interest within these subcategories are airports and toll roads and renewable energy. A theoretical review of the characteristics of aviation finance and infrastructure provide the building blocks to answer the research question. A quantitative part consisting of risk-return, correlation and regression analyses supports the analysis empirically. The equity of aircraft leasing companies and the S&P 500 Airlines Index represent the aviation finance data set. Infrastructure equity indices represent the infrastructure data set. Monthly correlations of returns between aviation finance and infrastructure for the time frame December 2006 to December 2017 are calculated based on historical prices and index levels.

Aviation finance shows similar economic characteristics, similar asset characteristics, similar cash flows, similar risk-return characteristics and a high correlation to airports. However, aviation finance exhibits some specific asset characteristics that distinguishes it from the investment types airports and toll roads. The mobility of the aircraft around the globe, its homogeneity as well as it being a naturally wasting asset make aviation finance an investment type in its own right. But, aviation finance is part of the subcategory transport and therefore part of the asset class infrastructure. The results are valid for equity investments in aircraft leasing companies and airlines. A further study could put a focus on debt capital or private markets. One key driver that is similar in aviation finance

and airports is the high discretionary component. An analysis of the discretionary component of aviation finance and airports could provide additional insights to the similarities of the two investment types.

Table of Contents

I. List of Tables

II. Table of Figures

III. List of Abbreviations

ABS	Asset-backed securities
ACWI	All Country World Infrastructure
APAC	Asia-Pacific
AUD	Australian Dollars
BCC	Boeing Capital Corporation
BICS	Bloomberg Industry Classification Systems
CAGR	Compound annual growth rate
CAPEX	Capital expenditure
CTC	Cape Town Convention
DJ Airport	Dow Jones Brookfield Airports Index
DJ Comm	Dow Jones Brookfield Communications Index
DJ Infra	Dow Jones Brookfield Global Infrastructure Index
DJ TollRoad	Dow Jones Brookfield Toll Road Index
DJ Transport	Dow Jones Transportation Average
EASA	European Aviation Safety Agency
ECA	Export Credit Agency
EEA	European Environment Agency
EETC	Enhanced Equipment Trust Certificates
EIA	U.S. Energy Information Administration
EY	Ernst & Young
GDP	Gross domestic product
GICS	Global Industry Classification Standard
IATA	International Air Transport Association
IoT	Internet of things
KBRA	Kroll Bond Rating Agency
LRF	Lease Rate Factor
MSCI Ren	MSCI ACWI Independent Power Producers & Renewable Electricity Producers Index
NYSE	New York Stock Exchange
PTB	Pacific Turbine Brisbane
S&P	Standard & Poor's
S&P Airlines	S&P 500 Airlines Index
S&P Infra	S&P Global Infrastructure Index

S&P Util	S&P 500 Utilities Sector GICS Level 1 Index
T&D	Transmission and distribution
USD	U.S. Dollars

1 Introduction

In a sustained low yield environment, alternative investment opportunities become increasingly important to institutional investors (Ernst & Young [EY], 2017, p. 1). Investors' increased appetite for illiquid, alternative investments put pressure on yields of such investments (EY, 2017, p. 1). Therefore, less conventional investment opportunities, such as aviation finance, are gaining much attention (EY, 2017, p. 1). On the other hand, the growing aviation industry requires additional funding sources (Boeing Capital Corporation [BCC], 2016, p. 4). Historically, bank debt has been one of the main funding sources to purchase aircraft (Timotijevic, n.d., p. 20). In 2017, 44 per cent of the aircraft fleet was financed by bank debt and BCC expects bank debt to remain the major source of aviation financing in 2018 (BCC, 2017, p. 6). However, the proposed Basel IV regulations could increase the capital charge for aviation financing provided by banks and therefore reduce bank lending (EY, 2017, p. 3). The other two large sources of financing aircraft are cash (26 per cent in 2017) and capital markets (24 per cent in 2017) (BCC, 2017, p. 6). Capital market financing is largely used by leasing companies, which "accounted for 70 percent of the volume" in 2017 (BCC, 2017, p. 7). Airlines' activity in capital markets declined in 2017 due to their deleveraging and better bank debt access (BCC, 2017, p. 7). However, the continuously increasing demand for air travel, which is estimated by Boeing to grow at 4.7 per cent over the next 20 years (Boeing, 2017, p. 4) and grew by a compound annual growth rate (CAGR) of six per cent over the past 40 years will increase funding needs for aircraft (Timotijevic, n.d., pp. 15). BCC (2017, p. 6) forecasts a funding requirement of 139 billion U.S. Dollars (USD) for new aircraft deliveries in 2018, and expects this to increase to 189 billion USD in 2022. Boeing (2017, p. 4) expects 41,030 new airplane deliveries worth 6.1 trillion USD market value over the next 20 years. The backdrop for institutional investors entering the aviation finance market is herewith given.

1.1 Problem Definition and Aim of the Thesis

Institutional investors' increasing demand for aviation finance, the different forms of financing aircraft, and the peculiarities of the aviation finance market require classification of the asset class. Since aviation finance as an asset class shows similar characteristics, physically and economically, to infrastructure, a comparison of the two asset classes is suggesting (Timotijevic, n.d., p. 3). Infrastructure investments, for example, have some key features such as providing essential services to the public, require large initial capital investment, and are assets with a long life period (Russ, Thambiah, & Foscari, 2010, p.

2). At least the last two features are similar to an investment in aircraft. Investments in aircraft amount to millions of dollars, infrastructure investments require even larger amounts of hundreds of millions to several billions (Timotijevic, n.d., p. 8). The economic life of an aircraft is 25 years or more, the life of infrastructure assets is 35 years or more (Timotijevic, n.d., pp. 8). But are there sufficient similarities to classify aviation finance within the infrastructure asset class? The aim of this thesis is to explain the peculiarities of the aviation finance market, to compare it to infrastructure investments and to assess if a classification of aviation finance under the infrastructure asset class is reasonable or if aviation finance is rather an asset class in its own right. Classification of an asset is practically relevant as it serves the investor in making capital allocation decisions, improving portfolio efficiency and monitoring the assets accordingly.

1.2 Structure and Methodology of the Thesis

The theoretical framework starts with the issue of asset classification. A review of the characteristics of the infrastructure asset class is following. Then, the characteristics of the aviation finance market are outlined. To make the thesis better readable, the working definitions applied in this thesis are directly stated after the respective theoretical part. The next chapter outlines the research question and scope of the thesis. To support the analysis empirically, a quantitative analysis is conducted. For that, the data set that has been used for the analysis is first identified and how the data was collected is explained in detail in the methodology. It follows the quantitative analysis based on the data collected. This includes descriptive statistics and graphical representations in order to assess risk-return characteristics of the different asset classes. Further, a correlation analysis is conducted to detect potential relationships between the different asset classes. To support the correlation analysis and better explain the sources of return, a regression analysis is carried out. The results of the risk-return, correlation and regression analyses are discussed and assessed together with the characteristics of the aviation finance and infrastructure asset classes. Finally, conclusions will be drawn and an outlook to further research is given.

2 Theoretical Framework and State of Research

This chapter provides the building blocks of the thesis. It first outlines the different theories of how to define an asset class, which is the fundamental base to perform an asset classification analysis. Furthermore, the characteristics and peculiarities of the aviation finance and infrastructure market are reviewed in order to provide a qualitative foundation for the analysis carried out in this thesis.

2.1 Asset Classification

Modern portfolio theory suggests that an investor chose a portfolio deemed to be efficient, which is a portfolio with maximum expected return for a given risk or minimum risk for a given expected return (Markowitz, 1952, p. 82). Risk is defined as the covariance, which is the correlation of returns of a number of assets times the standard deviations of these assets (Markowitz, 1952, p. 80). To achieve diversification within a portfolio, increasing the number of securities is not enough (Markowitz, 1952, p. 89). If securities with low correlation to each other are added to the portfolio, diversification is improved, and risk is reduced (Markowitz, 1952, p. 89). Markowitz (1952, p. 89) suggests to "diversify across industries [...] with different economic characteristics", as these exhibit lower correlations than firms in the same industry. Markowitz provided the foundation for optimal asset allocation (Bianchi, Drew, & Whittaker, 2017, p. 8). But how is an asset defined and what exactly is an asset class? Even though the term asset class is widely used in finance, the literature concerning definition of an asset class is scarce (Bianchi et al., 2017, p. 8). Whereas Merton explains the sources of return of an asset with a statistical regression model, industry researchers use more qualitative approaches to define an asset class (Bianchi et al., 2017, p. 8). Greer (1997, p. 86) for example, defines an asset class as "An asset class is a set of assets that bear some fundamental economic similarities to each other, and that have characteristics that make them distinct from other assets that are not part of that class". Greer (1997, p. 89) argues for this definition to be applicable, correlations within the same asset classes should be higher than correlations between different asset classes.

Other industry researchers define an asset class through different characteristics that need to be exhibited by certain assets to form an asset class (Bianchi et al., 2017, pp. 8). In the case of commodities these characteristics are "long positions only", an investment that is thoroughly backed by collateral, rarely traded and exposes the investor to a large universe of the said asset (Ankrim, & Hensel, 1993, p. 22). Another examination of commodities defines the following characteristics to form an asset class: the asset must be able to provide a return above the risk-free rate, its correlation with other asset classes is low or negative, and "it cannot be replicated with a simple linear combination of assets" (Mongars, & Marchal-Dombrat, 2006, n.p. cited in Bianchi et al., 2017, p. 9). An analysis conducted on hedge funds resulted in the following six characteristics for justifying an asset class in its own right: almost identical securities within the class, high correlation of returns of these securities, the asset class forms a substantial part of the investment opportunity set, data of the securities in the asset class is easily available, passive investment in the asset class of an acceptable amount at traded prices is feasible, and finally, all of the defined asset classes approximately sum up to the whole investment opportunity set (Oberhofer, 2001, n.p. cited in Bianchi et al., 2017, p. 9). Idzorek, & Armstrong (2009, p. 7) support the argument that all individually defined asset classes sum up to the whole investment opportunity set and the asset classes should therefore not overlap. Idzorek, & Armstrong (2009, p. 8) define an asset class as "logical groupings of assets that share similar characteristics (e.g. risk, return, correlation, legal structure, etc.)".

The above outlined theories suggest having a look at correlations in order to find out if two assets belong to the same asset class. Correlation measures the strength of "the linear relationship between two asset classes" and ranges from minus one to plus one (Chin, 2013, p. 4). High correlation implies that two assets move in the same direction (Chin, 2013, p. 4). This thesis uses high correlation as an indicator that the assets belong to the same asset class, and low or negative correlation as an indicator that the assets do not belong to the same asset class. None of the authors expresses high correlation in a number. Neither does this thesis. It assesses high correlation based on experience and in comparison to the other correlations in the data set. However, all of the above mentioned authors suggest additional criteria for defining an asset class. In terms of measurement and the alternative character of the assets analyzed in this thesis, the most suitable definition of an asset class arises from Markowitz' theory of diversification and Greer's definition of an asset class. The following definition of an asset class is applied in this thesis:

> *Assets that share some economic fundamentals and specific characteristics that distinguish these assets from other assets and exhibit similar risk-return characteristics and high correlations to each other form an asset class.*

2.2 Infrastructure

Before it can be assessed whether aviation finance is part of the asset class infrastructure, the question whether infrastructure is an asset class itself needs to be answered. According to Idzorek, & Armstrong (2009, p. 37), infrastructure is an asset class. Idzorek, & Armstrong (2009, p. 8) justify their answer with their definition of an asset class as outlined in the previous chapter as logical groupings of assets with similar characteristics. Idzorek, & Armstrong (2009, p. 8) identify the different assets as "transportation […], energy and utilities […], communication […], and social […] assets of society" and the grouping of these assets as infrastructure. However, Idzorek, & Armstrong (2009, p. 8) state that this broad classification can result in some securities being allocated to different asset classes at the same time, which creates an overlapping investment opportunity set. That is why they defined an asset class called unique infrastructure that only accounts for direct infrastructure assets that are not yet considered in more established asset classes such as public and private equity (Idzorek, & Armstrong, 2009, p. 8). Peng, & Newell (2007, pp. 1) argue that even though an investment in infrastructure exhibits some similar characteristics to an investment in real estate, it also shows significant differences and should therefore be regarded as a separate asset class. Inderst (2010, p. 101) states that there is no financial theory suggesting that infrastructure is its own asset class. Inderst (2010, p. 101) argues that infrastructure should be treated as a sub-asset class or sector within the more established asset classes of public and private equity and bonds. Bianchi et al. (2017, p. 5) take an asset pricing approach in order to find out if infrastructure is a separate asset class. Bianchi et al. (2017, p. 30) argue that unique characteristics such as assets with a long life period, recurring cash flows, monopolistic environment and regulatory structures make infrastructure a separate asset class. Their findings, however, suggest that listed infrastructure does not differ remarkably from global listed stocks with regards to their risk, return and correlation characteristics and therefore is not warranted a separate asset class (Bianchi et al., 2017, p. 5). Possible excess returns from private infrastructure could be a result of idiosyncratic risk, investment selection, risk from valuation model inputs, liquidity premium or a composition of these (Bianchi et al., 2017, p. 30).

Considering the definition of an asset class in this thesis, it can be said that infrastructure exhibits some economic fundamentals and specific characteristics that distinguish it from other asset classes. Also, the extensive research available about infrastructure itself suggests that it is an asset class in its own right. However, it is of great importance to define infrastructure in a narrower sense to conduct reasonable analyses. The following paragraph breaks down infrastructure in its subcategories and explains different ways to distinguish assets within the infrastructure asset class.

Infrastructure is typically grouped in two categories, namely social infrastructure and economic infrastructure (Russ et al., 2010, p. 2). According to Thierie, & De Moor (2016, p. 286) social infrastructure refers to assets that are fully regulated and therefore less exposed to the stages of the economic cycle. Examples of social infrastructure are healthcare facilities, schools, homes for the elderly people (Weber, Staub-Bisang, & Alfen, 2016, p. 249). Economic infrastructure can be divided in subcategories of transport, energy and utilities, and communications (Russ et al., 2010, p. 2). These subcategories can be broken down even further into different investment types (Russ et al., 2010, p. 2). Figure one shows the breakdown of economic infrastructure.

Figure 1: Economic Infrastructure, its Subcategories and Investment Types

Economic Infrastructure		
Transport	**Energy and Utilities**	**Communications**
- Airports - Bridges - Parking systems - Ports - Toll roads - Tunnels	- Gas networks - Storage facilities - Electricity networks - Power generation - Renewable energy - Water and sewage	- Cellular towers - Transmission networks - Cable networks - Satellites

Figure one shows the subcategories of economic infrastructure and the different investment types within each subcategory. Adapted from Russ et al., 2010, p. 2.

The infrastructure asset class itself is heterogeneous (Thierie, & De Moor, 2016, p. 280). EY (2015b, p. 4) further distinguishes by common types within the asset class. According to EY (2015b, pp. 4), common types are greenfield or brownfield, construction or operational phase, availability or demand based, corporate entities or concession structures, debt or equity investment. Greenfield projects first need to be build, whereas brownfield projects involve already existing assets and finance improvement or repair of the asset (EY, 2015b, p. 4). Construction phase investments involve investments during the construction of an asset, whereas operational phase investments occur when an asset is already operating (EY, 2015b, p. 4). In availability based projects the investor gets paid for making the asset available, usually to the public, demand based projects exhibit revenue risk since the cash generation of the asset depends on customers' demand (EY, 2015b, p. 4). Corporate entities are entities that generate economic revenues or whose revenues are regulated, for example utility or airport companies (EY, 2015b, p. 5). Concession structures involve pre-agreed payments from the public sector over a long time horizon for delivering specific public services (EY, 2015b, p. 5). Debt is typically collateralized by physical assets or contracts and makes up 80 to 90 per cent of the total required capital of a project (EY, 2015b, p. 5). This leaves the equity investor with a ten to 20 per cent stake that provides a claim on the remaining cash flows after operating costs and income used for debt service have been deducted (EY, 2015b, p. 5). The leveraged exposure exposes the equity investor to increased cash flow volatility and more volatile asset valuations (EY, 2015b, p. 5).

Since social infrastructure is fully regulated, a comparison of aviation finance to economic infrastructure is more reasonable. For the remainder of the thesis, the term infrastructure refers to economic infrastructure if not stated otherwise. The subcategories of transport, energy and utilities, and communications as outlined in figure one are employed in this thesis. A special focus is given on the investment types airports and toll roads as well as renewable energy. These were selected due to the data availability. The subcategories and investment types are explained in more detail in the following chapter. Since the common types of infrastructure are overlapping, for example a construction phase project could also be a greenfield or a brownfield project, this thesis does not explicitly differentiate between the common types of infrastructure.

2.2.1 Characteristics of Infrastructure

Whereas Thierie, & De Moor (2016, p. 286) differentiate infrastructure and its characteristics according to sectors, regions and project stage, Weber et al. (2016, p. 11) state that investors' key interest is the particular risk-return profile rather than the different sectors or stages. The particular risk-return profile depends on numerous characteristics a specific investment opportunity provides (Weber et al., 2016, p. 11). That is why the financial industry defines infrastructure according to specific financial and economic characteristics, which apply according to Weber et al. (2016, p. 11) only to the most conservatively structured infrastructure assets. The typical characteristics of infrastructure named by Weber et al. (2016, pp. 11) and explained by different authors are outlined below.

Key public service: Infrastructure assets provide essential services to the public, which foster economic growth, abundance and quality of life (Weber et al., 2016, p. 11).

Low elasticity of demand: Infrastructure services exhibit relatively constant demand, which is less sensitive to business cycles than other assets (Russ et al., 2010, p. 2).

(Quasi-)monopoly situation with high barriers to market entry: Infrastructure assets are characterized by their large initial capital requirement (EY, 2015b, p. 6). Subsequent investments are rather low, which creates high barriers to market entry and results in a low or non-competitive environment (Weber et al., 2016, p. 11).

Regulation: Regulatory authorities intervene in low competitive markets through fixed prices for example (Weber et al., 2016, p. 11). Whereas long-term contracts provide predictable revenues (Russ et al., 2010, p. 2), the exposure to a change in regulation and therefore the risk increases (EY, 2015b, p. 6).

Long service life: The service life of an infrastructure asset can be as long as 100 years (Weber et al., 2016, p. 12). According to Timotijevic (n.d., pp. 8) the economic life of infrastructure assets is 35 years plus.

Inflation protection: Contractual agreements of infrastructure projects often provide inflation protection, either through the regulation of income, guaranteed returns or user charges tied to gross domestic product (GDP) or the consumer price index (Weber et al., 2016, p. 12).

Regular, stable cash flows: A captive customer base, low demand elasticity, regulated and in most cases inflation-protected revenues characterize infrastructure as an investment providing regular and stable cash flows (Weber et al., 2016, p. 12).

As Weber et al. (2016, p. 11) outline, the above characteristics do not apply to every infrastructure investment. Furthermore, Thierie, & De Moor (2016, p. 286) state that especially the sensitivity to the economic cycle differs from subcategory to subcategory. Other characteristics of infrastructure assets are for example the illiquid nature of the asset and the local currency investment (Timotijevic, n.d., pp. 8). The currency is given by the selection of the country (Weber et al., 2016, p. 43). Regulation and politics differ from country to country and the choice of such can have a significant impact on the success of the infrastructure investment (Barry, Andrews, & Synnott, 2015, p. 10). Infrastructure is a local business (Timotijevic, n.d., p. 30). Infrastructure assets can be movable or immovable (Weber et al., 2016, p. 19). Trains are an example of a movable infrastructure asset, whereas immovable assets are physical structures and fixed buildings (Weber et al., 2016, p. 19). The type of asset is relevant regarding the realization and operation of infrastructure assets (Weber et al., 2016, p. 19). A closer look at the different infrastructure assets is given in the following chapters. Economic fundamentals and specific characteristics are outlined, whereas the specific characteristics put a special focus on the asset itself and the cash flows or revenues arising from the investment. Table one provides an overview of the economic fundamentals and specific characteristics of infrastructure.

Table 1: Economic Fundamentals and Specific Characteristics of Infrastructure

Criteria	**Infrastructure**
Economic Fundamentals	Key public service
	Low elasticity of demand
Asset	Capital intensive
	Regulation
	Long economic life
	Locality
	Immovability
	Illiquidity
	Local currency
Cash flows / Revenues	Regular, stable cash flows
	Inflation protection

Table one shows economic fundamentals and specific characteristics that apply to infrastructure.

2.2.1.1 Transport

According to Weber et al. (2016, pp. 113) transport is one of the most important infrastructure sectors. The transport sector includes different vehicles and forms of transport, which are interrelated and compete with each other (Weber et al., 2016, p. 114). The increasing demand for mobility drives infrastructure investments in roads, highways, railways, waterways and airports and is an important driver of economic growth (Weber et al., 2016, p. 114). The transport sector exhibits a strong correlation to GDP growth, industrial activity and private consumption (Roberts, Patel, & Minella, 2015, p. 12). This in turn impacts the volumes of passenger and freight transportation (Roberts et al., 2015, p. 12).

