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Flying more efficiently: Joint impacts of fuel prices, capital costs and fleet size on airline fleet fuel economy

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Abstract
We investigate the factors that affect airlines' choice of fleet fuel economy using plane-level data for 1267 airlines in 174 countries. Larger and newer planes are usually more fuel- efficient. Controlling for the effect of aircraft size and age, we find that the technically achievable fleet fuel economy improves with the size of airlines and the price of fuel and worsens with higher capital costs. The elasticity of fuel economy with respect to the price of fuel is between -0.07 and -0.13. We find evidence for regional differences in fleet fuel economy that are attributable to the adoption of distinct groups of technologies.

Keywords:
Energy efficiency; air transport

JEL Classification:
D22; L93; O14; Q40

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1. Introduction

The International Energy Agency (IEA) expects that, up to 2040, reductions in energy intensity will contribute 42% of the reduction in greenhouse gas emissions relative to business as usual required to achieve the goal of limiting climate change to a 2°C increase in temperature (IEA, 2016). The IEA expects the majority of this improvement in energy intensity to come from improvements in the energy efficiency of energy services (IEA, 2014: 285-286). On the other hand, the mechanisms enabling the geographical spread of such energy saving technological improvements have not been sufficiently investigated (Barretto and Kemp 2008; Verdolini and Galeotti, 2011). The airline industry is perhaps unique in the availability of global data on installed equipment at the individual machine (and firm) level together with information on model energy efficiency. Though carbon emissions from air travel were less than 11% of transport emissions in 2010 (Sims *et al*., 2014), they will likely be of increasing importance (Nava *et al*., 2017).

These facts raise the question of what factors affect the selection of fleet fuel economy by airlines across countries. Do increases in fuel price or a reduction of capital costs improve long-run fleet fuel economy more? Are larger or smaller airlines likelier to invest in fuel efficiency, while controlling for plane size? Are there any regional variations? In this paper, we construct a unique dataset for 1267 airlines, using plane-level technical efficiency data to answer these questions. The purpose of this paper is to understand what determines the technically achievable efficiency level of airline fleets, assuming airlines intend to utilize their fleet in the most efficient way, for example flying long-range planes on longer routes. We do not however study how airlines utilize their existing planes under different economic circumstances (see Kahn and Nickelsburg, 2016). Therefore, the term “fleet fuel economy” denotes the technically achievable fleet fuel economy of airlines in this paper.

Our estimates increase the understanding of how key long-run cost components impact on airline fleet fuel economy, and aid policy design aimed at increasing industrial efficiency as countries work to deliver their Paris Agreement (2015) emission reductions pledges. Such policies are especially important, as currently there is no set of agreed international environmental and emissions standards for air transport (ICAO, 2016), with the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) scheme only coming into effect in 2021 on a voluntary basis.

Our approach extends the literature in several key ways. First, the dataset used is more comprehensive than in any other publication before. We have collected technical data on over 140 airplanes to determine fleet fuel economy based on the number and type of aircraft flown for each carrier. The use of this data pose some challenge however, as other data such as wages had to be approximated for a large number of airlines. Second, we introduce two new fleet fuel economy measures, which remove the impact of aircraft size and age, thereby effectively allowing us to concentrate on the effect of non-technical variables with policy implications.

Simple (or observed) fleet fuel economy is the seat weighted fleet fuel economy of the various aircraft models used by an airline. Larger (Babikian *et al*., 2002) and newer aircraft tend to be more fuel-efficient. Though airlines can improve fuel economy by using larger planes, the main reasons for using larger aircraft are route distance and traffic volume. Therefore, we construct a "size-adjusted fleet fuel economy" measure, which removes the technological effect of aircraft size from aircraft fuel economy before computing fleet fuel economy. Though a major reason for using newer aircraft is to reduce fuel costs there will also be other motivations such as improving passenger comfort and reducing maintenance costs. Therefore, we also compute a "size- and age-adjusted fleet fuel economy." Finally, this allows us to report the responsiveness of fleet fuel economy to fuel prices, which has not been done before. A number of studies deal with the historical and projected development of aircraft fuel efficiency (Babikian *et al*. 2002; Lee *et al*. 2001; Lee, 2010; Peeters *et al*., 2005, Zou *et al*., 2014), the impact of fuel prices on airline operations and finances (Adrangi *et al*. 2014; GAO, 2014; Kahn and Nickelsburg, 2016; Murphy *et al*., 2013), airline profitability (Berry and Jia, 2010; Borenstein, 2011), fleet scheduling and optimization (Naumann and Suhl, 2013; Rosskopf *et al*. 2014), and the impact of a carbon price on firm value (Vespermann and Wittmer, 2011; Scheelhaase *et al*., 2010, Murphy *et al*., 2013, Anger and Koehler, 2010). Also, a few studies estimate cost or production functions for relatively small numbers of airlines (e.g. Caves *et al*., 1984; Gillen *et al*., 1990; Oum and Yu, 1998; Coelli *et al*., 1999; Inglada *et al*., 2006). However, we are not aware of a study of similar scale to ours that systematically examines the factors affecting airlines' choice of fuel economy.