One characteristic of the transport sector are the increasingly rigorous requirements regarding sustainability, which lead to long approval processes with lots of uncertainties and potentially high follow-up costs (Weber et al., 2016, p. 115). Industrialized countries focus on efficiency improvement and maintenance of the existing transport infrastructure rather than on expansion projects (Weber et al., 2016, p. 115). Emerging countries rely on external financing to develop a basic infrastructure, which exposes the investor to currency risk, since revenues in these countries are generated in local currency only (Weber et al., 2016, p. 115). Significant risk of investing in transport infrastructure arises from potential transport policy changes, transport-specific legislation or changes in responsibilities and structures such as safety requirements or minimum environmental standards that the infrastructure needs to comply with (Weber et al., 2016, p. 115). Such political, legal and institutional changes can have a significant impact on revenues and costs (Weber et al., 2016, p. 115). Transport projects are prioritized by politics based on a cost-benefit analysis, whereby not only direct costs and benefits, but also external effects are taken into account (Weber et al., 2016, p. 116). External effects are for example job creation, improved environmental and health conditions and security (Weber et al., 2016, p. 116).

Revenue sources from the transport sector are:

"- Sector specific taxes, charges, fees

- for consumer goods (e.g. fuel)

- for transport services (e.g. airport services)

- VAT on consumer goods and services

- User charges (e.g. charges for public transport, rail, ship)

- other revenues (e.g. sales of airports or rail companies)

- Retail/franchising/commercials in airports and rail stations etc. [])"

(Weber et al., 2016, p. 117)

Within the transport sector the categories airport and road transport generally create enough revenue to cover costs and often make a profit (Weber et al., 2016, p. 116). The rail sector on the other hand must be subsidized as it does not generate enough revenue to cover costs (Weber et al., 2016, p. 116). The following two chapters focus on the infrastructure investment types toll roads and airports.

2.2.1.1.1 Toll Roads

Main investments in this category include providing and managing the road network, which are considered of most importance (Weber et al., 2016, p. 121). Road transport revenues come from specific taxes, for example on fuel or vehicle ownership or direct charges to the user in the form of a toll for example (Weber et al., 2016, p. 117). Toll roads are such facilities that charge the user a fee for access to the toll road (Kroll Bond Rating Agency [KBRA], 2016b, p. 4). Tolls can be used to control traffic and for price differentiation, for example charging higher fees during peak times to better spread traffic across the day or week (Weber et al., 2016, p. 119). Price differentiation according to vehicle class, frequency of usage or time-dependency are subject to regulatory approval (Weber et al., 2016, p. 123).

KBRA (2016b, p. 3) differentiates between multi-asset facilities, which include several roads that form a network of routes and single asset facilities, which consist of only one toll road in each way. Key risks an investor in toll roads is exposed to are traffic volume and the toll rate charged (Weber et al., 2016, p. 121). Traffic volumes for multi-asset facilities are more stable due to a broader area being serviced (KBRA, 2016b, p. 6). However, with a broader scope competition from alternative routes increases (KBRA, 2016b, p. 6). Single asset facilities profit from their assets' uniqueness and the lack of alternative, which allow more flexibility in determining the toll rate (KBRA, 2016b, p. 6). The price elasticity of demand depends on how essential the facility is to customers (KBRA, 2016b, p. 8).

GDP growth and increasing consumption levels are important drivers of traffic volume (Roberts et al., 2015, p. 12). A diverse user base makes the asset less vulnerable to adverse economic changes or increases in gasoline prices (KBRA, 2016b, p. 7). Roberts et al. (2015, pp. 5) however state that traffic volumes are inelastic to fuel prices, which lessens the direct negative impact of increased gasoline prices to traffic volumes. The composition of traffic is an important factor affecting the stability of cash flows from a toll road investment (KBRA, 2016b, p. 8). Commercial traffic increases as production levels in the industrial and retail sector increase (Roberts et al., 2015, p. 12). This makes commercial traffic more sensitive to the economic cycle of the nation (KBRA, 2016b, p. 8). Commuter traffic is said to be the most stable traffic class (KBRA, 2016b, p. 8). It is however also related to the employment level of the economy. Leisure traffic is the least stable class due to its higher discretionary component (KBRA, 2016b, p. 8). Russ et al. (2010, p. 2) argue that the discretionary component is even higher in the case of airports and that toll roads encompass a customer base with relatively less elasticity of demand. The following chapter sheds more light on the characteristics of airports.

2.2.1.1.2 Airports

This chapter forms an important part of the thesis as airports is the asset class that most obviously compares to aviation finance. Weber et al. (2016, pp. 134) classify the aviation market into aircraft manufacturers, airlines and airports, which are compared to other infrastructure sectors to a great extent independent of each other. Similar to toll roads, which are classified in multi-asset and single asset facilities, airports can be grouped into primary and secondary airports (Weber et al., 2016, p. 135). “Primary airports include hub or transfer airports”, whereas secondary airports are the final destination or origin airport (Weber et al., 2016, p. 135). Primary airports around the world and the associated airlines compete with each other (Weber et al., 2016, p. 138). If one hub increases prices and the airlines pass the price increase on to the end-customer, passengers can choose another airline that offers the same destination through another transfer airport at a cheaper price (Weber et al., 2016, p. 138). Secondary airports are more exposed to other airports nearby, which can be reached by passengers within a reasonable time frame and offer more attractive prices (Weber et al., 2016, p. 138). Furthermore, these airports sometimes compete with other transportation means such as rail (KBRA, 2016a, p. 23). Further factors that affect the competitiveness of an airport are transport options and connections to the city center, parking space, “[…] attractiveness for airlines and, […] comfort for passengers”, such as reduced waiting time (Weber et al., 2016, p. 138).

An airport generates revenue through paying users, such as airlines and travelers and visitors using solely service facilities (Weber et al., 2016, p. 135). Airlines pay fees “[…]

for take-off and landing, […] aircraft parking, […] ground handling services such as baggage handling and aircraft refuel[l]ing and maintenance" (Weber et al., 2016, p. 135). Additional sources of revenues are provided by non-aviation services, such as shopping, which can make up more than 50 per cent of the total airport revenue (Weber et al., 2016, pp. 135). Airports also benefit from airlines cutting free meal services and from increased security requirements, which creates dwell time for passengers (KBRA, 2016a, p. 33). Airports with a big land area can create additional revenue from renting the space to industries or farmers (KBRA, 2016a, p. 33). Further services that generate revenue for airports include restaurants, gift shops, car rental, office buildings and hotels (KBRA, 2016a, pp. 33). The revenue streams highlight the higher discretionary component of airports compared to toll roads as mentioned in the previous chapter.

Passenger volume is a key determining factor of an airport's success, which is driven by the size, wealth and strength of the economy in which the airport operates (KBRA, 2016a, p. 14). Air travel is supported by increasing business activity (KBRA, 2016a, p. 14). The presence of large corporations is an important factor as they generate air travel and are less sensitive to price increases than leisure travelers (KBRA, 2016a, pp. 14). The educational level of the working-age population is another driver of air travel and further attracts businesses (KBRA, 2016a, p. 14). Economies with a diverse employment base are more resilient than economies whose workforce primarily is active in cyclical sectors such as agriculture or manufacturing (KBRA, 2016a, p. 15). Furthermore, demand for air travel is likely generated by ethnically diverse groups, either due to visiting their home country or visits of relatives from overseas (KBRA, 2016a, p. 14).

According to Roberts et al. (2015, p. 13), the home base airline plays a crucial role to an airports' prospects. KBRA (2016a, p. 19) states that airports that have a dominant airline charge higher fees. Even though airports and airlines seem to be affected by similar determinants, the key metric for airports is traffic whereas airlines rely on their business model's profitability (KBRA, 2016a, p. 19). Airlines base their decisions on serving specific locations depending on the profitability of the route (KBRA, 2016a, p. 19). Airports rely on passenger activity, which not only attracts airlines, but also creates revenues from non-aviation services (KBRA, 2016a, p. 20). As well as toll roads, airports have an indirect relationship to oil prices since their customers are affected by a change in the oil price rather than the airport itself (Roberts et al., 2015, p. 6). Due to business model changes and the increasing oil price, airlines increased ticket prices and decreased capacity in recent years (KBRA, 2016a, p. 21). This in turn affects airports through reduced passenger volumes. Table two summarizes the economic fundamentals and specific characteristics of transport infrastructure including airports and toll roads.

Table 2: Economic Fundamentals and Specific Characteristics of Transport

Criteria	Transport	Toll Roads	Airports
Economic Fundamentals	Strong correlation to GDP growth	GDP growth / consumption levels	Size, wealth, strength of economy
	Traffic volume	Traffic volume	Passenger volume
		Moderate elasticity of demand	Business activity / educational level
		Indirect relationship to oil price	Indirect relationship to oil price
Asset	Sustainability requirements	Traffic control	Home base airline
	Safety requirements	Regulation	
	Locality	Locality	Locality
	Local currency		
Cash flows / Revenues	User charges	User charges	User payments (e.g. airlines)
	Retail, franchising, commercials	Traffic composition	Non-aviation services (e.g. shopping)
	Taxes, charges, fees	Taxes	Land / office rentals

Table two illustrates economic fundamentals and specific characteristics that apply to transport, toll roads and airports respectively.

2.2.1.2 Energy and Utilities

Global energy consumption is expected to grow by 28 per cent over the next 22 years (U.S. Energy Information Administration [EIA], 2017, p. 9). Oil, coal and natural gas make up 80 per cent of the energy consumption as of 2016 (Thomas, & Haigh, 2017, p. 6). The remaining part is covered by nuclear, biomass and renewable energy (Thomas, & Haigh, 2017, p. 6). The economic sector that consumes the majority of the energy is the industrial sector, namely construction and manufacturing, mining and agriculture (EIA, 2017, p. 18). It accounted for 49 per cent of the world energy consumption in 2016, whereas transport made up for 28 per cent and residential buildings accounted for 23 per cent (Thomas, & Haigh, 2017, p. 6). Even though it is expected that the industrial sector remains the biggest consumer of energy, demand in the other sectors is expected to grow more rapidly (EIA, 2017, p. 18). Demand from the transport sector is expected to increase one per cent per year between 2015 and 2040, demand from buildings 1.1 per cent per year and demand from the industrial sector 0.7 per cent per year over the same period

(EIA, 2017, p. 18). In 2016, electricity accounted for 18 per cent of the world energy consumption and fuels made up for 82 per cent (Thomas, & Haigh, 2017, p. 6). The following paragraphs focus first on electricity and second, given its relation to aviation and other infrastructure assets, on the transport sector's usage of energy.

The current structure of the electricity sector consists of "centrali[s]ed power plants, unilateral transmission and distribution (T&D) networks, and minimal energy storage availability" (Weber et al., 2016, p. 183). The energy is converted into electricity through different transformation processes depending on the energy source (Weber et al., 2016, p. 183). The electricity is then transported from the power plant to transmission grids from where it is distributed to the end-customer (Weber et al., 2016, pp. 183). The electricity network encompasses the T&D of the electricity, which has limited capacity and is a monopolistic market with high entry barriers (Weber et al., 2016, p. 184). Investments in the electricity markets are mainly made in the set-up and management of power plants, transmission networks and storage facilities (Weber et al., 2016, p. 185). Revenues from power generation mainly come from selling electricity in the wholesale market (Weber et al., 2016, pp. 192). The wholesale market consists of electricity producers as sellers and utility companies as buyers, who then re-sell electricity to the end-customers (Weber et al., 2016, p. 185). Revenues from T&D networks are determined by the regulator (Weber et al., 2016, p. 210). Regulated revenues may be linked to government bond yields and inflation (Fitch Ratings, 2014, n.p. cited in Roberts et al., 2015, p. 8). During times of low demand and low market prices, energy storage providers buy and store energy in order to sell it when demand and prices increase (Weber et al., 2016, p. 223). This is how they generate income from costs of purchase and storage being lower than sales price (Weber et al., 2016, p. 223).

Electricity consumption is expected to grow 2.9 per cent per year between 2015 and 2040 (EIA, 2017, p. 78). With the expected rise in personal incomes and the migration to cities in less developed countries, the increasing usage of electricity is expected to come the most from residential and commercial buildings (EIA, 2017, p. 78). The demand for electric vehicles is expected to double the electricity being used in transportation between 2015 and 2040 (EIA, 2017, p. 78). Whereas the former economic driver translates into increasing stable demand, the latter has a higher discretionary component. In both cases the demand for electricity is driven by economic growth (EIA, 2017, p. 10). The link between oil prices and electricity prices depends on oil being a major electricity generation source or not (Roberts et al., 2015, p. 6). In Europe for example, a declining oil price can result in lower electricity prices as gas supply contracts may be coupled to oil prices and gas is a more broadly used electricity generation source (Roberts et al., 2015, p. 6). Whereas toll roads and airports have an indirect relationship to the oil price, the electricity market has a direct relationship, which translates into revenues of the utility companies or power generators. However, the less discretionary component of electricity results in a more stable demand.

The transportation sector absorbed 54 per cent of fossil fuel consumption in 2015 and its consumption is expected to grow at a faster rate than other sectors' consumption to 56 per cent by 2040 (EIA, 2017, pp. 37). Consumption of jet fuel is expected to double between 2015 and 2040 due to the sustaining rise in demand for air travel (EIA, 2017, p. 120). Energy demand from the transportation sector is expected to increase significantly in China and India due to increasing demand from personal travel and freight transportation from the large populations of these countries (EIA, 2017, p. 122). In more developed countries, a decline is expected due to the improved efficiency of vehicles, which is offset by a respective increase in jet fuel demand (EIA, 2017, pp. 122). Also, in less developed countries, jet fuel consumption increases due to the growing private and business air travel, pointing at the economic growth and the rising middle class in these countries (EIA, 2017, p. 126).

2.2.1.2.1 Renewable Energy

National and emission policies are the driver of how electricity generation will develop in the coming years (Roberts et al., 2015, pp. 10). In Europe, for example, a target of the "Europe's 2030" climate-energy policy framework is to gather 27 per cent of the energy from renewables by 2030 (Roberts et al., 2015, p. 10). Renewables have the potential to cover 50 to 90 per cent of the worldwide electricity demand by 2030 (Weber et al., 2016, p. 186).

Most renewable energy cannot be stored and therefore creates volatility in the electricity network (Weber et al., 2016, p. 187). Hydropower generation for example depends on rainfall, which can vary from season to season (Weber et al., 2016, p. 187). T&D operators have to balance the electricity network, meaning input from electricity suppliers must equal output consumed by electricity users (Weber et al., 2016, p. 187). This causes economic and technical challenges when energy supply does not equal energy demand (Weber et al., 2016, p. 188). Renewable energy gets priority in case there is excess supply, requiring other energy producers to wait to feed the network, which can cause the generation of power that is never used (Weber et al., 2016, p. 188). This affects prediction of energy sales volumes and prices (Weber et al., 2016, p. 188). Another unique characteristic of renewable energy is its location being far away from most power consumption and therefore access to transmission networks can be costly (Weber et al., 2016, p. 188).

Renewables are subsidized (Roberts et al., 2015, p. 7). Either through long-term contracts that provide renewable energy producers with price certainty or through quotas, which can be met by producing renewable energy itself or buying certificates from other parties (Weber et al., 2016, pp. 188). The former requires utility companies to pay above market rates and allows them to pass the higher rate on to the government or to the end-customer (Weber et al., 2016, pp. 188). The latter exposes energy producers to volume and price risk (Weber et al., 2016, p. 189). However, utility companies have to buy a certain amount of renewable energy each year, else they get fined in the amount of the maximum price of such certificates (Weber et al., 2016, p. 189). The profitability of renewable energy producers depends on their technical ability of producing relevant electricity volume and the marginal cost of production (Weber et al., 2016, p. 191). However, relatively predictable, long-term cash flows can be expected from renewable energy investments (Weber et al., 2016, pp. 193). Incentives from the government as well as technological progress support the increasing use of renewable energy, whose generation is expected to grow 2.8 per cent per year between 2015 and 2040 (EIA, 2017, p. 80). Government support seems to drive the increasing demand for renewable energy. This results in a more stable demand, less prone to the economic cycle, but also to increased risk from potential policy changes. Table three summarizes the economic fundamentals and specific characteristics of energy and utilities including renewable energy.

Table 3: Economic Fundamentals and Specific Characteristics of Energy and Utilities

Criteria	Energy and Utilities	Renewable Energy
Economic Fundamentals	Industrial activity, transport, buildings	Government support drives demand
	Personal incomes (emerging markets)	
	Urbanization (emerging markets)	
	Low elasticity of demand	
	Direct relationship to oil price	
	Demand for air travel	
Asset	Monopoly, high barriers to entry (T&D)	National and emission policies
		Cannot be stored (technical challenge)
		Long distance (costly access)
Cash flows / Revenues	Sale of electricity in wholesale market (power generation)	Subsidies (price certainty, quotas)
	Regulated revenues (T&D)	Predictable, long-term cash flows
	Inflation protection (T&D)	
	Energy storage revenues	

Table three illustrates economic fundamentals and specific characteristics that apply to energy and utilities and renewable energy respectively.

2.2.1.3 Communications

Communication infrastructure includes transmission and cable networks, satellites and towers (Inderst, 2010, p. 72). Global mobile data growth is huge and a current topic in nearly every industry throughout the world (Hughes, & Graves, 2018, p. 44). Monthly mobile traffic grows at a CAGR of 42 per cent (Hughes, & Graves, 2018, p. 44). Capital expenditure (CAPEX) within the telecommunications industry has grown at a five per cent CAGR between 2005 and 2015 (EY, 2015a, p. 10). Improved network quality is one of the key expectations of customers mobile operators have to meet (EY, 2015a, p. 18). Improved network quality is reached through CAPEX in existing assets as well as investments in new assets (EY, 2015a, p. 20). Since the tower infrastructure makes up the biggest part of an operators' CAPEX, sharing towers has become popular (Dobberstein, Narasimhan, Gupta, & Singh, 2012, p. 2). Independent companies that own the tower infrastructure rent it out to operators "under long-term, typically non-cancellable, contracts with annual escalators" (Hughes, & Graves, 2018, p. 42).

The tower business is a global business (Hughes, & Graves, 2018, p. 43). Towers are concentrated in cities, which requires rationalization and consolidation to cut costs (Dobberstein et al., 2012, p. 4). Having a large portfolio of tower assets is key to tower operators as it allows them to better negotiate terms with their customers, the mobile operators, and to lower incremental costs of adding towers (Hughes, & Graves, 2018, p. 42). Same as for the mobile operators, network quality is a key element for tower operators to "attract and retain customers" (Hughes, & Graves, 2018, p. 42). Energy consumption of telecom towers is questioned by the public and regulators, and requirements for green solutions, such as solar power, increase (Dobberstein et al., 2012, p. 4). Maintenance of the infrastructure is crucial to avoid outages and aids in controlling fuel costs (Dobberstein et al, 2012, p. 7). Rent, power and fuel can make up for 70 to 80 per cent of an operator's network costs (Dobberstein et al, 2012, p. 8).

Increasing demand for mobile data and the internet of things (IoT), such as self-driving cars, requires capacity expansion (Hughes, & Graves, 2018, p. 44). It is projected that by 2021 there will be 1.5 connected mobile devices per capita worldwide (Hughes, & Graves, 2018, p. 44). The growing network is built upon the existing telecom towers (Hughes, & Graves, 2018, p. 44). This will in turn increase cash flows and revenues for tower operators (Hughes, & Graves, 2018, p. 44). Key driver of demand for telecom infrastructure is the long-term growth of global wireless utilization (Hughes, & Graves, 2018, p. 45). Table four summarizes the economic fundamentals and specific characteristics of communications.

Table 4: Economic Fundamentals and Specific Characteristics of Communications

Criteria	**Communications**
Economic Fundamentals	Mobile traffic growth
	Long-term growth wireless utilization
	Demand for mobile data and IoT
	Indirect relationship to oil price
Asset	Global
	Sustainability requirements
	Maintenance is key
Cash flows / Revenues	Long-term, stable and growing cash flows

Table four illustrates economic fundamentals and specific characteristics that apply to the communications sector.

2.3 Aviation Finance

Aviation finance is defined as providing capital to airlines and leasing companies for them to buy or refinance commercial aircraft (EY, 2017, p. 2). Commercial aircraft can be defined as aircraft used for transportation of passengers and freight (Timotijevic, n.d., p. 13). Capital can be provided in the form of equity or debt (EY, 2017, p. 2). Debt can take on various forms, whereas it needs to be distinguished if capital is provided to an airline or to a leasing company (EY, 2017, p. 5). For example, airlines issue enhanced equipment trust certificates (EETC), whereas leasing companies favor asset-backed securities (ABS) (EY, 2017, p. 5). ABS are issued in tranches, which relate to the rank of repayment, and entitle investors to coupon and principal payments (EY, 2017, p. 5). EETC are similar to ABS, but typically include a credit enhancement (EY, 2017 p. 5). The collateral pool of EETC usually consists of aircrafts, which are strategically important to the airline and can be more than ten (KBRA, 2017e, p. 3). The debtor is one single airline and EETC are publicly issued (KBRA, 2017e, p. 3). ABS on the other hand have several debtors (KBRA, 2017e, p. 12). Aircraft leasing companies act as servicer in ABS transactions (KBRA, 2017e, p. 12). This allows leasing companies to keep the relationship with airlines (KBRA, 2018c, p. 1). Leasing companies employ ABS transactions as a source of permanent financing or to manage concentration risks in their aircraft portfolio through selling the aircraft to a special purpose vehicle (KBRA, 2018c, p. 1). In case an airline defaults, in an ABS transaction, the leasing company is responsible for repossessing and reselling the aircraft (EY, 2017, p. 8). In an EETC transaction, the investor is responsible for handling the default (EY, 2017, p. 8).

Other forms of debt issued by both airlines and aircraft leasing companies are secured loans, unsecured bonds and Export Credit Agency (ECA) debt (EY, 2017, p. 5). Secured loans are primarily issued privately and secure less aircraft than EETC (KBRA, 2017e, p. 3). In the case of unsecured bonds, which are publicly issued, investors do not have recourse to collateral in case the issuer defaults (EY, 2017, p. 5). ECA debt is debt guaranteed by quasi-governmental institutions (EY, 2017, p. 3). It supports foreign airlines in purchasing domestically manufactured aircraft (KBRA, 2016c, p. 6). Equity investors have a residual claim in a company. In case of investing in an aircraft leasing company, equity investors have security against aircrafts, but rank behind all other debt capital providers in the waterfall structure (Timotijevic, n.d., p. 72).

Weber et al. (2016, pp. 134) state that the aviation market shows a high level of disintegration, meaning that aircraft production, airlines and airports are mostly independent of each other. Aircraft leasing companies and airlines fit into this definition, however, they are closely related when it comes to financing aircraft. Airlines financing aircraft with their own cash and equity diminished considerably over the past years and was taken up by leasing companies (Timotijevic, n.d., p. 20). According to Dozic, & Krnic (2016, p. 8) the percentage of leased aircraft depends on the airline's fleet size. For example, airlines with less than 50 aircraft in their fleet lease more than 50 per cent of their fleet (Dozic, & Krnic, 2016, p. 8). Dozic, & Krnic (2016, pp. 4) argue that this could be due to the lower credit rating of smaller airlines, which makes access to capital markets more difficult. Airline bankruptcies in turn affect aircraft leasing companies (KBRA, 2018c, p. 3). In case of an airline default, costs to the leasing company arise from repossessing and remarketing the aircraft, which causes the aircraft to be on ground for a longer time, and the potential for releasing the aircraft at lower rates (KBRA, 2018c, p. 3). Functioning capital markets are key to leasing companies, which exposes them to economic and financial downturns (KBRA, 2017a, p. 5).

The growing demand for air travel affects leasing companies as well as airlines (KBRA, 2017a, p. 2). More established airlines in Europe and America currently face competition from new Chinese airlines (The Economist, 2018, p. 13). The increasing demand for aircraft leads to new market entrants in the aircraft leasing industry and increased competition among lessors (KBRA, 2017a, p. 2). Here also, competition mainly comes from China (KBRA, 2017a, p. 4). As explained in the previous paragraph aircraft leasing companies and airlines operate independent of each other but are heavily dependent on each other when it comes to financing. That is why this thesis defines aviation finance in accordance with EY (2017, p. 2) as providing capital to airlines and leasing companies for them to buy or refinance commercial aircraft. And this thesis defines commercial aircraft in accordance with Timotijevic (n.d., p. 13) as aircraft used for passenger and freight transportation. The physical asset of interest for both airlines and aircraft leasing companies is the aircraft, whose characteristics are explained in the following chapter. An assessment of the economics affecting aviation finance is following and includes a short explanation of the different business models of airlines and aircraft leasing companies. Finally, a special focus is given on the cash flows of aircraft leasing companies and an equity investment in aircraft. This focus is chosen due to the data availability and the fact that leasing companies are more directly exposed to the aircraft asset than airlines.

2.3.1 Aircraft Asset

This chapter first outlines the most common characteristics of the aircraft asset. Then, the different aircraft types and their respective characteristics are explained. Finally, special characteristics of regional aircraft are presented.

2.3.1.1 Characteristics of the Aircraft

The most common characteristics of the aircraft asset that are presented below are the result of an extensive research and include peculiarities mentioned by several authors.

Long-term quasi-stable cash flows: Aircraft typically have a useful life of 25 years (KBRA, 2017e, p. 15). Due to depreciation of the aircraft, cash flows decline as the aircraft ages, but increase relative to the residual value of the aircraft (Timotijevic, n.d., p. 4). This topic is addressed in more detail in the chapter on leasing companies' cash flows.

Limited asset characteristics: According to EY (2017, p. 6) the fact that airlines operate on similar aircrafts worldwide limits aircraft types and provides a liquid secondary market. KBRA (2017e, p. 16) on the other hand states that the aircraft is a heterogeneous product and some aircraft types are more sought after in the secondary market than others. According to Timotijevic (n.d., p. 4) the aircraft is a homogeneous asset and due to that and its sensitivity to the economic cycle impacted by common risk factors rather than risk factors specific to the asset type as is the case for property and infrastructure. As discussed in chapter 2.2 infrastructure is heterogenous itself, not least due to the different assets that belong to infrastructure, such as toll roads, airports and communication towers. In this regard with the physical characteristics and the employment of the aircraft, it can be said that the aircraft is a homogeneous asset (Timotijevic, n.d., p. 14). The different types of aircraft and their specific characteristics are addressed later on.

Mobility: An aircraft can be moved from one location to another with ease (EY, 2017, p. 6). This increases the number of potential buyers and therewith liquidity (KBRA, 2017e, p. 15). The aircraft's nature of being a mobile asset relates to global demand (EY, 2017, p. 6). Global demand is discussed in more detail in the chapter economics.

U.S. Dollar Pricing: "Aircraft are typically purchased and sold in US dollars" (EY, 2017, p. 7). Depending on the investor's home base this can still create a currency mismatch when investing in aircraft (EY, 2017, p. 7). However, the importance of the USD in global financial markets makes it a liquid currency and many hedging instruments for the currency exist.

Naturally wasting asset: Timotijevic (n.d., p. 13) calls the aircraft a "naturally wasting asset". The economic life of an aircraft is limited (EY, 2017, p. 6). Aircrafts are depreciated over time as their value reduces (EY, 2017, p. 6). The aircraft can be separated and sold in parts (KBRA, 2017e, p. 15). This is typically done for end of life aircraft, but increasingly so for mid-life aircraft (KBRA, 2017e, p. 15).

Regulation: The aviation market, being global in its nature, requires international regulations such as security standards (Weber et al., 2016, p. 133). Security standards as well as other aspects concerning market liberalization are governed in global open skies policies (Weber et al., 2016, p. 134). Open skies policies include bilateral agreements between two countries as well as multilateral agreements between several countries (U.S. Department of State, n.d., para. 2). Open skies policies address among others international air transportation rights, security standards, commercial opportunities such as the sale of airline tickets in foreign countries, non-discriminatory ticket prices and fair competition (U.S. Department of State, 2012, pp. 3).

Environmental regulations increasingly become important (Weber et al., 2016, p. 133). In Europe for example, the aviation sector is part of the "EU's internal 20% greenhouse gas […] emission reduction target for 2020" (European Aviation Safety Agency [EASA], European Environment Agency [EEA], & Eurocontrol, 2016, p. 37). Airlines can either reduce their CO2 emission or buy emission reduction certificates from other economic sectors (EASA et al., 2016, pp. 37). Environmental regulations affect the aircraft asset in terms of its fuel-efficiency (International Air Transport Association [IATA], 2017c, p. 1).

The aircraft is further regulated through operational control and maintenance requirements by regulatory bodies (EY, 2017, p. 7). The Cape Town Convention (CTC) allows borrowers of aircraft a period of usually 60 days to give the aircraft back to the creditor in case of a default (EY, 2017, p. 7). It makes sure that repossession of the aircraft is handled rapidly and with certainty (EY, 2017, p. 7). The CTC came into effect in March 2006 and was signed by a number of countries (KBRA, 2017e, p. 13).

Capital intensive: 40 million USD to 200 million USD is the approximate value of a new commercial aircraft, depending on its magnitude and technology (Timotijevic, n.d., p. 13). Maintenance requirements when the aircraft gets older further increase CAPEX requirements (KBRA, 2017e, p. 16).

Technological change is another factor affecting aircrafts (KBRA, 2017e, p. 15). Technological improvement tends to decrease the value of existing aircraft at a faster pace (KBRA, 2017e, p. 15). However, the transparency regarding introduction of new design and technology as well as the very long lead times make this factor manageable (Timotijevic, n.d., p. 13). The global mobility of the aircraft as well as its separability into parts makes it a reasonable liquid asset (KBRA, 2017e, pp. 14). The large number of aircraft in operation globally as well as the expected new aircrafts to be delivered over the next several years provide a solid base for the aircraft market (KBRA, 2017e, p. 14). Also, the number of participants is growing, which makes the market even more liquid (KBRA, 2017e, p. 14). Investment funds are entering the market to purchase mid-life and end of life aircraft, which are mainly sold by leasing companies (KBRA, 2017e, p. 14). These assets offer potentially higher yields (KBRA, 2017e, p. 14). Larger global airlines and some lessors prefer newer aircraft and pay the respective high prices, smaller regional airlines look for lower cost aircraft (KBRA, 2017e, p. 14). Demand for all types of aircraft is herewith given (KBRA, 2017e, p. 14). The following chapter introduces the different types of aircraft.

2.3.1.2 Aircraft Types

The quality of an aircraft and therewith its value depends on the respective aircraft type (KBRA, 2017d, p. 7). Timotijevic (n.d., p. 14) categorizes commercial aircraft into narrow body, wide body and regional aircraft. Narrow body aircraft have a single aisle, whereas wide body aircraft have a twin aisle (Timotijevic, n.d., p. 14). Narrow body aircraft are smaller types of aircraft and wide body are larger types of aircraft (Timotijevic, n.d., p. 14). Narrow body aircraft are typically used for short to medium distances and wide body for medium to long distances (Timotijevic, n.d., p. 14). Regional aircrafts are even smaller types of aircraft and are used for even shorter routes, they are not allowed to cross the Atlantic or the continent (Timotijevic, n.d., p. 14). Regional aircrafts include aircrafts with 50 up to 150 seats (KBRA, 2017b, p. 1). The 150 seat aircrafts can be overlapping with smaller narrow body aircraft but are mainly used for regional transport in certain markets (KBRA, 2017b, p. 1). Regional aircrafts are discussed in a separate chapter subsequent to this chapter.

Narrow body aircraft account to approximately 75 per cent of all commercial passenger aircrafts in use (Timotijevic, n.d., p. 14). This represents the demand from airlines for short to medium travel distances and the higher rate of production of these types of aircraft (Timotijevic, n.d., p. 14). Narrow body aircraft also exhibit lower repossession and remarketing costs than wide body aircraft to aircraft leasing companies in case an airline defaults (KBRA, 2017d, p. 16). This makes sense considering the share of narrow body aircraft of total commercial passenger aircraft in use and the therewith increased liquidity of these types of aircraft. The leasing and trading market of wide body aircraft has been challenging recently (KBRA, 2018a, p. 1). Lease rates for used wide body aircraft were lower than expected due to the overload of new and existing aircraft in the market (KBRA, 2018a, p. 1). The order book for wide body aircraft is declining, which represents the end of the wide body order cycle (KBRA, 2018a, p. 2). Airlines incorporate current deliveries into their fleet before placing additional orders (KBRA, 2018a, p. 2). Most of the ordered wide body aircraft will be used for replacing older aircraft over the next couple of years (KBRA, 2018a, p. 2). Liquidity of wide body aircraft depends on the model, whereby airlines prefer smaller wide body aircraft than larger ones (KBRA, 2018a, p. 3). Both wide body and narrow body aircraft face competition from their own newer generation models, called in-production aircraft, which are more fuel-efficient and comprise more advanced technology (Timotijevic, n.d., p. 14). Obsolescent technology is one specific risk that mid-life aircraft face (KBRA, 2018c, p. 2). Further, their values are more volatile, potential for re-leasing the aircraft is lower and ongoing maintenance requirements cause higher costs (KBRA, 2018c, p. 2). Also, the in-production aircraft are said to be relatively stable in market turmoil, indicated by a fall in their value by ten to 20 per cent following 9/11 compared to airline stocks, which plummeted by more than 40 per cent in a similar period (Fitch Ratings, n.d., n.p. cited in EY, 2017, p. 6).

Boeing 737-800 is an example of a more popular narrow body aircraft, Boeing 777-300ER is an example of a more popular wide body aircraft (Ascend Advisory, 2013, n.p. cited in Timotijevic, n.d., p. 14). Another example of a more popular wide body aircraft is the A330 from Airbus (KBRA, 2018a, p. 1). The A330 family consists of the A330-200, A330-300 and two neo-models, which are more fuel-efficient (Airbus, n.d.b, para. 1). The A320 family provides another example of a narrow body aircraft (Airbus, n.d.a, para. 2). Figure two shows annual transaction volumes of the mentioned types of aircraft. The higher demand for narrow body aircraft is reflected by the higher transaction volumes of the Boeing 737-800 and the Airbus A320-200. Timotijevic (n.d., p. 25) states that transaction data is not transparent, and therefore irrelevant effects can affect aircraft valuation.

Figure 2: Annual Transaction Volume of Selected Aircraft Types 2009 – 2013

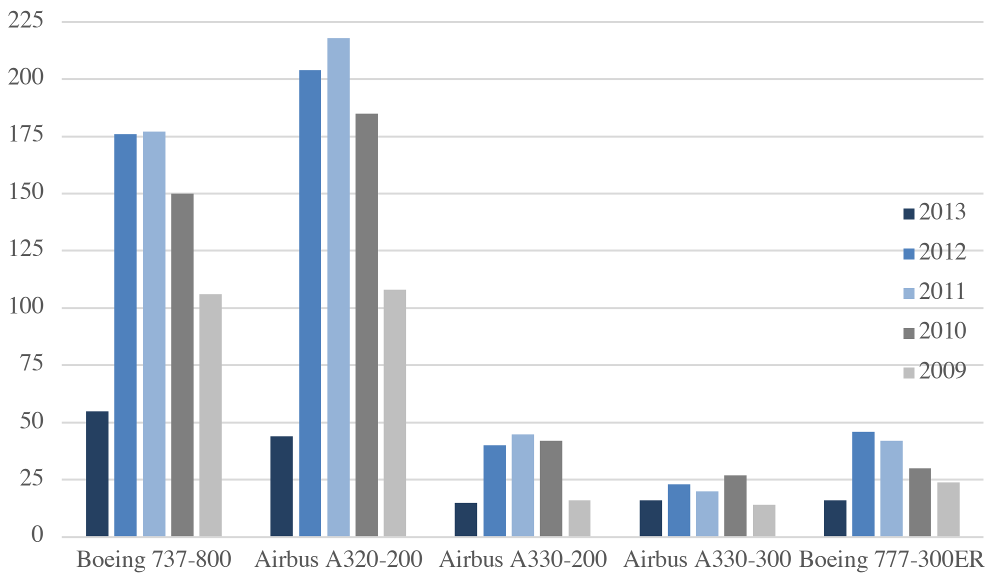

Figure two shows the annual transaction volumes for the years 2009 to 2013 of the Boeing 737-800, Airbus A320-200, Airbus A330-200, Airbus A330-300 and Boeing 777-300ER. The figure is adapted from Ascend Advisory, n.d., n.p. cited in Timotijevic, n.d., p. 25. The transaction volumes were read off the figure provided in Timotijevic (n.d., p. 25) and are an approximation of the exact trading volumes.

When comparing the above mentioned types of aircraft, the Boeing 737-800, a narrow body aircraft, performed best in terms of profitability in the period 1991 to 2012 (Ascend Advisory, n.d., p. 10). This is in line with the high demand for narrow body aircraft as explained in the previous paragraph. The Boeing 737-800, however, showed medium volatility (Ascend Advisory, n.d., p. 10). The A330-300 exhibited the highest Sharpe ratio in this period (Ascend Advisory, n.d., p. 11). The Sharpe ratio "measures excess return per unit of risk" (Van Eaton, 2016, p. 139). The Boeing 777-300ER ranked second in terms of Sharpe ratio followed by the Boeing 737-800 (Ascend Advisory, n.d., p. 11). The A320-200 had the lowest Sharpe ratio among these models (Ascend Advisory, n.d., p. 11). Table five provides an overview of the different aircraft types' risk and return in the period 1991 to 2012. The A330-300 and the Boeing 777-300ER indicate that wide body aircraft perform better on a risk-adjusted basis than narrow body aircraft. This is, however, not confirmed by the higher demand for narrow body aircraft.

Table 5: Risk-Return Analysis of Selected Aircraft Types 1991 – 2012

Model	Type	Return	Volatility	Sharpe Ratio
A330-300	Wide Body	6.63%	5.13%	0.416
Boeing 777-300ER	Wide Body	6.72%	5.49%	0.404
Boeing 737-800	Narrow Body	6.89%	7.28%	0.328
A330-200	Wide Body	5.66%	6.92%	0.168
A320-200	Narrow Body	5.48%	6.39%	0.153

Table five shows average annual returns and volatility as well as the Sharpe ratio for selected aircraft types for the period 1991 to 2012. Adapted from Ascend Advisory, n.d., p. 11.

2.3.1.2.1 Regional Aircraft

Regional aircraft is a much smaller market of commercial aircraft (Timotijevic, n.d., p. 18). Firm demand for air travel driven by the increased connectivity between emerging markets, especially in the Asia-Pacific (APAC) region, make it reasonably important (KBRA, 2017b, p. 2). These markets are expected to become the key driver for growth in the regional aircraft segment (KBRA, 2017b, p. 3). IATA (2017a, para. 3) expects more than half of the passenger growth over the next 20 years coming from the APAC region. The demand shifts towards larger regional aircraft with up to 150 seats and smaller ones with approximately 50 seats are vanishing (KBRA, 2017b, p. 2). Bombardier (2017, para. 4) expects 12,550 new aircraft in the 60 to 150 seat segments worth 820 billion USD over the next 20 years. Considering Boeing's global forecast of new aircraft deliveries as stated in the introduction over the same period, regional aircraft represent 31 per cent of the total number of aircraft deliveries and 13 per cent of the total value. The growing demand in the APAC region is driven by the growth of the economy, increasing share of the middle class, larger private consumption and urbanization (KBRA, 2017c, p. 3). Even though emerging markets are seen as key driver for growth in regional aircraft, North America continues to be the largest market for such types of aircraft (KBRA, 2017b, p. 3).

Regional aircraft are exposed to specific risks (KBRA, 2017b, p. 1). For example, the lack of pilots and regulatory measures could restrain the demand for regional aircraft (KBRA, 2017b, p. 5). Regulatory measures include “the more stringent requirements for pilot qualifications in the U.S.” (KBRA, 2017b, p. 2). Further, in the U.S. the scope clause restricts smaller aircraft with 70 to 90 seats to cover routes operated by the larger main airlines (KBRA, 2017b, p. 4). Similar rules exist outside the U.S., but are less stringent (KBRA, 2017b, p. 4). In emerging markets, the lack of infrastructure is a more prevalent risk (KBRA, 2017c, p. 9). The number of airports relative to residents is substantially lower in Asia than in the U.S. or in Europe (KBRA, 2017c, p. 9). Additionally, access to airports is difficult as public transportation does not exist and car ownership is sparse (KBRA, 2017c, p. 9). The demand for air travel in these economies is negatively impacted by the recent change in trade policies, “such as the U.S. withdrawal from the Trans-Pacific Partnership with Japan and other Asian-Pacific economies” (KBRA, 2017c, p. 9). If this direction continues, it is estimated that this reduces the forecasted annual CAGR for air travel demand by 0.9 per cent annually (KBRA, 2017c, p. 9). Another drag on air travel demand comes from the high-speed train network in China, which allows for a short travel time at a reduced cost compared to air travel (KBRA, 2017c, p. 9). Historical experience has shown that regional aircraft markets are less sensitive to economic conditions than the global aircraft market (KBRA, 2017b, p. 5). The following chapter explains the economic factors affecting the global aviation finance market. First, table six summarizes the economic fundamentals and specific characteristics that are unique to regional aircraft.

Table 6: Economic Fundamentals and Specific Characteristics of Regional Aircraft

Criteria	Regional Aircraft
Economic Fundamentals	Economic growth
	Share of middle class
	Private consumption
	Urbanization
Specific Characteristics	Lack of pilots
	Regulation
	Lack of infrastructure
	Difficult access to airports
	Trade policies

Table six illustrates economic fundamentals and specific characteristics that apply to regional aircraft.

2.3.2 Economics

The key driver of air travel is global economic growth (Timotijevic, n.d., p. 15). According to Timotijevic (n.d., p. 15) 60 to 80 per cent of the demand for air travel is coming from economic activity. Economic activity refers to the amount of transactions (purchases and sales) happening in an economy within a certain time frame and can be measured by GDP (Mankiw, & Taylor, 2010, p. 689). Airbus (2017, p. 14) lists GDP, private consumption, imports and exports, the total population and employment as the main factors affecting air transport. Dozic, & Krnic (2016, p. 3) on the other hand find a positive correlation between lease rentals and GDP. Dozic, & Krnic (2016, p. 3) argue that air travel demand is driven by GDP "and air travel demand further influences aircraft demand". This argument indicates that both airlines and aircraft leasing companies are exposed to the same economic factors. Boeing (2017, p. 4) expects air travel to grow at 4.7 per cent over the next 20 years, translating into a fleet growth of 3.5 per cent and a requirement of 41,030 new airplanes with a market value of 6.1 trillion USD. According to Timotijevic (n.d., p. 16) structural factors affecting air traffic growth are emerging market growth and the replacement cycle of aircraft. Whereas the former is driven by the increasing travel demand of the growing middle class in emerging markets, the latter is resulting from replacing older aircraft with more fuel-efficient ones in developed markets (Timotijevic, n.d., p. 17).