Our model is based on a long-run translog cost function where cost depends, *inter alia*, on the fuel economy of the planes owned or leased by each airline. We find that higher domestic fuel prices and greater airline size are associated with better fleet fuel economy. The elasticity of fuel economy with respect to the price of fuel is between -0.07 and -0.13. Higher capital costs are associated with lower fleet fuel economy. Therefore, policies aiming at higher fuel prices such as the removal of fuel subsidies or the introduction of carbon taxes would all result in increased fleet fuel economy. If induced technical change reduced the cost of more fuel-efficient aircraft, the effect could be larger than this. Reduced costs of credit, for example through loan guarantees enabling economy investments, would especially benefit those airlines that face high credit costs. Most such airlines are in developing countries.

The paper is structured as follows: Section 2 reviews the relevant literature, Section 3 introduces our model, Section 4 our data, Section 5 presents the results, and Section 6 concludes.

2. Airline Fuel Economy

Aircraft fuel efficiency has been improving over time (EASA, 2016; GAO, 2014; IEA 2009; Peeters *et al*., 2005), even though the rate of efficiency improvement is currently slowing (IEA, 2009; Peeters *et al*., 2005), as airplane designs get closer to the technical optimum. At the same time natural diffusion processes might not "reliably spread the best innovations" in the market (Greve and Seidel, 2015). The IEA (2009) asserts that in the United States, technological and operational improvements led to a 60% improvement in the energy efficiency of aircraft between 1971 and 1998, even though the majority of improvements happened prior to the 1980s. On the other hand, there was an earlier decline in fuel economy due to the shift from piston engine to jet engine aircraft. (Peeters *et al*., 2005) The EASA (2016) reports that the mean age of European aircraft is increasing. This highlights the problem that the diffusion of newer, (more) efficient technology is generally slow and gradual (Jaffe and Stavins, 1994), with the IEA (2009) noting that the average efficiency of fleet stock may lag 20 years behind new aircraft efficiency.[1]

Many factors affect airlines' decisions on the portfolio of planes they choose to hold and operate, including the average distance of the flights (long or short haul) usually flown, the fuel economy of the available aircraft, expected fuel prices (IEA, 2009), the price of new and

[1] Zou *et al*. (2014) find by studying 15 large jet operators in the US that the mean airline fuel efficiency in 2010 was 9–20% worse than that of the most efficient carrier, while the least efficient airlines were 25–42% behind industry leaders in terms of efficiency. Therefore, the hypothetical cost savings from enhanced efficiency for mainline airlines could be in the vicinity of a billion dollars in 2010.

used aircraft, financing requirements including owning vs. lease decisions (Gavazza, 2011), and the wages of staff.

For North American airlines the two largest expenditure items are fuel and labor (Neumann and Suhl, 2013). Kahn and Nickelsburg (2016) estimate[2] that fuel prices make up about 25% of the operating expenses of US airlines, however, when kerosene and aviation fuel prices are higher, the cost share of fuel can go up to 33% (Adrangi *et al.* 2014). Larger planes are usually more fuel efficient per seat-km for a given load factor (Naumann and Suhl, 2013), but they are also more difficult to fill, therefore, owning or leasing high-capacity airplanes in times of high fuel prices and low passenger numbers due to economic downturns can be financially very risky. Borenstein (2011) noted, that in times of high demand, adjustment to shocks (in taxes or fuel prices) might be relatively smooth, while the large losses of US airlines during the 2000s were due to demand shocks, when sticky labor costs, high fixed costs, and high fuel costs coincided with depressed prices.