"The [aviation] industry is highly cyclical with an average cycle ranging between 6-10 years" (Timotijevic, n.d., p. 15). Aircraft liquidity is also cyclical, corresponding to the cyclical nature of the airline industry, whose downturns can last several years, but eventually recover (KBRA, 2017e, p. 16). The aviation industry is further exposed to non-cyclical shocks such as terrorism, financial crises, war and oil price volatility (Timotijevic, n.d., p. 15). During such events, the aircraft market was illiquid, but not for a long time (KBRA, 2017e, p. 16). KBRA (2018b, p. 4) views airlines to be more cyclical than aircraft leasing companies, due to airlines being directly exposed to consumer demand and oil price volatility. Fuel costs were estimated to account for more than 17 per cent of an airline's operating expenses in 2017 (IATA, 2017b, p. 1). Currency strength of the respective countries is further affecting airlines (KBRA, 2017a, p. 6). A strong currency results in more outbound traffic than inbound traffic (KBRA, 2017a, p. 6).

The growing demand for air travel requires substantial capacity expansion "of both aircraft and airports" (Weber et al., 2016, p. 133). Boeing (2017, p. 9) expects airport infrastructure investments to amount to one trillion USD between today and the end of 2021. These include both the building of new airports and improvements of existing airports (Boeing, 2017, p. 9). 400 billion out of the one trillion USD is expected to be invested in the APAC region (Boeing, 2017, p. 9). According to KBRA (2017a, p. 7) the growth of passenger traffic stays strong relative to the growth of aircraft capacity with global load factors amounting to 80 per cent. A high load factor means that planes are full, with most available seats being filled by passengers (Investopedia, n.d., para. 1). However, the expected growth in demand for air travel could lead to limited or no delivery times for a couple of years for the most popular aircraft such as the A320 and the Boeing 777 models (Timotijevic, n.d., p. 18). The expected annual requirement of 1,500 new aircraft requires aircraft manufacturers to increase their factory capacities as well (Timotijevic, n.d., p. 18). Airbus' and Boeing's annual production amounted to roughly 1,000 aircraft per year in the past couple of years (Timotijevic, n.d., p. 18).

2.3.2.1 Business Models

According to Ascend Advisory (n.d., p. 7) an investment in the aircraft asset is less risky than an investment in the airline company. As mentioned in the previous chapter, KBRA (2018b, p. 4) views airlines to be more cyclical than aircraft leasing companies, due to airlines being directly exposed to consumer demand and oil price volatility. These two statements suggest providing a short explanation of the different business models, which is done in the following two paragraphs.

An aircraft leasing company is a finance company and therewith exposed to risks affecting finance companies. The asset base of most finance companies is concentrated, and they generate revenues from a single business line (KBRA, 2017f, p. 5). This holds true for large leasing companies (KBRA, 2017f, p. 5). Finance companies are exposed to product cyclicality and must demonstrate robust funding and performance (KBRA, 2017f, p. 4). Robust funding and performance helps them to access diverse financing sources (KBRA, 2017f, p. 4). Asset quality is especially important due to the lack of diversification of a finance companies' assets (KBRA, 2017f, p. 7). Adequate depreciation of the assets as well as the payment behavior of the companies' customers are factors affecting a finance companies' strength (KBRA, 2017f, p. 7).

Airlines are known for operating on low margins, going bankrupt frequently, having poor credit profiles and their financial results are highly unstable (KBRA, 2016c, p. 3). Airlines operate in a highly competitive market and are exposed to a volatile commodity input they cannot control (KBRA, 2016c, p. 3). "At its peak, fuel costs accounted for approximately 40% of airline operating costs" (KBRA, 2016a, p. 6). The impossibility to hedge jet fuel directly and the weak credit profile of a number of airlines makes fuel a substantial risk factor to them (KBRA, 2016c, p. 7). Airlines' revenues not only depend on air travel demand but are also impacted by a number of additional factors (KBRA, 2016c, p. 5). These are the strength of their brand, the number of countries, currencies or industries they are exposed to, competition, customer composition, hub power and diversity of revenue streams such as freight transportation (KBRA, 2016c, p. 5). State-owned airlines profit from sovereign support (KBRA, 2016c, p. 8). Preventing new airlines from entering the country's market is a form of sovereign support (KBRA, 2016c, p. 8). KBRA (2016c, p. 13) measures the strength of an airline supported by government depending on how important the airline is to the country "as a source of national identity and pride", its commercial importance and the impact to that country's economy if the airline fails.

2.3.3 Aircraft Leasing Cash Flows

Leasing companies' market share "of the total number of commercial aircraft in operation globally" is close to 40 per cent and expected to increase further (Timotijevic, n.d., pp. 21). From an investor's perspective, leasing is often a favorite to other aviation industry sectors as its return on invested capital is one of the highest in the sector (Timotijevic, n.d., p. 22). The increasing importance of aircraft leasing companies in the aviation finance market suggest having a closer look at the cash flows derived from the aircraft leasing business. But first, specific characteristics of aircraft leasing companies are outlined.

Aircraft leasing companies focus on popular narrow body aircraft (KBRA, 2017d, p. 4). Wide body aircraft are usually securitized and therewith taken off balance sheet of the leasing company (KBRA, 2017d, p. 4). Further, leasing companies engage in trading and selling of older aircraft to reduce the average age of their portfolio (KBRA, 2017a, p. 4). This leaves leasing companies with highly liquid aircraft in their portfolio (KBRA, 2017d, p. 4). A proper aircraft leasing portfolio has a certain turnover amount of leasing contracts, meaning only part of the portfolio requires new lessees every year (Ascend Advisory, n.d., p. 5). Leasing companies actively monitor their fleet with regards to aircraft utilization and payment of lease rates, which allows them to anticipate potential lessee default and take appropriate actions (KBRA, 2017d, p. 4). Remarketing and repossessing an aircraft should be done prior to lease expiration or default and is considered simpler for global leasing companies (KBRA, 2017d, p. 4). An established legal framework supports repossession of the aircraft (KBRA, 2017d, p. 15). In case the aircraft cannot be re-leased directly after expiration of the lease term, the leasing company faces storage costs, which can be calculated as part of the transition costs of an aircraft (Ascend Advisory, n.d., p. 16). The lessee bears the maintenance costs of the aircraft and has to return the aircraft in a full life condition upon lease expiry (Ascend Advisory, n.d., p. 14). Full life condition means that the key components of the aircraft are freshly maintained, or cash is on hand to bring the aircraft in such a condition (Timotijevic, n.d., p. 28). Further, the lessee bears the insurance cost of the aircraft on lease and is responsible for insuring "loss or damage to the aircraft" (KBRA, 2017d, p. 12). Residual value risk is the only risk that remains with the lessor (Timotijevic, n.d., p. 42). KBRA (2017d, p. 7) states that lease rates are directly linked to an aircraft's value. Therefore, the following paragraph first explains the value of an aircraft before providing details on leasing cash flows.

According to EY (2017, p. 10) forecasting the residual value of an aircraft is fundamental for a leasing company to be successful. The residual value is affected by "supply and demand for air travel and specifics relating to the underlying asset" (EY, 2017, p. 10). Specifics include among others regulatory changes, prominence of the aircraft type among airlines and technology (EY, 2017, p. 10). These factors were discussed in more detail in chapter 2.3.1. Whitehouse (2018, p. 49) differentiates between base value, market value and distressed value of an aircraft. Base value reflects the mid-life, mid-time status of the aircraft in an average physical condition valued at “highest, best use” (Whitehouse, 2018, p. 49). This value is obtained in a stable and unrestricted market with involved parties being “willing, able, prudent & knowledgeable” to buy or sell a single aircraft for “cash or equivalent” in a reasonable time frame at arm’s length (Whitehouse, 2018, p. 49). Market value reflects the actual time status and physical condition of the aircraft appraised at “highest, best use” (Whitehouse, 2018, p. 49). Unlike the base value, the market value reflects the current status of the market (Whitehouse, 2018, p. 49). The distressed value also reflects the current status of the market, but the seller is usually forced to sell, and the value might not be the “highest, best use” (Whitehouse, 2018, p. 49). Further, time pressure is accounted for in a distressed value (Whitehouse, 2018, p. 49). Timotijevic (n.d., p. 28) states that the market value is fluctuating around the base value with the volatility relating to the type of aircraft and its liquidity. Narrow body aircraft are more liquid than wide body aircraft, in-production aircraft are more liquid than out-of-production aircraft (Timotijevic, n.d., p. 28). Further, an established customer base and how fuel efficient an aircraft is impacts its market value (Timotijevic, n.d., p. 28). KBRA (2017e, p. 5) stresses the value of an aircraft through application of different depreciation curves to different aircraft types depending on their liquidity in the secondary market, the production status of the model, the number of operating aircraft against the number of parked ones and the mixture of airlines using the aircraft.

Leasing revenue is generated over the useful life of the aircraft (KBRA, 2017d, p. 3). Lease rates are typically fixed at the beginning of the lease agreement (Ascend Advisory, n.d., pp. 5). This exposes the aircraft leasing company to interest rate risk (KBRA, 2017a, p. 2). The typical length of an aircraft leasing agreement is between five and ten years (Timotijevic, n.d., p. 42). Newer in-production aircraft generate higher levels of leasing income due to the higher value of the aircraft at the beginning and provide longer term cash flows than older out-of-production or less popular aircraft (KBRA, 2017d, p. 8). For older aircraft, the generation of cash originates from continuing leasing or from selling parts of the aircraft, such as the engine (KBRA, 2018c, p. 3). The risk of the aircraft being on ground between two lease terms has to be factored in when calculating cash flows from leasing agreements (Ascend Advisory, n.d., p. 16). The relationship between the leasing cash flows and the lease rate can be expressed as follows:

Lease Rate Factor (LRF) = "(Lease Income per month) / (Aircraft Value)" (Timotijevic, n.d., p. 42).

As stated in chapter 2.3.1 due to depreciation of the aircraft (aircraft value in the above equation), cash flows (or lease income per month in the above equation) decline as the aircraft ages but increase relative to the residual value of the aircraft (the lease rate factor in the above equation). New aircraft usually have an LRF of 80 basis points (bps), whereas the LRF for older aircraft is more than 150 bps (Timotijevic, n.d., p. 42). This translates into an annual rate of 9.6 per cent for newer aircraft and 18 per cent for older aircraft (Timotijevic, n.d., p. 42). According to KBRA (2017d, p. 8) the LRF depends on "cyclical and demand/supply dynamics of lease rates over time". Timotijevic (n.d., p. 43) is more precise and states that besides age the following factors are affecting lease rates: "type of lease; interest rates; tax considerations; terms of the lease; starting value of the aircraft; assumption of residual value of aircraft; and credit quality of the airline lessee." The leasing cash flow in an aircraft leasing business is typically used as follows: 27 per cent to cover interest costs from debt financing, 32 per cent depreciation, 32 per cent cash available to equity, nine per cent operating expenses (Timotijevic, n.d., pp. 46).

Before explaining the details of an equity investment in aircraft, table seven provides a summary of the economic fundamentals and specific characteristics of aviation finance.

Table 7: Economic Fundamentals and Specific Characteristics of Aviation Finance

Criteria	**Aviation Finance**
Economic Fundamentals	Global economic growth
	Private consumption
	Emerging market growth
	Oil price volatility
Asset	Long economic life
	Limited asset characteristics
	Mobility
	USD currency
	Regulation
	Sustainability requirements
	Safety requirements
	Capital intensive
	Technological change
	Reasonable liquidity
Cash flows / Revenues	Long-term quasi-stable cash flows
	Fixed lease rates for lease term
	Aircraft part-outs (end life)

Table seven illustrates economic fundamentals and specific characteristics that apply to aviation finance.

2.3.4 Equity Investment

Since many different debt instruments exist in the aviation finance industry and due to the lack of data availability of debt instruments, this thesis focuses on equity investments. This chapter provides a short introduction to aircraft equity investments as presented by Timotijevic.

As outlined in the beginning of the chapter aviation finance, equity investors have security against aircrafts, but rank behind all other debt capital providers in the waterfall structure. As explained in the previous chapter, 32 per cent of the leasing cash flow is attributable to equity investors. This amount is distributed on a quarterly basis (Timotijevic, n.d., p. 72). When a leasing agreement matures, equity investors can earn a profit from the residual value in case of an aircraft sale or re-lease the aircraft (Timotijevic, n.d., p. 72). The overall return to an equity investor depends on the residual value as well as on the debt level used to purchase the aircraft and the debt amortization (Timotijevic, n.d., p. 72). A higher level of gearing and amortizing the debt faster than depreciating the aircraft result in higher equity returns (Timotijevic, n.d., p. 5). Figure three shows a possible structure of an investment in aircraft adapted from Timotijevic (n.d., p. 73). Timotijevic (n.d., p. 73) states that most structures involve a faster debt amortization than aircraft depreciation and hence generate additional return to equity investors when the aircraft is disposed of.

Figure 3: Aircraft Investment Structure

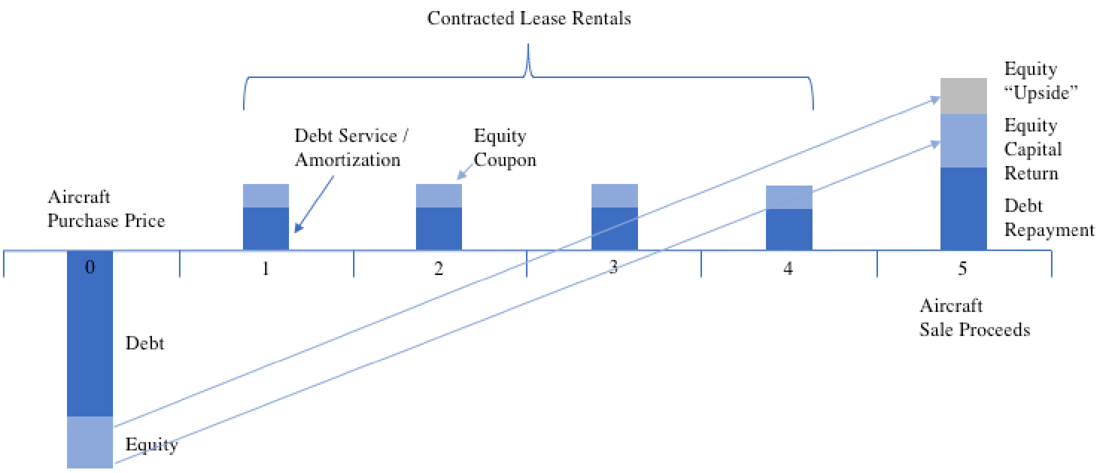

Figure three shows a possible structure of an investment in aircraft and indicates the different cash flows attributable to debt and equity investors during the life time of the transaction. Adapted from Timotijevic, n.d., p. 73.

3 Research Question and Scope

The current state of research suggests comparing aviation finance to infrastructure investments. The theoretical background raised the question if infrastructure is an asset class itself. This thesis assumes that infrastructure is its own asset class and does not provide a thorough analysis of this question. An asset class is defined as follows in this thesis:

> *Assets that share some economic fundamentals and specific characteristics that distinguish these assets from other assets and exhibit similar risk-return characteristics and high correlations to each other form an asset class.*

Economic fundamentals are economic factors that affect an investment asset. Specific characteristics include factors that specifically apply to the underlying asset and the nature of its cash flows and revenues. Similar risk-return characteristics are measured by the

Sharpe ratio. This thesis measures the correlation of returns between two asset classes. The main research question reads as follows:

Is aviation finance part of the asset class infrastructure?

Aviation finance is defined as providing capital to airlines and leasing companies for them to buy or refinance commercial aircraft. Commercial aircraft is defined as aircraft used for passenger and freight transportation. Due to the data availability and the fact that leasing companies are more directly exposed to the aircraft asset than airlines, a special focus is given to leasing companies. The aircraft's nature of being a global asset makes aviation finance a global market. However, besides the global market, also the regional aircraft market is covered, which leads to the following sub-question:

Is regional aircraft finance part of the asset class infrastructure?

Aviation finance refers to global aviation finance, which includes regional aircraft finance. When compared to regional aircraft finance, the term global aviation finance is used to make statements clearer. As outlined in chapter 2.2 infrastructure is typically grouped in two categories, social infrastructure and economic infrastructure. Social infrastructure is not covered in this thesis since these assets are fully regulated and a comparison to aviation finance is less suggesting. The term infrastructure refers to economic infrastructure if not stated otherwise. To make certain statements clearer, the term economic infrastructure is still used. Economic infrastructure is grouped into transport, energy and utilities, and communications. Within these subcategories, toll roads and airports, and renewable energy are covered. These sectors were chosen in accordance with data availability. This thesis does not explicitly differentiate between the common types of infrastructure. The main research question as well as the first sub-question can be divided in the following sub-questions:

Is aviation finance (regional aircraft finance) part of the asset class transport within infrastructure?
Is aviation finance (regional aircraft finance) part of the asset class toll roads within transport infrastructure?

Is aviation finance (regional aircraft finance) part of the asset class airports within transport infrastructure?
Is aviation finance (regional aircraft finance) part of the asset class energy and utilities within infrastructure?
Is aviation finance (regional aircraft finance) part of the asset class renewable energy within energy and utilities infrastructure?
Is aviation finance (regional aircraft finance) part of the asset class communications within infrastructure?

Within the capital structure, the focus is on public equity investments. Due to lack of data availability, this thesis does neither cover debt instruments nor private markets.

4 Methodology

The methodology first explains the aviation finance data set and how it was defined. Second, the infrastructure data set is presented and reasons for the choice of data are given.

4.1 Aviation Finance Data Set

Leasing companies are a good representation of the aviation capital market since they accounted for 70 per cent of the capital market financing volume in 2017 as outlined in the introduction. Further, as stated in chapter 2.3.3 leasing companies' market share of the number of operating aircraft worldwide is close to 40 per cent and expected to increase further. To identify aircraft leasing companies, the Bloomberg Industry Classification Systems (BICS) was used. BICS, which was developed by Bloomberg, classifies companies according to their general business activities (Di Clemente, Chiarotti, Cristelli, Tacchella, & Pietronero, n.d., p. 2). The aircraft finance and leasing classification contains 33 companies as of March 18, 2018 (Bloomberg, 2018a). These companies were sorted according to their percentage of revenue that corresponds to the specific classification. The next step filtered for companies that derive more than 90 per cent of their revenues from aircraft finance and leasing, which resulted in eleven companies with a total market capitalization of 19.6 billion USD and total revenues of 8.9 billion USD as of March 18, 2018 (Bloomberg, 2018a). Finally, selected were companies with historical data available back to December 2006 in order to capture a long enough time frame to make statistical inferences and a time frame that includes the global financial crisis of 2007/08. The final aircraft finance and leasing data set contains four companies, which account for 48 per cent of the classification's market capitalization of companies deriving more than 90 per cent of their revenues from aircraft finance and leasing and for 63 per cent of the total revenues generated by these companies (Bloomberg, 2018a). Table eight shows a summary of the selected four aircraft finance and leasing companies.

Table 8: Aircraft Finance and Leasing Companies

Company	Year Listed	Total Assets (mUSD)	Mkt Cap (mUSD)	% of Total (Top 11)	Revenues (mUSD)	% of Total (Top 11)	% Total Revenue Air. Fin.
Aircastle	2006	7’199	1'607	8.19%	797	8.94%	100%
PTB Group	2006	57	29	0.15%	35	0.39%	100%
AeroCentury	1998	236	24	0.12%	27	0.30%	100%
AerCap Holdings	2006	42’040	7'728	39.39%	4'714	52.92%	94%
Total		**49’532**	**9'387**	**47.85%**	**5'573**	**62.57%**	

Table eight shows basic information of the four aircraft finance and leasing companies selected. Total assets and revenues are as of year-end 2017 in million USD, except for PTB Group, whose balance sheet values are as of June 2017 due to the company's financial year ending in June. Market capitalization is as of March 18, 2018 in million USD. Year listed and total assets (mUSD) are retrieved from the Bloomberg database (2018b). All other values are retrieved from the Bloomberg database (2018a).

Aircastle Limited is listed on the New York Stock Exchange (NYSE) and acts worldwide as an acquirer, lessor and seller of commercial aircraft to airlines (Bloomberg, 2018c). PTB stands for Pacific Turbine Brisbane and is a public company traded on the Australian Stock Exchange and active in the aviation business (PTB, n.d., para. 1). Besides leasing, renting and financing short and long term aircraft and turbine engines as well as components of turbine engines, PTB Group offers repair and overhaul services of specific turbine engines (PTB, n.d., para. 2). AeroCentury is specialized in leasing to and providing financing for regional airlines and commercial customers throughout the world (AeroCentury, n.d., para. 1). AeroCentury is listed on the NYSE and is the oldest company in the data set (Bloomberg, 2018b). AerCap is the largest company in the data set. With a fleet value of 42 billion USD, AerCap dominates the aircraft leasing market and calls itself a "global leader in aircraft leasing and aviation finance" (AerCap, n.d., para. 1). The sample provides a good representation of the global aircraft finance and leasing market. According to Timotijevic (n.d., p. 21), there exist more than 150 aircraft leasing companies with an approximate market value of airplanes of 140 billion USD. The above sample represents 35 per cent of the said market. It is also aligned with the aircraft finance and leasing market being a fragmented market and includes one of the two major companies dominating the sector (Timotijevic, n.d., p. 21).

As a representation of the airlines market, the Standard & Poor's (S&P) 500 Airlines Index (S&P Airlines) was used, which consists of the five biggest airlines in the U.S. and thereby represents the U.S. airlines market with a total market capitalization of 130 billion USD (Bloomberg, 2018b). Table nine represents basic information of the index.

Table 9: S&P 500 Airlines Index

Index	Year Listed	Mkt Cap (mUSD)	# Index members	Sector
S&P 500 Airlines	1989	130'478	5	Airlines

Table nine shows an overview of the S&P 500 Airlines Index. All values are as of March 18, 2018 and retrieved from the Bloomberg database (2018b).

The four aircraft finance and leasing companies plus the S&P Airlines Index are chosen as a representation of the global aviation finance market. The aircraft finance and leasing companies PTB and AeroCentury are chosen as a representation of regional aircraft finance. As stated, AeroCentury provides financing to regional airlines. PTB is an Australian company and was chosen as part of the regional aircraft finance data set due to its size, which points at PTB being active in the regional market.

4.2 Infrastructure Data Set

Finding the relevant infrastructure indices was cumbersome, as there exist many infrastructure indices on a broad level, but not so many on a more specific level, namely the subcategories of infrastructure and the respective investment types as defined in chapter 2.2. The selected indices result from an extensive search of infrastructure indices and are based on a subjective assessment, data availability and/or size measured by market capitalization. As a representation of the economic infrastructure market, the S&P Global Infrastructure Index (S&P Infra), which consists of 73 infrastructure companies around the world and has balanced weights (each one third) to the utilities, transport and energy sector, was selected (Bloomberg, 2018c). Idzorek & Armstrong (2009, p. 10) list the S&P Infra as one of the majority listed infrastructure benchmarks. It was preferred to other indices that Idzorek & Armstrong (2009, pp. 10) list in their paper as it consists of balanced weights to the subsectors of economic infrastructure as compared to the MSCI All Country World Infrastructure (ACWI) Index for example that further includes the social sector, which is not covered by this thesis. Since the S&P Infra does not cover the communications sector, which is also a subcategory of economic infrastructure, the Dow Jones Brookfield Global Infrastructure Index (DJ Infra) was further included in the data set as a representation of the economic infrastructure market. The DJ Infra consists of companies that derive more than 70 per cent of their cash flows from the infrastructure business (Bloomberg, 2018c). It has a concentration towards energy and utilities when looking at the number of companies in the index (Bloomberg, 2018c). Telecommunication services are represented by three companies in the index (Bloomberg, 2018c).

As a representation of the transport market, the Dow Jones Transportation Average (DJ Transport) was selected, as it is a well-known index, whose history dates back to 1896 (Bloomberg, 2018c). Within the transport bucket, indices for airports and toll roads were identified. Hereby the data availability played a major role in selecting the respective indices. The Dow Jones Brookfield Toll Road Index (DJ TollRoad) consists of companies that derive more than 70 per cent of their cash flows from the infrastructure business and more than 50 per cent from the toll road sector (Bloomberg, 2018c). The Dow Jones Brookfield Airports Index (DJ Airport) consists of companies that derive more than 70 per cent of their cash flows from the infrastructure business and more than 50 per cent from the airport sector (Bloomberg, 2018c).

As a representation of the utilities sector, the S&P 500 Utilities Sector GICS Level 1 Index (S&P Util) was applied. GICS refers to the Global Industry Classification Standard, which was developed by MSCI and S&P Global in 1999 and classifies companies according to their primary business activity identified by the source of revenues (MSCI, n.d., para. 5). There are four levels of classification (MSCI, n.d., para. 5). Level one refers to the sector group, which is the broadest classification (Bloomberg, 2018c). Level two refers to industry groups, level three to industries and level four to sub-industries (MSCI, n.d. para. 5). The S&P Util consists of 28 utility companies and has a market capitalization of 644 billion USD as of March 18, 2018 (Bloomberg, 2018b). Within the utilities sector the MSCI ACWI Independent Power Producers & Renewable Electricity Producers Index (MSCI Ren) was selected. The index consists of 18 companies with a total market capitalization of 107 billion USD as of March 18, 2018 (Bloomberg, 2018b). As a representation of the communications sector, the Dow Jones Brookfield Communications Index (DJ Comm) was chosen. The index consists of "companies worldwide that are owners and operators of pure-play infrastructure assets" (S&P Dow Jones Indices, 2018, p. 3). These companies are active in the broadcast and mobile towers business, satellites and fiber optic/copper cable business, but exclude telecom services (S&P Dow Jones Indices, 2018, p. 17). Table ten provides an overview of the different infrastructure indices selected.

Table 10: Infrastructure Indices

Index	Year Listed	Mkt Cap (mUSD)	# Index members	Sector
S&P Global Infrastructure	2001	1'343'640	73	Infrastructure
Dow Jones Brookfield Global Infra	2002	1'125'749	103	Infrastructure
Dow Jones Transportation Average	1987	545'079	20	Transport
Dow Jones Brookfield Toll Road	2002	n.a.	n.a.	Toll Road
Dow Jones Brookfield Airports	2002	n.a.	n.a.	Airports
S&P Utilities Sector	1989	643'959	28	Utilities
MSCI ACWI Ind. Power Producers	2005	107'091	18	Renewable Energy
Dow Jones Brookfield Communications	1990	n.a.	n.a.	Communications

Table ten shows basic information of the different infrastructure indices. All values are as of March 18, 2018 and retrieved from the Bloomberg database (2018b).

To analyze the correlations of returns of the companies and indices selected, monthly price level and index data from Bloomberg was collected for the time frame from December 2006 to December 2017. This time period is long enough to make statistical inferences and includes the global financial crisis of 2007/08. For all indices, total return data gross dividends were used in order to avoid discrepancies coming from different dividend policies and payment dates and different tax jurisdictions. The indices are quoted in index points and the aircraft leasing companies are quoted in USD, except for PTB, which is an Australian company listed on the Australian Stock Exchange and quoted in Australian Dollars (AUD). Local currency returns were chosen to measure the correlation between returns in order to avoid an impact from currency movements. Further, eight data points for PTB in the selected sample period were not available. These data points were filled with the next previous available price. In four cases, the previous price was the price of the previous month, which results in four data points showing a return of zero per cent.

From November 2008 to February 2009, the data points were missing sequentially. Here, the stock price from October 2008 was carried forward until February 2009, resulting in another four data points that show a return of zero per cent. The calculated returns are discrete returns. The final sample includes 132 observations for each of the four companies and for each of the nine indices selected. Since the whole data set consists of equities and equity indices, mainly U.S. stocks and indices, the S&P 500 Index was included in the data set as a reference point and to support the analysis. Here also, the total return gross dividends index levels were used. In order to calculate the Sharpe ratio, the US Generic Government 10 Year Yield was used as the risk-free rate.

5 Results

This chapter presents the results. First, the risk-return analysis is presented. The risk-return analysis includes graphical representations of the price levels. Second, the correlation analysis provides insights to correlations during the whole sample period. Third, a regression analysis is carried out to support the results of the correlation analysis.

5.1 Risk-Return Analysis

Before the correlations are run with a statistical program, the price charts of the stocks and indices are shown, which allow for a first interpretation of a potential relationship between aviation finance and infrastructure. Figure four shows the index levels of the infrastructure indices and the S&P Airlines as well as the S&P 500 Index from December 2006 to December 2017. Figure five shows the price levels of the four aircraft leasing companies during the same time frame.

Figure 4: Index Levels of Indices 2006 – 2017

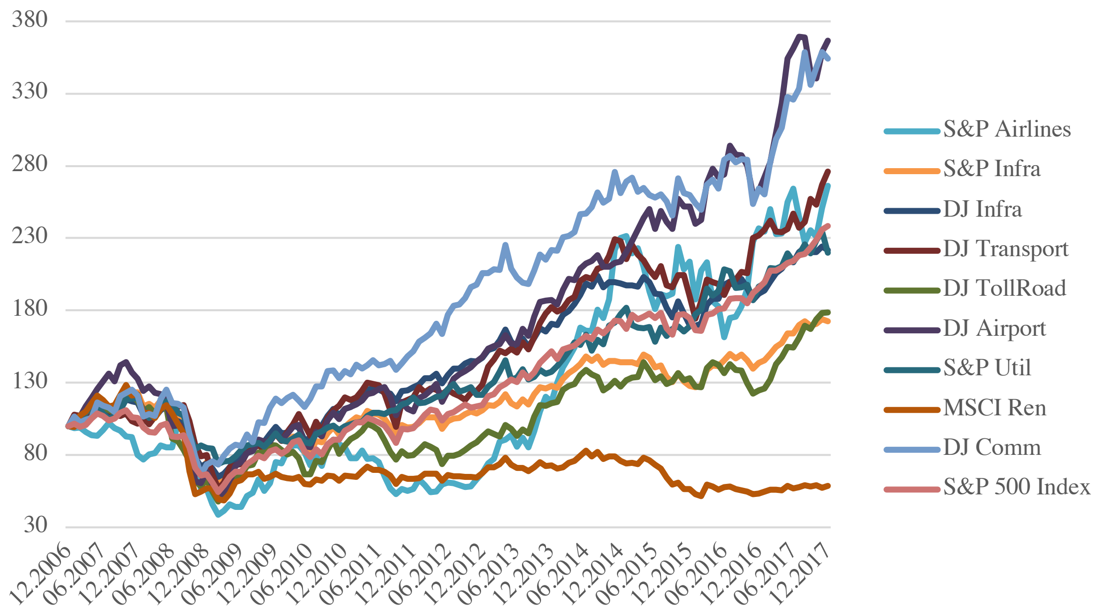

Figure four shows index levels of the infrastructure indices as well as the S&P 500 Index and the S&P Airlines, rescaled to 100. All values are retrieved from the Bloomberg database (2018d-m).

Figure four indicates a positive relationship between the different infrastructure indices, which was expected since they belong to the same asset class. The S&P Airlines, which represents the aviation finance asset class, shows a higher volatility. This is in line with airlines' business model of operating on low margins and being exposed to the volatile oil price. The S&P Airlines moves in the same direction as the infrastructure indices, indicating a positive relationship between the two asset classes. The DJ Comm, the DJ Transport and the DJ Airport are more volatile than the rest of the infrastructure indices. The DJ Transport for example moved from a scaled 228 level in December 2014 to 174 in January 2016, a drop of 24 per cent, whereas the S&P Infra (and the DJ Infra) moved from 144 (199) to 127 (169) levels, a drop of 12 per cent (15 per cent) over the same time frame. This suggests that the subcategories of infrastructure are more volatile than the economic infrastructure sector. The higher volatility of subcategories can be explained by the broader economic infrastructure indices providing more diversification than the more concentrated subcategories. The DJ TollRoad on the other hand moves closely with the two economic infrastructure indices. The DJ TollRoad and the two economic infrastructure indices are closely aligned with the overall equity market, represented by the S&P 500 Index. Figure four indicates that all of the indices have a positive relationship to the

S&P 500 Index. The MSCI Ren is the index that shows the weakest relationship to the other indices in the data set.

Figure 5: Price Levels of Aircraft Leasing Companies 2006 – 2017

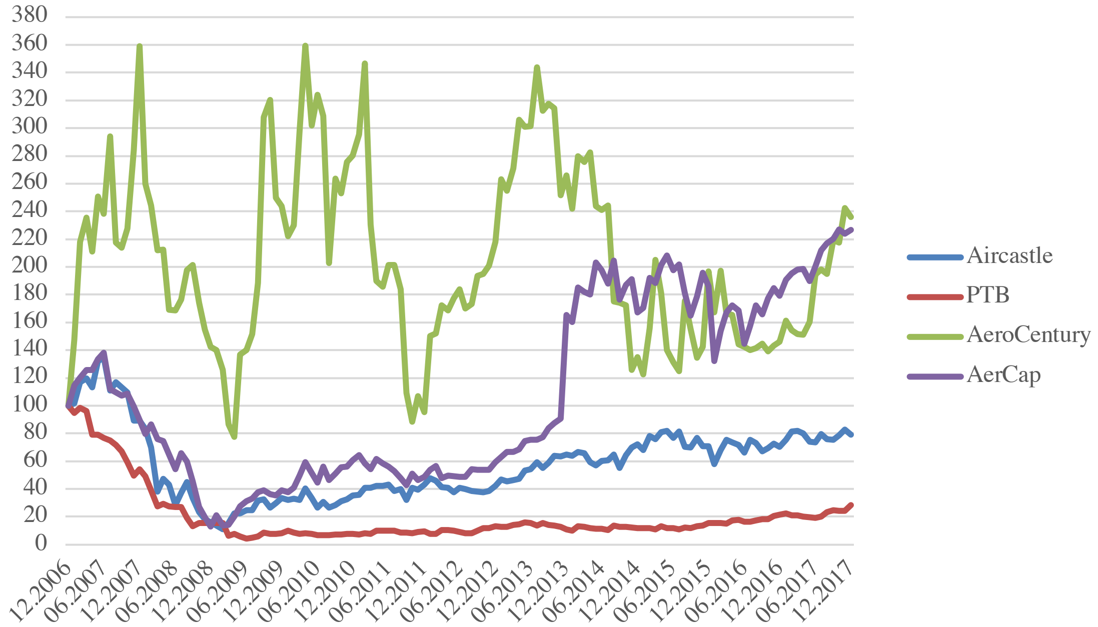

Figure five shows price levels in USD for Aircastle, AeroCentury and AerCap. The price level for PTB is in AUD. All values are rescaled to 100. All values are retrieved from the Bloomberg database (2018n-q).

Figure five shows that until October 2013 the stocks of Aircastle, AeroCentury and AerCap moved in the same direction. Then, AerCap's stock skyrocketed, whereas AeroCentury's stock plummeted and Aircastle's stock moved relatively stable in between the two. PTB's stock shows a different profile. It plummeted in the beginning of the sample period, between 2006 and 2009, and then moved relatively stable until the end of the sample period. When comparing figure five to figure four, it shows that the single stocks of the aircraft leasing companies move more or less in the same direction as the infrastructure indices, indicating a positive relationship between aviation finance and infrastructure. The aircraft leasing companies are much more volatile than the infrastructure indices, which is in line with the indices' nature of providing diversification and single stocks' nature of exhibiting idiosyncratic risk.

Table eleven shows the mean monthly return and standard deviation for the sample period for each of the four aircraft leasing companies, the S&P Airlines and the different infrastructure indices as well as for the S&P 500 Index. For better comparison of the results the Sharpe ratio was calculated. Further descriptive statistics, such as the minimum and maximum return as well as the skewness and kurtosis are included in the table to provide additional insights.

Table 11: Risk-Return / Descriptive Statistics 2006 – 2017

	Mean	Std. Deviation	Sharpe Ratio	Min.	Max.	Skew-ness	Excess Kurtosis
Aircastle	0.70%	13.05%	0.05	-45.39%	41.94%	0.01	1.86
PTB AUD	0.00%	13.19%	0.00	-60.00%	41.94%	-0.30	3.48
AeroCentury	2.21%	18.47%	0.12	-40.61%	76.57%	1.01	2.54
AerCap	1.66%	14.98%	0.11	-40.25%	82.36%	1.43	7.83
S&P Airlines	1.11%	8.55%	0.13	-26.57%	24.29%	-0.11	0.42
S&P Infra	0.52%	4.54%	0.12	-18.60%	12.36%	-0.88	2.23
DJ Infra	0.68%	3.90%	0.18	-14.54%	8.79%	-0.77	1.20
DJ Transport	0.93%	5.60%	0.17	-16.16%	17.21%	-0.33	1.15
DJ TollRoad	0.62%	5.98%	0.11	-18.70%	14.31%	-0.52	0.89
DJ Airport	1.19%	6.17%	0.20	-28.75%	18.33%	-1.09	4.00
S&P Util	0.68%	4.03%	0.17	-12.41%	8.05%	-0.87	0.82
MSCI Ren	-0.24%	5.57%	-0.04	-27.63%	15.31%	-1.19	5.61
DJ Comm	1.10%	5.24%	0.21	-16.52%	15.10%	-0.59	1.73
S&P 500 Index	0.75%	4.23%	0.18	-16.80%	10.93%	-0.78	1.88
Number of observations							*132*

Table eleven shows monthly risk-return characteristics and further descriptive statistics of the data set over the sample period December 2006 to December 2017. Except for the Sharpe ratio, all values are calculated with a statistical program. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d-r).

Over the whole sample period, AeroCentury provided the highest average monthly return of 2.21 per cent, but also the highest standard deviation of 18.47 per cent, which is reflected by the Sharpe ratio of 0.12 that ranges in the average of the whole data set. AerCap ranks second in terms of return, but also showed the second largest standard deviation in the data set and a similar Sharpe ratio to AeroCentury. Overall, the aviation finance data set provided higher returns than the infrastructure data set. However, the infrastructure indices clearly showed lower standard deviations and higher Sharpe ratios. The DJ Comm for example had the highest Sharpe ratio of 0.21, followed by the DJ Airport with a Sharpe ratio of 0.20 and the DJ Infra with a Sharpe ratio of 0.18. The MSCI Ren provided the only negative return in the data set.

Minimum and maximum returns were much higher for the aircraft leasing companies than for the infrastructure indices and also higher for the S&P Airlines. This indicates higher volatility for the aviation finance data set, which confirms the outcome of figure four and five in the previous chapter. The skewness was negative for all infrastructure indices, positive for three aircraft leasing companies and negative for the S&P Airlines as well as for PTB. Negative skewness means that there is a disproportionate large amount of extreme negative values (Van Eaton, 2016, p. 140). Positive skewness means that there is a disproportionate large amount of extreme positive values (Van Eaton, 2016, p. 140). Skewness indicates whether "deviations from the mean are more likely to be positive or negative" (Van Eaton, 2016, p. 140). The data set shows that infrastructure indices are more likely to return negative values than aircraft leasing companies. Even though skewness was negative for the S&P Airlines and PTB, it was much more negative for the infrastructure indices. AerCap shows the highest excess kurtosis with a value of 7.83. Kurtosis measures return deviations from the mean, whereby a higher value indicates that there is a higher probability of extreme deviations from the mean (Van Eaton, 2016, pp. 141). Excess kurtosis is the kurtosis above or below the kurtosis of the normal distribution, which is three (Van Eaton, 2016, p. 142). The high excess kurtosis value of AerCap indicates higher risk of the stock. Also, the excess kurtosis of the MSCI Ren is at a high level of 5.61, followed by the DJ Airport at a level of 4.00 and PTB, which shows a value of 3.48. The regional aircraft finance data set provided mixed results. Whereas the high return of AeroCentury could arise from it being a small cap stock, the return for PTB was zero on average. The high kurtosis of both PTB and AeroCentury points at a higher risk of regional aircraft finance but could also be due to the two stocks' nature of being small cap stocks.

5.2 Correlation Analysis

Correlation is measured for the whole sample period, which ranges from December 2006 to December 2017. Correlations are said to increase in times of financial and economic distress (Chin, 2013, p. 11). Correlations between asset classes increase during financial crises due to the flight into liquidity (Chin, 2013, p. 14). Therefore, the sample period was split in two sub-periods to detect a potential effect on correlations from the financial crisis of 2007/08. The results from the two sub-periods do not differ significantly and do not provide additional insights. Therefore, they were not included in the main part of the thesis and can be gathered from the appendix. Table twelve shows the monthly correlations between the aircraft leasing companies, the S&P Airlines and the infrastructure indices for the whole sample period. The full table that further includes correlations among the different infrastructure indices can be gathered from the appendix.

Table 12: Correlation Matrix 2006 – 2017

	Aircastle	PTB AUD	AeroCentury	AerCap	S&P Airlines
Aircastle	1				
PTB AUD	0.07	1			
AeroCentury	0.11	0.11*	1		
AerCap	0.51***	0.04	0.20***	1	
S&P Airlines	0.47***	0.06	0.12*	0.29***	1
S&P Infra	0.51***	0.02	0.18**	0.40***	0.40***
DJ Infra	0.50***	0.05	0.14*	0.42***	0.41***
DJ Transport	0.64***	0.05	0.1	0.42***	0.68***
DJ TollRoad	0.52***	0.02	0.13*	0.35***	0.43***
DJ Airport	0.52***	-0.03	0.27***	0.39***	0.44***
S&P Util	0.30***	-0.04	0.01	0.20**	0.21***
MSCI Ren	0.45***	0.13*	0.15**	0.44***	0.28***
DJ Comm	0.34***	0.07	0.10	0.30***	0.37***
S&P 500 Index	0.69***	0.05	0.14*	0.49***	0.54***

Table twelve shows the monthly correlations of the aircraft leasing companies and the S&P Airlines to the infrastructure indices and to the S&P 500 Index. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d-q).