The IEA (2009) claims that fuel-efficient aircraft can deliver net economic benefits already after a couple of years of service life. They estimate that given an oil price of USD 120/bbl that the benefit of upgrading and flying more efficient planes on long haul routes approximates to annually 6 to 8 million USD. Using a 10% discount rate and assuming 30 - years useful life, this amounts to about 10 years of undiscounted fuel savings or a net present value of 60 to 80 million. Assuming a purchase price of 40 million USD, the fuel savings easily pay for the additional price of newer aircraft.[3] These savings are larger the lower the discount rate is assumed to be. Since the price of oil has fallen to around USD 50/bbl since the IEA (2009) study was published, these savings have approximately halved resulting in much less incentive to improve fuel economy. However, the fleets in place in 2015 – the date of our study – will reflect the high oil prices in many recent years.

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[2] Kahn and Nickelsburg (2016) establish a binary choice model of airline fleet replacement and operation optimization based on US data. They find that in times of high fuel prices that airlines fly less fuel efficient planes more slowly, scrap older less efficient planes earlier, and use more fuel-efficient planes more.

[3] The United States Accountability Office (GAO) notes in its 2014 report that in response to fuel price increases airlines have taken a number of actions, including the "reconfiguration of fleets", and increasing of operational efficiency. The GAO (2014) reports that many less fuel-efficient aircraft (e.g., Boeing 737-300/400/500 and McDonnell Douglas MD-80) were retired and replaced with technologically more advanced options such as Airbus A320 and Boeing 737-700/800/900. As a result, many manufacturers saw increased demand for more fuel-efficient aircraft in the second half of the 2000s.

The relationship between fuel prices and fleet fuel economy has been the focus of longstanding academic interest. Prominent examples from road transportation include Alcott and Wozny (2014), who find that consumers value discounted future gasoline costs only 76% of what they value purchase prices. Li *et al*. (2009), examine the channels through which gasoline prices affect fleet fuel economy such as the purchase of new efficient vehicles and the scrapping of older vintages. Their simulations indicate that a 10% increase in fuel prices results in 0.22% increase in fleet fuel economy in the short, and 2.04% in the long run. Burke and Nishitateno (2013) find that 1% increase in gasoline price leads to 0.15-0.2% improvement in new vehicle fleet fuel economy. Klier and Linn (2010) report that a $1 per gallon increase in road gasoline prices improves the average fuel economy of new vehicles by 0.8-1 miles per gallon. Jacobsen and van Benthem (2015) estimate that a $1 per gallon increase in the price of gasoline results in an additional 0.5% of the fleet of least fuel efficient vehicles being scrapped while 0.4% of the fleet of most fuel efficient vehicles that would otherwise be scrapped is not.

Airlines may improve their fleet fuel economy through technological innovation and the replacement of their stock, or through increasing operational efficiency. Adrangi *et al*. (2014) note that efficiency improvements are necessary for long-term survival. These improvements may arise from hedging, improved scheduling, optimal pricing, through the replacement of old vintage airplanes in the fleet with advanced technology aircraft (Adrangi *et al*., 2014) or from strategic flight planning (Naumann and Suhl, 2013).

Firms however might be constrained in their ability to quickly transition to a significantly more fuel-efficient fleet. This constraint might arise from the necessity to first sell their older planes to buy new aircraft, therefore the associated transaction costs might be very high. Leasing planes makes it easier for airlines to replace their fleets. Accordingly, Gavazza (2011) finds that leased aircraft have 38% shorter holding durations on average, but fly 6.5% more hours than owned aircraft. As leasing reduces transaction costs, the number of new airplane leases have been constantly increasing in recent decades. Benmelech and Bergman (2011) claim that airlines are likelier to lease than to own aircraft in states with insufficient creditor rights, while Eisfeldt and Rampini (2009) assert that credit-constrained airlines are likely to lease more. The Economist (2012) estimated that about 40% of the world's airline fleet is now rented. However, Kahn and Nickelsburg (2016) note that in times of higher jet fuel prices the lease price of efficient aircraft is also higher in the US.

A few authors have applied cost function or production frontier approaches to modeling airline decisions. Compared to these studies, our data set includes far more airlines and has much wider geographical scope. The tradeoff to reach this level of comprehensiveness is a lack of accurate firm level data on a number of variables of interest and as a result we use proxies for some explanatory variables.

Earlier studies (e.g. Caves *et al*., 1984; Gillen *et al*., 1990) focused mostly on the North American airline industry[4]. More recent studies (e.g. Oum and Yu, 1998; Coelli *et al*., 1999; Inglada *et al*., 2006) have investigated small numbers of international airlines. Oum and Yu (1998) apply a short-run translog unit cost function and cost share equations to 22 major international airlines over 1986-93. They use a capital stock index for aircraft and ground equipment, *inter alia* aggregate output, labor, energy and materials prices, revenue shares of freight and mail, average stage length, a TFP index, and time fixed effects. They found that Non-Japanese Asian carriers were generally more cost competitive than the major U.S. carriers but Japanese carriers and major European carriers were less cost competitive. Coelli *et al*. (1999) apply a translog stochastic production frontier model to 32 international airlines in the period 1977-1990. The inputs include labor and capital and three "environmental variables" that explain "inefficiency": mean stage length, mean number of seats per aircraft, and load factor. However, they do not consider energy efficiency explicitly.

Inglada *et al*. (2006) estimate cost and production stochastic frontiers for 20 airlines for 1996-2000. The cost frontier has random efficiency terms but does not have biased technical change. Explanatory variables are KLEM prices and output measured in ton kilometers (using weight of passengers and freight), allowing for variable returns to scale. However, the study suffers from several endogeneity problems. In particular, capital prices are measured by capital expenditures divided by capacity and energy prices as energy cost divided by kilometers. However, all of these prices depend on the fuel economy and capital investment decisions made by airlines earlier, and so are not exogenous. Our paper addresses these issues by measuring the cost of capital by interest rates, and energy prices by exogenously determined gasoline prices and oil reserves.

[4] Applying a translog total cost function and share equations to panel data, Caves *et al*. (1984) found no economies of scale that affected the relative costs of "trunk" and smaller regional airlines in the U.S. Instead, density of traffic within an airline's network rather than differences in the size of the network explained cost differences.

3. Model

We assume that the total operating costs, *C*, of airline *i* at time *t*, is given by the long-run cost function:

$$C_{it} = f(Q_{it}\ , p_t, d_{it}, r_{it}, w_{it}, E_{it}\ , \mathbf{z}_{it}, t) \tag{1}$$

where *Q* is output, *p* is the international price of fuel, *d* is the domestic price of fuel, *r* is the cost of capital, *w* is the wage rate, *E* is fleet fuel economy, $\mathbf{z}$ is a vector of "environmental variables", and the final explanatory variable indicates that technology evolves over time. While fuel for international flights is effectively untaxed, fuel used for domestic aviation is taxed in many countries (Keen and Strand, 2007). We measure fleet fuel economy, *E*, as fuel consumed per seat-km assuming aircraft are used at full capacity. Therefore, it reflects the technical characteristics of the installed capital stock rather than actual operational fuel efficiency, which is influenced by load factors (and could be measured by fuel consumption per passenger-km). However, this is not a concern as the purpose of our paper is not to study how airlines utilize their existing stock (flying at maximum range or with a full load factor), but to understand how they build up their stock, given the assumption they plan to utilize them most efficiently. For example, we assume that when an airline invests in a long-range craft, it does not intend to fly it systematically on short-routes. Environmental variables reflect the type of services provided by an airline – here we try to capture factors such as the typical flight segment length and plane. Details for all these variables are discussed in the Data Section below.

If larger aircraft are more fuel-efficient than smaller aircraft, *E* will depend on the size of aircraft employed. If newer aircraft are more efficient for a given seat size, *E* will depend on the age of the fleet as well. While airlines can choose larger and newer aircraft to improve fuel economy there are also other reasons why they would choose these over smaller and older aircraft. Therefore, we also investigate alternative measures of fuel economy, clean of size and age effects.