Aircastle shows the highest positive correlations to the different infrastructure indices with all correlations being statistically significant at the one per cent level. Its highest correlation with a value of +0.69, however, is to the S&P 500 Index, suggesting a high correlation to the overall stock market. The S&P Airlines also shows positive correlations to all of the infrastructure indices and all correlations are statistically significant at the one per cent level. The S&P Airlines has its highest correlation with the DJ Transport with a value of +0.68, followed by its correlation to the S&P 500 Index at +0.54. AerCap shows positive correlations to all the infrastructure indices. These correlations are all statistically significant at the one per cent level, except for the correlation to the S&P Util, which is statistically significant at the five per cent level. AerCap also has its highest correlation, with a value of +0.49, to the S&P 500 Index. AeroCentury shows positive correlations to all the infrastructure indices, however, not all of them are statistically significant. AeroCentury has its highest correlation to the DJ Airport with a value of +0.27, which is statistically significant at the one per cent level. It also shows a statistically significant positive correlation of +0.18 to the S&P Infra. PTB shows very low and sometimes negative correlations to the infrastructure indices. Only the correlation to the MSCI Ren is statistically significant at the ten per cent level, but also with a low value of +0.13. The very low and negative correlations could be due to PTB being an Australian company and the rest of the data set referring to the U.S. market. Overall, global aviation finance has a high positive correlation to infrastructure, whereas regional aircraft finance has a low positive correlation to infrastructure. The high positive correlations between the aviation finance data set and the S&P 500 Index imply that the high correlations between global aviation finance and infrastructure might arise from equity markets. The regression analysis that follows tests how the S&P 500 Index and the infrastructure variables affect the aviation finance variables.

5.3 Regression Analysis

In order to find out how infrastructure returns affect aviation finance returns, the aviation finance variables (dependent y variables) are regressed on the infrastructure variables (independent x variables). The following two regression models were run for each of the aviation finance variables.

$$R_{\text{AviationFinance}} = \beta_0 + \beta_1 * R_{\text{S\&P 500}} + \varepsilon \qquad (1)$$

$$R_{\text{AviationFinance}} = \beta_0 + \beta_1 * R_{\text{S\&P 500}} + \beta_2 * R_{\text{S\&P Infra}} + \beta_3 * R_{\text{DJ Transport}} + \beta_4 * R_{\text{DJ TollRoad}} + \beta_5 * R_{\text{DJ Airport}} + \beta_6 * R_{\text{S\&P Util}} + \beta_7 * R_{\text{MSCI Ren}} + \beta_8 * R_{\text{DJ Comm}} + \varepsilon \qquad (2)$$

$R_{\text{AviationFinance}}$ = return of Aircastle, PTB, AeroCentury, AerCap, S&P Airlines respectively

β_0 = constant

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ = coefficients

$R_{\text{S\&P 500}}$ = return of the S&P 500 Index

$R_{\text{S\&P Infra}}$ = return of the S&P Infra

$R_{\text{DJ Transport}}$ = return of the DJ Transport

$R_{\text{DJ TollRoad}}$ = return of the DJ TollRoad

$R_{\text{DJ Airport}}$ = return of the DJ Airport
$R_{\text{S\&P Util}}$ = return of the S&P Util
$R_{\text{MSCI Ren}}$ = return of the MSCI Ren
$R_{\text{DJ Comm}}$ = return of the DJ Comm
ε = error term

Since both the S&P Infra and the DJ Infra represent economic infrastructure, only one variable had to be included in the regression model. Table twelve shows that there is no big difference in correlations between the aviation finance variables and the S&P Infra and the DJ Infra respectively. The S&P Infra was selected to run the regression models as its correlations to the aviation finance variables are more highly significant than the DJ Infra's correlations to the aviation finance variables.

The two regression models were run in order to find out if the variation of the returns in the aviation finance data set is mainly caused by the variation of the returns in the S&P 500 Index or if part of the variation can be explained by the infrastructure indices. The variation of returns of the dependent variable that is explained by the regression model is measured by the R-squared. The R-squared increases if additional independent variables are added to the regression model, even if these variables have no explanatory power (Bachmann, 2016a, p. 62). The adjusted R-squared solves this problem by adjusting for the number of independent variables used in the regression model (Bachmann, 2016a, p. 62). By comparing the adjusted R-squared of the two regression models, it can be assessed whether the infrastructure indices explain part of the variation of returns in the aviation finance data set. However, model (1) might suffer from specification bias. Specification bias occurs if significant independent variables are not captured by the regression model (Bachmann, 2016b, p. 3). If the omitted variables are correlated with the included variables, some of their influence is captured by the parameters of the included variables (Bachmann, 2016b, p. 3). Here, the S&P 500 Index (sole independent variable in model (1)) is highly correlated to the omitted independent variables, which are captured by model (2). The correlations can be gathered from the extended table twelve in the appendix. Therefore, part of the explanatory power of the infrastructure variables might be captured by the parameter estimate β_1 in model (1). The adjusted R-squared of model (1) could therefore appear higher than it actually is. Table 13 shows the adjusted R-squared of regression model (1) and regression model (2) for each dependent variable.

Table 13: Adjusted R-squared

	Model (1)	Model (2)
Aircastle	46.74%	49.47%
PTB AUD	-0.50%	3.55%
AeroCentury	1.24%	6.70%
AerCap	23.12%	23.97%
S&P Airlines	28.71%	49.09%

Table 13 shows the adjusted R-squared of regression model (1) and regression model (2) for each dependent variable. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d-q).

Both models are statistically significant for each dependent variable except for model (1) with dependent variable PTB. For all variables of the aviation finance data set, including infrastructure indices in addition to the S&P 500 Index improves the explanatory power of the model as can be seen from the increasing R-squared from model (1) to model (2) in table 13. The biggest improvement is seen for dependent variable S&P Airlines. AerCap's model minimally improves. Aircastle's and AeroCentury's models slightly improve, however in the case of AeroCentury, the explanatory power of the model still is extremely low. In the case of PTB and AeroCentury, it can be said that neither the S&P 500 Index nor the infrastructure indices cause a main part of the variation of returns in these stocks. All regression results can be gathered from the appendix. In the following, the regression results of model (2) for S&P Airlines, Aircastle and AerCap are presented as the models (2) provide a better fit than the models (1) and are meaningful only for these three dependent variables.

The results of the regression model (2) for the dependent variable S&P Airlines are shown in table 14.

Table 14: Regression Results Model (2) – S&P Airlines

dependent variable				*S&P Airlines*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	−0.006	0.006	0.284	
S&P 500 Index	−0.248	0.322	0.442	
S&P Infra	−0.851	0.465	0.070	*
DJ Transport	1.196	0.189	<0.0001	***
DJ TollRoad	0.233	0.248	0.350	
DJ Airport	0.376	0.168	0.028	**
S&P Util	0.257	0.182	0.160	
MSCI Ren	−0.318	0.154	0.042	**
DJ Comm	0.372	0.156	0.018	**
Number of observations				*132*
F(8, 123)				*19.14373*
P-value(F)				*1.89e-18*
Adjusted R-squared				*0.490931*

Table 14 shows the regression results of model (2) for the dependent variable S&P Airlines. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d-m).

Table 14 shows that if the S&P 500 Index increases by one per cent, the S&P Airlines decreases by 0.248 per cent holding all other variables constant. Also, the marginal effect of the S&P Infra on the S&P Airlines is negative. This could be due to the S&P Infra's high correlation to the subcategories and investment types of infrastructure, indicating that its effect is captured by one or more of the other independent variables in the model. Same applies to the S&P 500 Index. The marginal effect of the DJ Transport is highly significant and states that if the DJ Transport increases by one per cent, the S&P Airlines increases by 1.196 per cent holding all other variables constant. Also the marginal effect of the variables DJ Airport and DJ Comm is positive and significant at the five per cent level.

Table 15 shows the results of the regression model (2) for the dependent variable Aircastle.

Table 15: Regression Results Model (2) – Aircastle

dependent variable				*Aircastle*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	−0.011	0.006	0.072	*
S&P 500 Index	2.278	0.554	<0.0001	***
S&P Infra	−2.301	0.775	0.004	***
DJ Transport	0.336	0.311	0.282	
DJ TollRoad	0.708	0.314	0.026	**
DJ Airport	0.384	0.269	0.156	
S&P Util	0.435	0.194	0.027	**
MSCI Ren	0.257	0.232	0.270	
DJ Comm	−0.129	0.255	0.614	
Number of observations				*132*
F(8, 123)				*34.44489*
P-value(F)				*5.72e-28*
Adjusted R-squared				*0.494668*

Table 15 shows the regression results of model (2) for the dependent variable Aircastle. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018e-n).

Aircastle's model slightly improved by including the infrastructure indices in the second regression. The only slight improvement indicates that most of the variation of the returns in Aircastle's stock is explained by the variation of returns in the S&P 500 Index. Table 15 shows that if the S&P 500 Index increases by one per cent, Aircastle increases by 2.278 per cent holding all other variables constant. Here also, the marginal effect of the S&P Infra is negative, indicating that its effect is captured by one or more of the other independent variables in the model. If the DJ TollRoad increases by one per cent, Aircastle increases by 0.708 per cent holding all other variables constant. If the S&P Util increases by one per cent, Aircastle increases by 0.435 per cent holding all other variables constant. Both marginal effects of the DJ TollRoad and the S&P Util are positive and statistically significant at the five per cent level.

Table 16 shows the results of the regression model (2) for the dependent variable AerCap.

Table 16: Regression Results Model (2) – AerCap

dependent variable				*AerCap*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	0.012	0.011	0.289	
S&P 500 Index	1.711	0.891	0.057	*
S&P Infra	−1.063	1.321	0.422	
DJ Transport	0.046	0.413	0.911	
DJ TollRoad	−0.072	0.350	0.837	
DJ Airport	0.142	0.470	0.764	
S&P Util	−0.436	0.362	0.232	
MSCI Ren	1.065	0.584	0.071	*
DJ Comm	0.084	0.384	0.828	
Number of observations				*132*
F(8, 123)				*13.49259*
P-value(F)				*6.87e-14*
Adjusted R-squared				*0.239719*

Table 16 shows the regression results of model (2) for the dependent variable AerCap. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018e-m,q).

AerCap's model minimally improved by including the infrastructure indices in the second regression. The only minimal improvement indicates that most of the variation of the returns in AerCap's stock is explained by the variation of returns in the S&P 500 Index rather than by infrastructure indices. As well as for Aircastle and the S&P Airlines, S&P Infra's marginal effect on AerCap is negative. Its effect could be captured by one or more of the other infrastructure variables or more likely by the S&P 500 Index. Most of the independent variables in the model are not statistically significant, which again confirms that most of the variation of the returns in AerCap' stock is explained by the variation of returns in the S&P 500 Index and additional variables that are not included in the model.

6 Discussion and Analysis of Results

In order to answer the main research question and the sub-questions the following structure is followed. Economic fundamentals and specific characteristics, namely asset characteristics and cash flow / revenue characteristics of infrastructure and aviation finance are weighed against each other. Further, based on the results of the quantitative part it is assessed whether infrastructure and aviation finance exhibit similar risk-return characteristics and high correlations to each other. The regression analysis supports the discussion and analysis of the results. The main research question to be answered is:

Is aviation finance part of the asset class infrastructure?

Table 17 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of infrastructure and aviation finance.

Table 17: Infrastructure vs. Aviation Finance

Criteria	Infrastructure	Aviation Finance
Economic Fundamentals	Key public service	Global economic growth
	Low elasticity of demand	Private consumption
		Emerging market growth
		Oil price volatility
Asset	Long economic life	Long economic life
	Locality	Limited asset characteristics
	Immovability	Mobility
	Local currency	USD currency
	Regulation	Regulation
		Sustainability requirements
		Safety requirements
	Capital intensive	Capital intensive
		Technological change
	Illiquidity	Reasonable liquidity
Cash flows / Revenues	Regular, stable cash flows	Long-term quasi-stable cash flows
	Inflation protection	Fixed lease rates for lease term
		Aircraft part-outs (end life)
Risk-Return	Lower returns	Higher returns
	Lower risk / volatility	Higher risk / volatility
Correlation	relatively high positive correlation	

Table 17 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of infrastructure and aviation finance.

The biggest difference between infrastructure and aviation finance is the elasticity of demand. Infrastructure provides key services to the public, whereas aviation finance depends on global economic growth. Infrastructure has a captive customer base that consumes the service also during economic downturns. Aviation finance on the other hand is driven by demand for air travel, economic growth and private consumption. All these variables require a healthy economic environment. Infrastructure being more defensive than aviation finance is also reflected by the lower volatility of infrastructure returns compared to aviation finance returns resulting from the risk-return analysis in chapter 5.1 and shown in table eleven. However, the higher volatility of aviation finance could be a result of the aviation finance data set mainly covering single stocks, whereas infrastructure is represented by indices. Indices provide diversification and single stocks exhibit idiosyncratic risk. Looking at table five in chapter 2.3.1.2, individual aircraft types show similar risk-adjusted returns as aircraft leasing companies. However, the two data sets cannot be compared directly as they do not cover the same time frame. Further, since aircraft leasing companies own different types of aircraft, they should provide diversification and be less risky than an exposure to a single aircraft type.

Infrastructure and aviation finance exhibit some similar asset characteristics. Both assets have long economic lives, require high initial capital investments and are subject to regulation. But there are also significant differences between the two assets. Infrastructure is a local business. Most of the infrastructure assets cannot be moved and are affected by the local legal, political and regulatory environment. Further, infrastructure assets are typically financed in local currency. This results in infrastructure assets being unique in their nature. The asset underlying aviation finance is the aircraft, which is movable around the globe and traded in USD. Further, the asset characteristics of aircraft are limited. Airlines operate on similar aircraft worldwide, which makes the aircraft a homogeneous asset that is exposed to common risk factors. These distinctive characteristics result in infrastructure assets being highly illiquid, whereas aviation finance assets are reasonable liquid in comparison. A similar characteristic of the two assets is the long-term nature of cash flows. Infrastructure cash flows are stable due to the captive customer base and the low elasticity of demand. Further, they sometimes provide inflation protection. In terms of aircraft leasing, the lease income per month declines with the age of the aircraft due to depreciation, but increases in relative terms as reflected by the LRF. Since lease rates are fixed at the beginning of the lease term, aircraft leasing companies are exposed to interest rate risk.

The correlation analysis shows statistically significant positive correlations between aviation finance and infrastructure. The correlation between the two asset classes is relatively high. However, the regression analysis shows that in most cases the variation of returns in aviation finance is caused by the variation of returns in the S&P 500 Index. This result arises from comparing listed equity of aircraft leasing companies and listed equity of airlines to listed equity of infrastructure companies. It is clear that the equity market influences the result. In the qualitative part, differences between the two asset classes outweigh similarities. The quantitative part provides mixed results, which could be due to the limited data availability. Since the above discussed characteristics of infrastructure are valid only for the most conservative structures, the research question whether aviation finance is part of the asset class infrastructure is not answered based solely on these characteristics. First, the sub-questions concerning the subcategories and investment types of infrastructure must be discussed. Before that, the results of the regional aircraft market are discussed and analyzed. The first sub-question is:

Is regional aircraft finance part of the asset class infrastructure?

Table 18 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of infrastructure and regional aircraft finance. Regional aircraft finance is subject to the same characteristics as global aviation finance plus additional characteristics. To avoid duplication from table 17, the most important characteristics that are meaningful for the analysis of regional aircraft finance are mentioned in table 18. The characteristics that are emphasized in regional aircraft finance are highlighted in grey.

Table 18: Infrastructure vs. Regional Aircraft Finance

Criteria	Infrastructure	Regional Aircraft Finance
Economic Fundamentals	Key public service	Economic growth
	Low elasticity of demand	Private consumption
		Share of middle class
		Urbanization
Asset	Long economic life	Long economic life
	Locality	Limited asset characteristics
	Immovability	Mobility
	Local currency	USD currency
	Regulation	Regulation
		Trade policies
		Lack of pilots
		Lack of infrastructure
		Difficult access to airports
	Capital intensive	Capital intensive
	Illiquidity	Reasonable liquidity
Cash flows / Revenues	Regular, stable cash flows	Long-term quasi-stable cash flows
	Inflation protection	Fixed lease rates for lease term
		Aircraft part-outs (end life)
Risk-Return	Lower returns	Higher returns
	Lower risk / volatility	Higher risk / volatility
Correlation	low positive correlation	

Table 18 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of infrastructure and regional aircraft finance.

The demand for regional aircraft finance is driven by the growth in emerging markets. The increasing share of the middle class and a movement towards urbanization drives demand for air travel in emerging markets. In the regional aircraft market as well, a healthy economic environment is key, whereas infrastructure is less affected by economic downturns. But, regional aircraft markets are less sensitive to economic conditions than the global aircraft market, pointing at a similarity to infrastructure. On the other hand, urbanization not only drives demand for regional aircraft, but also demand for infrastructure.

In addition to the asset similarities and differences discussed for global aviation finance and infrastructure, regional aircraft finance is affected by the lack of pilots and the lack of infrastructure. Lack of pilots is a general problem in aviation, but could affect regional aircraft more as a lower number of different routes in the region is provided by airlines, whereas larger routes are more likely to be served anyway. In emerging markets, the lack of infrastructure, especially the low number of airports limits regional air travel. Also, the access to airports is limited due to the lack of public transportation. This provides a direct link between regional aircraft finance and infrastructure. Demand for regional air travel drives demand for aircraft, which drives demand for infrastructure.

The cash flows and the risk-return profile of regional aircraft finance do not differ from that of global aviation finance and therefore are not similar to infrastructure, except for the long-term nature of cash flows. The two regional aircraft leasing companies in the data set show a similar risk-return profile to the rest of the aviation finance data set. The correlation of returns between infrastructure and regional aircraft finance is positive, but much smaller than that of global aviation finance. Further, only part of the correlations are statistically significant. The results of the regression analysis show that the variation of infrastructure returns does not explain a significant part of the variation of returns in regional aircraft finance. This could be due to the size of the regional aircraft leasing companies as shown in table eight, which is much smaller than the rest of the aviation finance data set. In addition to idiosyncratic risk, small cap companies are affected by a size risk, which could affect the results of the regression analysis. Even though there are more similarities between regional aircraft finance and infrastructure, the differences outweigh. Again, the above outlined characteristics of infrastructure are valid only for the most conservative structures. Before the sub-question whether regional aircraft finance is part of the asset class infrastructure is answered, the following sub-questions regarding subcategories and investment types of infrastructure are discussed and analyzed.

Is aviation finance (regional aircraft finance) part of the asset class transport within infrastructure?
Is aviation finance (regional aircraft finance) part of the asset class toll roads within transport infrastructure?
Is aviation finance (regional aircraft finance) part of the asset class airports within transport infrastructure?

Table 19 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of transport infrastructure, toll roads, airports and aviation finance. Toll roads and airports are investment types that belong to the transport category. As shown in figure one the transport category is broader and includes further transport facilities. Table 19 includes characteristics of the global aviation finance market, since these are also valid for regional aircraft finance. Each sub-question is also answered for regional aircraft finance with the insights gained from the previous paragraphs and table 18.

Table 19: Transport Infrastructure vs. Aviation Finance

Criteria	Transport	Toll Roads	Airports	Aviation Finance
Economic Fundamentals	Strong correlation to GDP growth	GDP growth / consumption levels	Size, wealth, strength of economy	Global economic growth
	Traffic volume	Traffic volume	Passenger volume	Private consumption
		Moderate elasticity of demand	Business activity / educational level	Emerging market growth
		Indirect relationship to oil price	Indirect relationship to oil price	Oil price volatility
Asset	Sustainability requirements			Sustainability requirements
	Safety requirements			Safety requirements
		Regulation		Regulation
	Locality	Locality	Locality	Mobility
	Local currency			USD currency
				Long economic life
				Capital intensive
		Traffic control	Home base airline	Limited asset characteristics
				Technology
				Reasonable liquidity
Cash flows / Revenues	User charges	User charges	User payments (e.g. airlines)	Long-term quasi-stable cash flows
	Retail, franchising commercials	Traffic composition	Non-aviation services (e.g. shopping)	Fixed lease rates for lease term
	Taxes, charges	Taxes	Land / office rentals	Aircraft part-outs (end life)
Risk-Return	Lower returns	Lower returns	Similar returns	Higher returns
	Lower risk / volatility	Lower risk / volatility	Lower risk / volatility	Higher risk / volatility
Correlation	relatively high positive correlation			

Table 19 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of transport infrastructure including toll roads and airports, and aviation finance.

Transport, toll roads, airports and aviation finance are all affected by global economic growth. Whereas toll roads are less affected by economic downturns due to certain routes that cannot be circumvented, airports exhibit a higher discretionary component. Commercial traffic is more sensitive to the economic cycle than commuter traffic, but less sensitive than leisure traffic. That is why the composition of traffic affects a toll road's revenues. Airports' and aviation's traffic mainly consist of commercial and leisure traffic, which makes them more exposed to economic downturns. Toll roads, airports as well as aviation finance are affected by the volatility in the oil price, either directly or indirectly. Sustainability and safety requirements are both characteristics that transport and aviation finance share. The biggest difference between transport infrastructure including toll roads and airports and aviation finance is the locality. Toll roads and airports are affected by the local economy and the region nearby. Both toll roads and airports face higher competition from alternative facilities than aviation finance. Transport including toll roads and airports have the possibility to diversify their revenue streams through shopping, traffic composition or land rentals for example. In the case of aviation finance, the aircraft can be sold in parts at the end of its life, which provides additional return when the asset is wasting.