We assume that (1) can be represented by a long-run translog cost function of the following general form:

$$lnC_{it} = \alpha_0 + lnA_t + \ln u_{it} + \boldsymbol{\beta}'\mathbf{x}_{it} + 0.5\mathbf{x}'_{it}\mathbf{B}\mathbf{x}_{it} + \mathbf{a}'_t\tilde{\mathbf{x}}_{it} + e_{it} \tag{2}$$

where $\mathbf{x}_{it} = [\ln Q_{it}, \ln p_t, \ln d_{it}, \ln r_{it}, \ln w_{it}, \ln E_{it}, \ln \mathbf{z}_{it}]'$, $\tilde{\mathbf{x}}_{it} = [\ln p_t, \ln d_{it}, \ln r_{it}, \ln w_{it}, \ln E_{it}, \ln \mathbf{z}_{it}]'$, and primes indicate transposes. α_0 is a constant, $\ln A_t$ represents movement of the frontier due to technical change, $\ln u_{it}$ represents the technical inefficiency of airline *i* relative to the frontier, and e_{it} is a random error term. The vector $\mathbf{a_t}$ contains technical change biases. These are not restricted to interactions of a linear time trend and price. We explicitly assume that $\partial lnC_{it}/\partial lnE_{it}$ may change over time holding $\mathbf{x}_{it}$ constant. The cost function is homogenous of degree one in input prices.

We assume that conditional on output, prices, environmental variables, and technology that there is a cost minimizing fuel efficiency level, E_{it}^*. Partially differentiating (2) with respect to ln*E* we have:

$$\frac{\partial lnC_{it}}{\partial lnE_{it}} = \beta_E + \beta_{EQ} lnQ_{it} + \beta_{Ep} lnp_t + \beta_{Ed} lnd_{it} + \beta_{Er} lnr_{it} + \beta_{Ew} lnw_{it} + B_{EE} lnE_{it}^* + \sum_j B_{Ej} lnz_{it} + a_{Et} \tag{3}$$

Then setting (3) to zero, we can solve for E_{it}^*:

$$lnE_{it}^* = -\frac{\beta_E}{B_{EE}} - \frac{\beta_{EQ}}{B_{EE}} lnQ_{it} - \frac{\beta_{Ep}}{B_{EE}} lnp_t - \frac{\beta_{Ed}}{B_{EE}} lnd_{it} - \frac{\beta_{Er}}{B_{EE}} lnr_{it} - \frac{\beta_{Ew}}{B_{EE}} lnw_{it} - \sum_j \frac{B_{Ej}}{B_{EE}} lnz_{it} - \frac{1}{B_{EE}} a_{Et} \tag{4}$$

Our empirical analysis assumes that E_{it}^* is at a long-run equilibrium and we estimate the following regression for a cross section, where we add a random error term to account for optimization errors, measurement errors or omitted variables etc.

$$lnE_i^* = \gamma_E + \gamma_Q lnQ_i + \gamma_d lnd_i + \gamma_p lnr_i + \gamma_w lnw_i + \sum_j \gamma_i lnz_i + \varepsilon_i \tag{5}$$

Therefore, both the common international fuel price and the technical change bias term have fallen out. One caveat of the above equation is that the domestic fuel prices might be correlated with energy efficiency policies of countries. We might assume that high fuel-tax countries would have policies encouraging efficiency improvements that are likely to result in a preference for more efficient types of planes as well.

The airlines in the sample vary tremendously in size from 15 to 183554 total seats. It is plausible that larger airlines will find it easier to adjust to the long-run equilibrium by maintaining a portfolio of different aircraft models and gradually introducing new models. By analogy with grouping heteroskedasticity, the variance of the residuals might be inversely proportional to the total number of seats. The Breusch-Pagan test statistic for heteroskedasticity related to the total number of seats in the first regression of Table 4 is 69.62, which is distributed as chi-squared with one degree of freedom (p=0.00). Therefore, we present weighted least squares (WLS) estimates as a robustness check, where the weights are the square root of the total number of seats available to each airline. We compute robust standard errors clustered by country for both OLS and WLS models. Using WLS together with heteroskedasticity consistent standard errors should result "in valid inference, even if the conditional variance model is misspecified" (Romano and Wolf, 2017, 2).