Looking at table eleven in chapter 5.1, aviation finance provides higher returns than transport and toll roads. Airports, however, provide similar returns to aviation finance. Transport, toll roads and airports are less risky than aviation finance. Especially transport and airports provide more attractive risk-adjusted returns than aviation finance. Toll road's Sharpe ratio is similar to that of aviation finance, which is not in line with the more stable demand toll roads provide. As table twelve in chapter 5.2 shows, the positive correlation of returns is the highest for transport, followed by airports. In the case of regional aircraft finance, the correlation of returns is the highest for airports, followed by toll roads. The regression models (chapter 5.3) for S&P Airlines (table 14) and Aircastle (table 15) show that transport, toll roads and airports all have a marginal positive effect on aviation finance.

Aviation finance shows the most similar economic fundamentals to airports. Even though airports are affected by the local economy, especially if most of their revenues come from non-aviation services, they also have an exposure to the global economy. Especially primary airports, which are hub or transfer airports are affected by the global economy. Consumption is another factor that prevails in airports and aviation finance. Safety requirements start at the airport and also affect aviation finance. Airports further exhibit the common characteristics of infrastructure such as long economic lives and large capital investments, which are characteristics of aviation finance. Although the economic life is longer and the capital investment is larger in the case of airports. In both airports and aviation finance, airlines are paying users of the asset. The similar returns of airports to aviation finance and the relatively high positive correlation between the two provide further arguments for classifying aviation finance as part of the airport investment type. The direct link between regional aircraft finance and transport infrastructure requirements speaks for a classification of regional aircraft finance as part of the transport subcategory. Regional aircraft finance is more closely linked to locality than global aviation finance and herewith provides another argument for a classification under transport. Regional aircraft finance' lower sensitivity to economic downturns speaks for a classification under toll roads. Regional aircraft finance' connection especially to airport infrastructure requirements speaks for a classification under airports. However, risk-return characteristics of transport infrastructure including airports and toll roads are not similar to regional aircraft finance and correlation is low. As this could be due to the data set chosen, running the analysis with another data set might provide more insights. Before aviation finance and regional aircraft finance are finally classified, the following sub-questions regarding the other subcategories and investment types of infrastructure are discussed and analyzed.

Is aviation finance (regional aircraft finance) part of the asset class energy and utilities within infrastructure?
Is aviation finance (regional aircraft finance) part of the asset class renewable energy within energy and utilities infrastructure?

Table 20 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of energy and utilities, renewable energy and aviation finance respectively.

Table 20: Energy and Utilities vs. Aviation Finance

Criteria	Energy and Utilities	Renewable Energy	Aviation Finance
Economic Fundamentals	Industrial activity, transport, buildings	Government support drives demand	Global economic growth
	Personal incomes (emerging markets)		Private consumption
	Urbanization (emerging markets)		Emerging market growth
	Low elasticity of demand		
	Demand for air travel		
	Direct relationship to oil price		Oil price volatility
Asset			Sustainability requirements
			Safety requirements
	Monopoly, high barriers to entry (T&D)	National and emission policies	Regulation
		Long distance	Mobility
			USD currency
			Long economic life
			Capital intensive
			Limited asset characteristics
		Cannot be stored	Technological change
			Reasonable liquidity
Cash flows / Revenues	Sale of electricity (power generation)	Subsidies (price certainty, quotas)	
	Regulated revenues (T&D)	Predictable, long-term cash flows	Long-term quasi-stable cash flows
	Inflation protection (T&D)		Fixed lease rates for lease term
	Energy storage revenues		Aircraft part-outs (end life)
Risk-Return	Lower returns	Lower returns	Higher returns
	Lower risk / volatility	Lower risk / volatility	Higher risk / volatility
Correlation	relatively low positive correlation	Moderate positive correlation	

Table 20 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of energy and utilities, renewable energy and aviation finance respectively.

Energy and utilities and aviation finance are both dependent on industrial activity translating in global economic growth. The demand for air travel affects both energy and utilities and aviation finance. In the former the demand for air travel increases demand for jet fuel and therewith demand for energy. In the latter demand for air travel increases demand for aircraft and therewith demand for aviation finance. However, the demand for energy and utilities is more stable than the demand for air travel. Increasing usage of electricity is expected from urbanization and the rise in personal incomes in emerging markets, which are the same characteristics that affect regional aircraft finance. In some regions electricity has a direct relationship to the oil price depending on oil being a major source of electricity generation or not, which points at electricity being a local business.

Energy and utilities as well as renewable energy are highly regulated markets with high barriers to entry. Aviation finance is also highly regulated and has high barriers to entry, but there is healthy competition between airlines and increasingly so between aircraft leasing companies. Whereas energy and utilities as well as renewable energy are subsidized by the government, aviation finance is not. Some airlines profit from government support, but it is not a main characteristic of aviation finance. Renewable energy producers face technical challenges as renewable energy cannot be stored. Whereas technological change affects renewable energy producers positively, it affects aviation finance both positively and negatively. When a new technology is introduced, existing aircraft lose value, which negatively affects the performance of aviation finance. Demand for new aircraft with advanced technology on the other hand positively affects aviation finance.

Energy and utilities including renewable energy and aviation finance differ in their risk-return profile. Correlations are higher between renewable energy and aviation finance than between energy and utilities and aviation finance, but still lower than the correlations from the transport sector and infrastructure overall. The inconsistent results of the regression models do not provide additional information. Based on the qualitative and quantitative analysis, aviation finance is not part of the asset class energy and utilities. Aviation finance is also not part of the asset class renewable energy. Regional aircraft finance shows more common characteristics to energy and utilities than global aviation finance, especially local considerations and emerging market growth. However, due to the data limitations of the regional aircraft finance data set, the two sub-questions whether regional aircraft finance is part of the asset class energy and utilities (renewable energy within energy and utilities) within infrastructure cannot be answered. The final sub-question reads as follows:

Is aviation finance (regional aircraft finance) part of the asset class communications within infrastructure?

Table 21 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of communications and aviation finance.

Table 21: Communications vs. Aviation Finance

Criteria	Communications	Aviation Finance
Economic Fundamentals	Mobile traffic growth	Global economic growth
	Long-term growth wireless utilization	Private consumption
	Demand for mobile data and IoT	Emerging market growth
	Indirect relationship to oil price	Oil price volatility
Asset	Sustainability requirements	Sustainability requirements
	Maintenance is key	Safety requirements
		Regulation
	Global	Mobility
		USD currency
		Long economic life
		Capital intensive
		Limited asset characteristics
		Technological change
		Reasonable liquidity
Cash flows / Revenues	Long-term, stable and growing cash flows	Long-term quasi-stable cash flows
		Fixed lease rates for lease term
		Aircraft part-outs (end life)
Risk-Return	Similar returns	
	Lower risk / volatility	Higher risk / volatility
Correlation	relatively low positive correlation	

Table 21 shows the economic fundamentals and specific characteristics as well as the risk-return and correlation characteristics of communications and aviation finance.

The key driver of demand for communications is the long-term growth of global wireless utilization. Global connectivity becomes increasingly important and in today's world demand for mobile data is a stable demand, relatively reluctant to economic downturns. Aviation finance is more cyclical. Both communications and aviation finance are affected by the oil price. In the case of communications, fuel is a main part of a an operator's network costs. The energy consumption of telecom towers evoke sustainability requirements, same applies to aviation finance. Communications is a global business, same as aviation finance. Whereas aircraft leasing companies' cash flows decrease on an absolute basis with the age of the aircraft, cash flows from communications typically increase on an annual basis.

Aviation finance and communications show similar returns, however aviation finance has higher volatility. Communications has the highest Sharpe ratio in the data set as shown in table eleven of chapter 5.1, which is in line with the relatively stable demand for communication. The correlation between communications and aviation finance is relatively low compared to the other infrastructure indices. The inconsistent results of the regression models do not provide additional information. Based on this analysis, aviation finance is not part of the asset class communications. Regional aircraft finance' similarity to communications is the lower sensitivity to the economic cycle and the increasing share of the middle class in emerging markets, which increases demand for mobile data. Increasing demand for mobile data will also increase infrastructure requirements in emerging markets. Risk-return characteristics of communications differ from regional aircraft finance' risk-return characteristics. The correlations between the two are low and not statistically significant. Due to the data limitations of the regional aircraft finance data set the sub-question whether regional aircraft finance is part of the asset class communications cannot be answered.

7 Conclusion and Outlook

Aviation finance shows similar economic characteristics, similar asset characteristics, similar cash flows, similar risk-return characteristics and a high correlation to airports. None of the other investment types showed similarities in each assessment criteria and the sub-questions were answered accordingly. However, aviation finance still shows some peculiarities that suggest it is an investment type in its own right. The mobility of the aircraft around the globe, its limited asset characteristics as well as it being a naturally wasting asset distinguish it from other assets. Aviation finance is not part of the investment type airports within transport infrastructure. And aviation finance is not part of the investment type toll roads within transport infrastructure. But, aviation finance is part of the subcategory transport within infrastructure. Toll roads and airports differ in their elasticity of demand for example, but belong to transport due to certain similarities, such as traffic volume and locality. Aviation finance differs from toll roads and airports in its mobility for example, but also exhibits certain similarities such as sustainability and safety requirements. Consequently, aviation finance is part of the asset class infrastructure. The sub-questions whether regional aircraft finance is part of the asset class communications, energy and utilities and renewable energy could not be answered due to data limitations. Data limitations also limit validity of regional aircraft finance classification under the subcategory transport and investment types toll roads and airports. Regional aircraft finance is more similar to infrastructure concerning locality and emerging market growth that drives demand for regional aircraft as well as demand for local infrastructure. But are these characteristics sufficient for a classification of regional aircraft finance under infrastructure? As regional aircraft finance is part of global aviation finance and affected by the same characteristics as global aviation finance, it could be classified within the investment type aviation finance as part of transport infrastructure. But due to the data limitations mentioned above this sub-question cannot be answered completely. A further study could analyze asset classification of regional aircraft finance under consideration of its local and global factors.

A key driver for classifying aviation finance as part of the subcategory transport was the high discretionary component, which is similar to airports. An analysis of the discretionary component of the different infrastructure subcategories and especially the investment types toll roads, airports and aviation finance could be subject to further research. The composition of airports' revenues is another factor that provides insights to the discretionary component. Airports that derive most of their revenues from shopping could exhibit a higher discretionary component than airports whose main revenues come from airlines user payments. The question is which part of air travel is in demand in any state of the economy and which part is subject to a healthy economic environment and economic growth. The discretionary component could answer this question and highlight similarities between airports and aviation finance. A key limitation of the analysis carried out in this thesis was the limited data availability. This thesis worked with public equity of aircraft leasing companies and equity indices of airlines and infrastructure, which provides an investment opportunity set that is overlapping. An analysis of the private market could provide additional insights, but would also provide an overlapping investment opportunity set. Further research could analyze debt capital investments in infrastructure and aviation finance and test whether this analysis comes to the same conclusions as this thesis.

Aviation finance and infrastructure are both assets with peculiarities. In both cases the physical asset is at its core. This thesis showed that aviation finance is part of the infrastructure asset class. The analysis, however, started at the bottom of the asset class. First, aviation finance was compared to toll roads and airports, where most similarities to airports were identified. Since airports belong to the subcategory transport, aviation finance was classified as transport infrastructure. And finally, since transport is a subcategory of infrastructure, it was classified as part of the asset class infrastructure. This analysis showed how important it is to closely examine the asset in consideration in order to classify it accordingly and not rely on general characteristics.

8 List of References

AerCap (n.d.). *Who We Are*. Retrieved from https://www.aercap.com/about/who-we-are/

AeroCentury (n.d.). *Worldwide, Regional Aircraft, Leasing*. Retrieved from http://www.aerocentury.com/

Airbus (2017). *Global Market Forecast. Growing Horizons 2017/2036*. Retrieved from http://www.airbus.com/content/dam/corporate-topics/publications/backgrounders/Airbus_Global_Market_Forecast_2017-2036_Growing_Horizons_full_book.pdf

Airbus (n.d.a). *A320 Family. The best keeps getting better*. Retrieved from http://www.airbus.com/aircraft/passenger-aircraft/a320-family.html

Airbus (n.d.b). *A330-800neo. Powering into the future*. Retrieved from http://www.airbus.com/aircraft/passenger-aircraft/a330-family/a330-800neo.html

Ankrim, E.M., & Hensel, C.R. (1993). Commodities in Asset Allocation: A Real-Asset Alternative to Real Estate? *Financial Analysts Journal,* 49:3, 20–29.

Ascend Advisory (n.d.). *Ascend Aircraft Investment Index. Benchmarking Historical Performance of Aircraft Leasing*. Retrieved from http://aviatia.ro/wp-content/uploads/docs/Ascend_Aircraft_Investment_Index_Aircraft_Leasing.pdf

Bachmann, O. (2016a). *Estimation*. Fall Semester 2016. Winterthur: Zurich University of Applied Sciences, School of Management and Law.

Bachmann, O. (2016b). *Diagnostics*. Fall Semester 2016. Winterthur: Zurich University of Applied Sciences, School of Management and Law.

Barry, J., Andrews, A.V., & Synnott, A. (2015). *Infrastructure Rising. An Asset Class Takes Shape*. Retrieved from https://www.laforum.co.uk/download-manager/download-white-paper/220/

Bianchi, R., Drew, M., & Whittaker, T. (2017). *Is "Listed Infrastructure" a fake asset class? An asset pricing approach*. Retrieved from http://edhec.infrastructure.institute/wp-content/uploads/publications/bianchi_whittaker2017.pdf

Bloomberg, L.P. (2018a). *Bloomberg Industry Classification Systems (BICS) as of 18 March 2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018b). *Bloomberg Fields (FLDS)*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018c). *Bloomberg Security Descriptions (DES)*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018d). *Historical Prices (HP) for S5AIRLTR Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018e). *Historical Prices (HP) for SPGTINTR Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018f). *Historical Prices (HP) for DJBGIT Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018g). *Historical Prices (HP) for DJTTR Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018h). *Historical Prices (HP) for DJBTRT Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018i). *Historical Prices (HP) for DJBART Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018j). *Historical Prices (HP) for S5UTIL Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018k). *Historical Prices (HP) for MXWD0IP Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018l). *Historical Prices (HP) for DJBCMT Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018m). *Historical Prices (HP) for SPXT Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018n). *Historical Prices (HP) for AYR US Equity from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018o). *Historical Prices (HP) for PTB AU Equity from 29.12.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018p). *Historical Prices (HP) for ACY US Equity from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018q). *Historical Prices (HP) for AER US Equity from 30.11.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Bloomberg, L.P. (2018r). *Historical Prices (HP) for USGG10YR Index from 31.10.2006 – 31.01.2018*. Retrieved from the Bloomberg database.

Boeing (2017). *Current Market Outlook 2017–2036*. Retrieved from http://www.boeing.com/resources/boeingdotcom/commercial/market/current-market-outlook-2017/assets/downloads/2017-cmo-6-19.pdf

Boeing Capital Corporation [BCC] (2016). *Current Aircraft Finance Market Outlook 2017*. Retrieved from http://www.boeing.com/resources/boeingdotcom/company/capital/pdf/2017_BCC_market_report.pdf

Boeing Capital Corporation [BCC] (2017). *Current Aircraft Finance Market Outlook 2018*. Retrieved from http://www.boeing.com/resources/boeingdotcom/company/capital/pdf/2018_cafmo.pdf

Bombardier (2017). *Bombardier Commercial Aircraft's New 20-Year 2017-2036 Market Forecast Shows Strong Opportunities for the 60- to 150- Seat Segment*. Retrieved from https://www.bombardier.com/en/media/newsList/details.bca-20170912-bombardier-commercial-aircrafts-new-20-year-2017-20.bombardiercom.html

Brunnermeier, M. K. (2008). *Deciphering the Liquidity and Credit Crunch 2007-08*. Working Paper 14612. Cambridge, MA: National Bureau of Economic Research. Retrieved on 17 April 2012 from the database Google Scholar.

Cheng, X. (2010). *Three Essays on Volatility Forecasting* (PhD thesis). Hong Kong Baptist University.

Chin, C.J. (2013). *Correlations Have Personality, Too: An Analysis of Correlations between Assets*. Retrieved from http://www.naaim.org/wp-content/uploads/2013/10/00L_Correlations_have_Personality_carlton_chin.pdf

Di Clemente, R., Chiarotti, G.L., Cristelli, M., Tacchella, A., & Pietronero, L. (n.d.). *Supplementary Information. Diversification versus specialization in complex ecosystems*. Retrieved from http://journals.plos.org/plosone/article/file?type=supplementary&id=info:doi/10.1371/journal.pone.0112525.s002

Dobberstein, N., Narasimhan, S., Gupta, A., & Singh, S. (2012). *The Rise of the Tower Business*. Retrieved from https://www.atkearney.com/documents/20152/434183/Rise%2Bof%2Bthe%2BTower%2BBusiness.pdf/e2243caf-7c97-bdd6-c468-7aad18307b00

Dozic, S., & Krnic, R. (2016). *Overview Of Airline Fleet Ownership Structure*. Retrieved from https://www.researchgate.net/profile/Slavica_Dozic/publication/303973789_OVERVIEW_OF_AIRLINE_FLEET_OWNERSHIP_STRUCTURE/links/576116b808ae227f4a3f39bd/OVERVIEW-OF-AIRLINE-FLEET-OWNERSHIP-STRUCTURE.pdf?origin=publication_detail

Ernst & Young [EY] (2015a). *Global telecommunications study: navigating the road to 2020*. Retrieved from http://www.ey.com/Publication/vwLUAssets/ey-global-telecommunications-study-navigating-the-road-to-2020/$FILE/ey-global-telecommunications-study-navigating-the-road-to-2020.pdf

Ernst & Young [EY] (2015b). *Infrastructure investments. An attractive option to help deliver a prosperous and sustainable economy*. Retrieved from http://www.ey.com/Publication/vwLUAssets/EY-infrastructure-investments-for-insurers/$FILE/EY-infrastructure-investments-for-insurers.pdf

Ernst & Young [EY] (2017). *Aviation finance: an interesting prospect for long-term investors*. Retrieved from http://www.ey.com/Publication/vwLUAssets/ey-aviation-finance-as-a-long-term-investment/$File/ey-aviation-finance-as-a-long-term-investment.pdf

Erny, M., Janik, C., & Schweiwiller, M. (2017). *Gold As A Hedge Or Safe Haven For Stock Market Investments?* Term Paper. Zurich University of Applied Sciences.

European Aviation Safety Agency [EASA], European Environment Agency [EEA], & Eurocontrol (2016). *European Aviation Environmental Report 2016*. Retrieved from doi: 10.2822/385503

Finanz und Wirtschaft [FuW] (2013). *Chronologie der Finanzkrise*. Retrieved from https://www.fuw.ch/article/chronologie-der-finanzkrise/

Greer, R.J. (1997). What is an Asset Class, Anyway? *The Journal of Portfolio Management,* 23:2, 86–91.

Hughes, F., & Graves, L. (2018). Telecom infrastructure – toning up. *Global Listed Infrastructure Organisation [GLIO] Journal, issue 2,* 42–46.

Idzorek, T., & Armstrong, C. (2009). *Infrastructure and Strategic Asset Allocation: Is Infrastructure an Asset Class?* Retrieved from https://corporate.morningstar.com/ib/documents/MethodologyDocuments/IBBAssociates/Infrastructure_SAA.pdf

Inderst, G. (2010). Infrastructure as an asset class. In: H. Strauss (Ed.): *Public and private financing of infrastructure. Evolution and economics of private infrastructure finance,* (pp. 70–104). European Investment Bank. Retrieved from http://www.eib.org/attachments/efs/eibpapers/eibpapers_2010_v15_n01_en.pdf

International Air Transport Association [IATA] (2017a). *2036 Forecast Reveals Air Passengers Will Nearly Double to 7.8 Billion*. Retrieved from http://www.iata.org/pressroom/pr/Pages/2017-10-24-01.aspx

International Air Transport Association [IATA] (2017b). *Fact Sheet – Fuel*. Retrieved from https://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-fuel.pdf

International Air Transport Association [IATA] (2017c). *Fact Sheet. "Green" Taxes*. Retrieved from https://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-greentaxation.pdf

Investopedia (n.d.). *How can I use the load factor as an indicator for the profitability of the airline industry?* Retrieved from https://www.investopedia.com/ask/answers/041515/how-can-i-use-load-factor-indicator-profitability-airline-industry.asp

Kroll Bond Rating Agency [KBRA] (2016a). *U.S. General Airport. Revenue Bond Rating Methodology*. Retrieved from https://www.krollbondratings.com/show_report/1174

Kroll Bond Rating Agency [KBRA] (2016b). *U.S. Public Toll Roads, Bridges & Tunnels. Revenue Bond Rating Methodology*. Retrieved from https://www.krollbondratings.com/show_report/282

Kroll Bond Rating Agency [KBRA] (2016c). *Global Passenger Airline Rating Methodology*. Retrieved from https://www.krollbondratings.com/show_report/4775

Kroll Bond Rating Agency [KBRA] (2017a). *2017 Update. Aircraft Leasing Industry*. Retrieved from https://www.krollbondratings.com/show_report/7025

Kroll Bond Rating Agency [KBRA] (2017b). *2017 Update: Regional Aircraft Market*. Retrieved from https://www.krollbondratings.com/show_report/7833

Kroll Bond Rating Agency [KBRA] (2017c). *2017 Update: Asia Pacific Aviation Market*. Retrieved from https://www.krollbondratings.com/show_report/7956

Kroll Bond Rating Agency [KBRA] (2017d). *Global Aviation ABS Rating Methodology*. Retrieved from https://www.krollbondratings.com/show_report/2266

Kroll Bond Rating Agency [KBRA] (2017e). *Global Enhanced Equipment Trust Certificates & Secured Aircraft Debt Rating Methodology*. Retrieved from https://www.krollbondratings.com/show_report/2291

Kroll Bond Rating Agency [KBRA] (2017f). *Global Finance Company Rating Methodology*. Retrieved from https://www.krollbondratings.com/show_report/459

Kroll Bond Rating Agency [KBRA] (2018a). *Widebody Aircraft Outlook*. Retrieved from https://www.krollbondratings.com/show_report/8577

Kroll Bond Rating Agency [KBRA] (2018b). *2017 Aircraft Lessors And Secured Aircraft Year in Review And 2018 Outlook*. Retrieved from https://www.krollbondratings.com/show_report/8576

Kroll Bond Rating Agency [KBRA] (2018c). *Aircraft ABS 2017: Year In Review*. Retrieved from https://www.krollbondratings.com/show_report/8582

Mankiw, N.G., & Taylor, M.P. (2010). *Economics: Special Edition*. Hampshire, United Kingdom: Cengage Learning EMEA.

Markowitz, H. (1952). Portfolio Selection. *The Journal of Finance,* 7:1, 77–91.

MSCI (n.d.). *The Global Industry Classification Standard (GICS)*. Retrieved from https://www.msci.com/gics

Pacific Turbine Brisbane [PTB] (n.d.). *About Pacific Turbine Brisbane*. Retrieved from https://www.pacificturbine.com.au/about-us/

Peng, H.W., & Newell, G. (2007, January). *The Significance Of Infrastructure In Investment Portfolios*. Paper presented at the Pacific RIM Real Estate Society Conference, Fremantle.

Roberts, M., Patel, J., & Minella, G. (2015). *European Infrastructure Update 2015: Mid-Year Review* [Research Report]. Retrieved from Deutsche Asset & Wealth Management https://www.fondsnieuws.nl/system/storage/serve/131846/Europe%20Infrastructure%20Update%20Mid%20Year%20Review%20-%20August%202015.pdf

Russ, D., Thambiah, Y., & Foscari, N. (2010). *Can Infrastructure Investing Enhance Portfolio Efficiency?* [White paper]. Retrieved from Credit Suisse Asset Management https://www.credit-suisse.com/pwp/am/downloads/marketing/infrastructure_ch_uk_lux_ita_scandinavia.pdf

S&P Dow Jones Indices (2018). *Dow Jones Brookfield Infrastructure Indices. Methodology*. Retrieved from https://us.spindices.com/documents/methodologies/methodology-dj-brookfield-infrastructure.pdf

The Economist (2018). Dragons fly. *The Economist, April 7th 2018,* 13–14.

Thierie, W., & De Moor, L. (2016). *The characteristics of infrastructure as an investment class*. Retrieved from doi: 10.1007/s11408-016-0273-9

Thomas, W., & Haigh, M. (2017). *Shell. World Energy Model. A View To 2100*. Retrieved from https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenarios-energy-models/world-energy-model/_jcr_content/par/textimage.stream/1510344160326/d62f12b8fe88e85dc3349c38b1ca5e44cc22c5ccc6f70beed634020cfb527c82/shell-world-energy-model.pdf

Timotijevic, D. (n.d.). *Aviation Leasing As Part Of A Broader Investment Portfolio*. Retrieved from https://www.investec.com/content/dam/australia/aviation/Investec_Report_Aviation_Leasing_as_Part_of_a_Broader_Investment_Portfolio.pdf

U.S. Department of State (2012). *Air Transport Agreement Between The Government Of The United States Of America And The Government Of [country]*. Retrieved from https://www.state.gov/documents/organization/114970.pdf

U.S. Department of State (n.d.). *Civil Air Transport Agreements*. Retrieved from https://www.state.gov/e/eb/tra/ata/

U.S. Energy Information Administration [EIA] (2017). *International Energy Outlook 2017*. Retrieved from https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf

Van Eaton, D. (2016). *2017 SchweserNotes. Level I. CFA Exam Prep. Ethical and Professional Standards and Quantitative Methods. eBook1*. United States of America: Kaplan.

Weber, B., Staub-Bisang, M., & Alfen, H.W. (2016). *Infrastructure as an asset class. Investment Strategy, Sustainability, Project Finance and PPP* (2nd ed.). Chichester, West Sussex, United Kingdom: Wiley.

Whitehouse, N. (2018). Appraisals. *Jetrader, Spring 2018,* 47–49.

9 Appendix

Table of Contents

I. List of Tables

II. Table of Figures

9.1 Correlation Analysis in Sub-periods

In order to split the data set in two sub-periods, the time frame of the financial crisis was first identified with a quantitative approach and then qualitatively assessed. A crisis can be identified by increasing volatility in the stock market (Erny, Janik, & Scheiwiller, 2017, p. 7). An annualized volatility of 20 per cent is said to be high (Erny et al., 2017, p. 7). The simple moving average is one of the early applications of forecasting volatility (Cheng, 2010, p. 27). A moving average smooths movements in a chart of any time series (Van Eaton, 2016, p. 311). In order to identify a trend towards increasing volatility, the six month moving average of the S&P 500 Index' monthly volatility was calculated. Longer moving average periods take out more short-term fluctuations (Van Eaton, 2016, p. 311). An annualized volatility of 20 per cent translates into a monthly volatility of 5.77 per cent. Figure six shows the monthly volatility of the S&P 500 Index, its six month moving average and the threshold of 5.77 per cent.

Figure 6: Moving Average Approach to Identify Financial Crisis of 2007/08

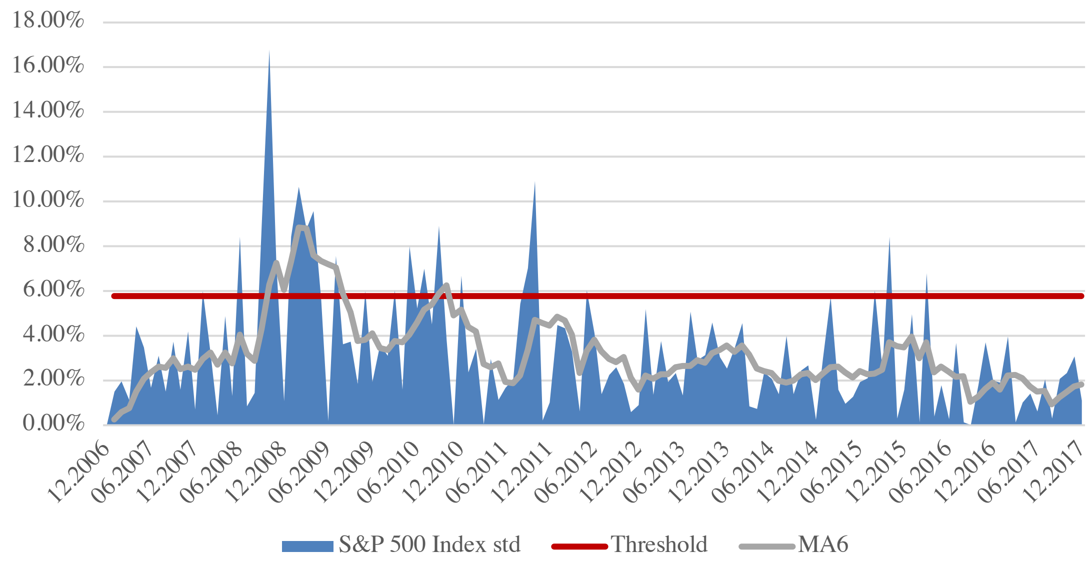

Figure six shows the monthly volatility of the S&P 500 Index, its six month moving average and the threshold of 5.77 per cent. Adapted from Erny et al., 2017, p. 7. The S&P 500 Index data is retrieved from the Bloomberg database (2018m).

Looking at figure six, the crisis is first identified in September 2008. According to Brunnermeier (2008, p. 2), the financial crisis burst in summer 2007 when markets declined, liquidity dried up and defaults and bailouts materialized. Finanz und Wirtschaft [FuW] (2013, para. 12), mentions that interbank market liquidity dried up on August 9, 2007. On the basis of this information, August 2007 was chosen as a starting point of the financial crisis. The end of the crisis was identified with the quantitative approach as August 2009, after which the six month moving average volatility crossed the high volatility threshold on the downside. The financial crisis period, as defined above, resulted in 25 observations for each of the aircraft leasing companies, the S&P Airlines and for each of the infrastructure indices and the S&P 500 Index. Table 22 shows the correlations between returns during the crisis.

Table 22: Correlations During Financial Crisis (August 2007 – August 2009)

	Aircastle	PTB AUD	Aero Century	AerCap	S&P Airlines	S&P Infra	DJ Infra	DJ Transport	DJ Toll-Road	DJ Airport	S&P Util	MSCI Ren	DJ Comm	S&P 500 Index
Aircastle	1.00													
PTB AUD	0.03	1.00												
AeroCentury	0.07	0.06	1.00											
AerCap	0.49***	0.06	0.33*	1.00										
S&P Airlines	0.54***	-0.06	0.04	0.33*	1.00									
S&P Infra	0.51***	-0.07	0.32*	0.41**	0.55***	1.00								
DJ Infra	0.56***	-0.04	0.33*	0.51***	0.59***	0.97***	1.00							
DJ Transport	0.63***	-0.01	0.02	0.32*	0.75***	0.76***	0.76***	1.00						
DJ TollRoad	0.60***	-0.15	0.15	0.34**	0.59***	0.91***	0.90***	0.79***	1.00					
DJ Airport	0.54***	-0.15	0.33*	0.42**	0.54***	0.92***	0.88***	0.73***	0.89***	1.00				
S&P Util	0.31*	-0.08	0.21	0.38**	0.24	0.76***	0.74***	0.54***	0.60***	0.60***	1.00			
MSCI Ren	0.38**	0.14	0.31*	0.53***	0.26	0.86***	0.85***	0.56***	0.69***	0.78***	0.84***	1.00		
DJ Comm	0.43**	-0.04	0.10	0.41**	0.55***	0.76***	0.85***	0.57***	0.72***	0.67***	0.55***	0.69***	1.00	
S&P 500 Index	0.71***	-0.09	0.18	0.45**	0.67***	0.92***	0.92***	0.88***	0.90***	0.87***	0.70***	0.74***	0.74***	1.00

Table 22 shows the correlations of the aircraft leasing companies, the S&P Airlines and the infrastructure indices as well as the S&P 500 Index during the financial crisis of 2007/08. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d-q).

During the financial crisis, the S&P Airlines showed the highest positive correlations to the infrastructure indices with all except for two being statistically significant at the one per cent level. The S&P Airlines had its highest positive correlation to the DJ Transport with a value of +0.75 followed by the correlation to the S&P 500 Index with a value of +0.67. Aircastle also shows high positive correlations to the infrastructure indices during the financial crisis with all values being statistically significant at either the one per cent, five per cent or ten per cent level. Aircastle had its highest correlation to the S&P 500 Index with a value of +0.71. AerCap shows statistically significant positive correlations to all infrastructure indices with its highest correlation to the MSCI Ren at +0.53 followed by a correlation of +0.51 to the DJ Infra. AeroCentury shows low positive correlations to the infrastructure indices with only half of them being statistically significant at the ten per cent level. AeroCentury has its highest correlations to the DJ Infra and the DJ Airport with a value of +0.33 in both cases. None of the results for PTB are statistically significant. PTB's correlations to the infrastructure indices turned negative during the financial crisis, except for its correlation to the MSCI Ren, which is +0.14. As theory suggests, correlations increased during the crisis compared to the whole sample period, which is shown in table twelve of the thesis. However, the results do not differ significantly from the analysis of the whole sample period and some variables lost their statistical significance, which could be due to the lower number of observations in the crisis period.

The remaining 107 observations in the data set are called normal times and their correlations are presented in table 23.

Table 23: Correlations During Normal Times

	Aircas-tle	PTB AUD	Aero Century	AerCap	S&P Airlines	S&P Infra	DJ Infra	DJ Transport	DJ Toll-Road	DJ Airport	S&P Util	MSCI Ren	DJ Comm	S&P 500 Index
Aircastle	1.00													
PTB AUD	0.05	1.00												
AeroCentury	0.15*	0.13*	1.00											
AerCap	0.52***	-0.03	0.13*	1.00										
S&P Airlines	0.43***	0.05	0.13*	0.25***	1.00									
S&P Infra	0.50***	0.03	0.09	0.36***	0.30***	1.00								
DJ Infra	0.43***	0.03	0.04	0.33***	0.29***	0.94***	1.00							
DJ Transport	0.65***	0.02	0.13*	0.48***	0.63***	0.53***	0.48***	1.00						
DJ TollRoad	0.44***	0.08	0.11	0.34***	0.32***	0.88***	0.79***	0.45***	1.00					
DJ Airport	0.48***	-0.04	0.25***	0.34***	0.37***	0.84***	0.76***	0.50***	0.78***	1.00				
S&P Util	0.28***	-0.09	-0.09	0.05	0.16**	0.61***	0.65***	0.19*	0.41***	0.37***	1.00			
MSCI Ren	0.51***	0.07	0.05	0.32***	0.29***	0.80***	0.77***	0.51***	0.70***	0.67***	0.54***	1.00		
DJ Comm	0.23***	0.09	0.10	0.18**	0.24***	0.66***	0.73***	0.26***	0.62***	0.61***	0.43***	0.55***	1.00	
S&P 500 Index	0.66***	0.07	0.11	0.50***	0.45***	0.77***	0.70***	0.80***	0.66***	0.69***	0.32***	0.65***	0.45***	1.00

Table 23 shows the correlations of the aircraft leasing companies, the S&P Airlines and the infrastructure indices as well as the S&P 500 Index during normal times. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d-q).

Aircastle shows the highest positive correlations to the different infrastructure indices during normal times with all correlations being statistically significant at the one per cent level. As well as during the whole sample period, Aircastle had its highest correlation to the S&P 500 Index with a value of +0.66, followed by the correlation to the DJ Transport at +0.65. The S&P Airlines also shows positive correlations to all of the infrastructure indices and all correlations are statistically significant at the one or five per cent level. As well as during the whole sample period the S&P Airlines had its highest correlation to the DJ Transport with a value of +0.63 during normal times. AerCap shows statistically significant correlations to all infrastructure indices, except for the S&P Util. AerCap had its highest correlation to the S&P 500 Index with a value of +0.50 in normal times. AeroCentury shows relatively low correlations during normal times with most of them not being statistically significant. Its highest correlation is to the DJ Airport with a value of +0.25 and statistical significance at the one per cent level. PTB shows very low and sometimes negative correlations to the infrastructure indices with none of them being statistically significant. The results during normal times only slightly differ from the results observed for the whole sample period.

9.2 Correlation Matrix 2006 – 2017 Extended

The extended table twelve shows the correlations between the aircraft leasing companies, the S&P Airlines and the infrastructure indices as well as the correlations among the different infrastructure indices.

Extended Table 12: Correlation Matrix 2006 – 2017

	Aircastle	PTB AUD	Aero Century	AerCap	S&P Airlines	S&P Infra	DJ Infra	DJ Transport	DJ Toll-Road	DJ Airport	S&P Util	MSCI Ren	DJ Comm	S&P 500 Index
Aircastle	1													
PTB AUD	0.07	1												
AeroCentury	0.11	0.11*	1											
AerCap	0.51***	0.04	0.20***	1										
S&P Airlines	0.47***	0.06	0.12*	0.29***	1									
S&P Infra	0.51***	0.02	0.18**	0.40***	0.40***	1								
DJ Infra	0.50***	0.05	0.14*	0.42***	0.41***	0.95***	1							
DJ Transport	0.64***	0.05	0.1	0.42***	0.68***	0.64***	0.60***	1						
DJ TollRoad	0.52***	0.02	0.13*	0.35***	0.43***	0.90***	0.84***	0.60***	1					
DJ Airport	0.52***	-0.03	0.27***	0.39***	0.44***	0.88***	0.82***	0.61***	0.83***	1				
S&P Util	0.30***	-0.04	0.01	0.20**	0.21***	0.67***	0.69***	0.34***	0.49***	0.48***	1			
MSCI Ren	0.45***	0.13*	0.15**	0.44***	0.28***	0.84***	0.81***	0.54***	0.69***	0.74***	0.66***	1		
DJ Comm	0.34***	0.07	0.10	0.30***	0.37***	0.71***	0.79***	0.41***	0.67***	0.65***	0.49***	0.62***	1	
S&P 500 Index	0.69***	0.05	0.14*	0.49***	0.54***	0.84***	0.80***	0.84***	0.77***	0.78***	0.48***	0.70***	0.60***	1

The extended table twelve shows the correlations of the aircraft leasing companies, the S&P Airlines and the infrastructure indices as well as the S&P 500 Index during the whole sample period. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d-q).

9.3 Regression Results

This chapter provides the regression results of the models run in this thesis and not included in the main part of the thesis. Table 24 shows the regression results of model (1) for Aircastle.

Table 24: Regression Results Model (1) – Aircastle

dependent variable				*Aircastle*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	−0.010	0.01	0.2	
S&P 500 Index	2.12	0.179	<0.0001	***
Number of observations				*132*
F(1, 130)				*139.9224*
P-value(F)				*2.29e-22*
Adjusted R-squared				*0.467368*

Table 24 shows the regression results of model (1) for dependent variable Aircastle. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018m,n).

Table 25 shows the regression results of model (1) for PTB.

Table 25: Regression Results Model (1) – PTB

dependent variable				*PTB*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	−0.001	0.01	0.909	
S&P 500 Index	0.161	0.289	0.578	
Number of observations				*132*
F(1, 130)				*0.311786*
P-value(F)				*0.577547*
Adjusted R-squared				*-0.004993*

Table 25 shows the regression results of model (1) for dependent variable PTB. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018m,o).

Table 26 shows the regression results of model (1) for AeroCentury.

Table 26: Regression Results Model (1) – AeroCentury

dependent variable				*AeroCentury*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	0.018	0.015	0.235	
S&P 500 Index	0.617	0.333	0.066	*
Number of observations				*132*
F(1, 130)				*3.428400*
P-value(F)				*0.066353*
Adjusted R-squared				*0.012392*

Table 26 shows the regression results of model (1) for dependent variable AeroCentury. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018m,p).

Table 27 shows the regression results of model (1) for AerCap.

Table 27: Regression Results Model (1) – AerCap

dependent variable				*AerCap*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	0.004	0.01	0.716	
S&P 500 Index	1.726	0.3	<0.0001	***
Number of observations				*132*
F(1, 130)				*33.03821*
P-value(F)				*6.11e-08*
Adjusted R-squared				*0.231227*

Table 27 shows the regression results of model (1) for dependent variable AerCap. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018m,q).

Table 28 shows the regression results of model (1) for S&P Airlines.

Table 28: Regression Results Model (1) – S&P Airlines

dependent variable				*S&P Airlines*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	0.003	0.007	0.68	
S&P 500 Index	1.094	0.166	<0.0001	***
Number of observations				*132*
F(1, 130)				*43.26215*
P-value(F)				*1.06e-09*
Adjusted R-squared				*0.287079*

Table 28 shows the regression results of model (1) for dependent variable S&P Airlines. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018d,m).

Table 29 shows the regression results of model (2) for PTB.

Table 29: Regression Results Model (2) – PTB

dependent variable				*PTB*
	Coefficient	**Std. Error**	**p-value**	**significance**
const	0.013	0.01	0.226	
S&P 500 Index	0.323	0.918	0.726	
S&P Infra	−0.256	1.041	0.806	
DJ Transport	0.019	0.427	0.965	
DJ TollRoad	0.187	0.518	0.719	
DJ Airport	−0.859	0.384	0.027	**
S&P Util	−0.765	0.352	0.032	**
MSCI Ren	1.067	0.413	0.011	**
DJ Comm	0.273	0.271	0.315	
Number of observations				*132*
F(8, 123)				*2.574208*
P-value(F)				*0.012420*
Adjusted R-squared				*0.035504*

Table 29 shows the regression results of model (2) for dependent variable PTB. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018e-m,o).

Table 30 shows the regression results of model (2) for AeroCentury.

Table 30: Regression Results Model (2) – AeroCentury

dependent variable				*AeroCentury*
	Coefficient	**Std. Error**	**p-value**	**significnance**
const	0.016	0.017	0.332	
S&P 500 Index	−0.440	1.126	0.696	
S&P Infra	0.951	1.82	0.602	
DJ Transport	−0.103	0.551	0.852	
DJ TollRoad	−0.977	0.796	0.222	
DJ Airport	1.59	0.527	0.003	***
S&P Util	−0.814	0.497	0.104	
MSCI Ren	0.065	0.565	0.909	
DJ Comm	−0.182	0.456	0.69	
Number of observations				*132*
F(8, 123)				*1.720455*
P-value(F)				*0.100052*
Adjusted R-squared				*0.067045*

Table 30 shows the regression results of model (2) for dependent variable AeroCentury. ***, **, * indicate statistical significance at the 1%, 5%, 10% levels respectively. The raw data on which these calculations are based on is retrieved from the Bloomberg database (2018e-m,p).