4. Data

Aircraft data

Our data on the aircraft operated by each airline is taken from the World Airliner Census (Flightglobal, 2015). The Census gives a snapshot as of 2015 of the type and number of different types of aircraft operated (owned and leased) by commercial airlines and air-freight companies throughout the world. After deleting 5 airlines for which we could not determine their country of registration, we have data on 1267 different airlines.

While the census data include "all commercial jet and turboprop-powered transport aircraft, built by Western, Chinese or Russian/CIS/Ukrainian manufacturers in service", as well as company orders, for the purpose of this study, we excluded not-yet delivered orders from the dataset. Flightglobal (2015) defines an aircraft "in service" when it is "active (in other words accumulating flying hours)."

The census data include all cargo, passenger and multi-purpose planes. We excluded aircraft types that are only used for cargo flights from the dataset,[5] as no seat number could be determined. If a plane is multi-purpose and can be operated both as a passenger plane and as cargo, we included it. Planes with fewer than 14 seats are excluded from the World Airliner

[5] Airbus A330-200F, Airbus C212, Antonov AN-12, Antonov AN-30, Antonov AN-124, Antonov AN-178, Antonov AN-225, Boeing 777F, GAF Nomad, Harbin Y-12, Ilyushin IL-76, Lockheed L-100 HERCULES, Lockheed L-188 ELECTRA, McDonnell-Douglas DC-3

Census data. We have allocated airlines to the countries where their company offices are registered. We determined the locations using information available on the Internet, such as ch-aviation.com, flightglobal.com, and other sources.

Technical Characteristics and Fuel Economy

We determined the maximum range, maximum fuel capacity, typical number of seats, and the year of first flight for each of the 143 aircraft types in our dataset. We used original company documentation from Airbus, Boeing, and other manufacturers, which are openly available on the Internet. For a small number of older aircraft, and for some specific models of a given type of aircraft we could not locate technical data. In this case, we took the data of the most similar model of the same type of aircraft, or the data for a different type of aircraft from the same manufacturer.[6] The exact list of aircraft used, their technical data, and the sources for the technical data are in the Appendix.

As explained above, we use three alternative measures of fleet fuel economy in our study. We calculate the simple (observed) fuel economy of aircraft model *j*, E_j, as follows:

$$E_j = \frac{F_j}{R_j S_j} * 100 \qquad (6)$$

where *F* denotes maximum fuel capacity, *R* maximum range in kilometers, and *S* is the typical number of seats.[7] Fuel economy of each airline fleet is calculated by weighting aircraft model fuel economy by the total number of seats available for model *j* for that airline, S_{jit}, dividing by the total number of seats on all aircraft available to that airline, S_{it}, and summing over all models:

$$E_{it} = \sum_{j=1}^{J} \frac{S_{jit}}{S_{it}} E_j \qquad (7)$$

Thus the metric we have is the average efficiency per seat in a fleet, calculated across the different aircraft types. Lower values indicate higher fleet fuel economy.

[6] These changes are documented in the Technical Appendix.
[7] We used typical number of seats in an aircraft. However, in some cases only maximum numbers were available. The exact sources and the seat number specifications are found in the Technical Appendix.

To account for the fact that larger aircraft tend to be more fuel-efficient, we also construct an alternative, "size-adjusted" fuel economy measure, clean of the effect of aircraft size. The reason we adjust the dependent variable rather than control for size in the regression analysis is that our intention is to remove only the technology effect of aircraft size on fuel economy. There may also be a behavioral effect of aircraft size on the choice fuel economy. This is done by regressing E_j on the average number of seats S_j for that model:

$$\ln E_j = \gamma_0 + \gamma_1\left(\ln S_j - \overline{\ln S}\right) + \sum_{k=1}^{K} \gamma_{k+1} d_{kj} + \varepsilon_J \tag{8}$$

where $\overline{lnS}$ is the mean of lnS_j across all aircraft models. Because average aircraft size may have increased over time, we include K-1 decadal dummies, d_k, for each decade prior to the most recent decade. These control for the time of the first flight of each aircraft model.[8] We then predict size-adjusted fuel economy for each plane model:

$$E_j^A = exp\left(\ln E_j - \gamma_1\left(\ln S_j - \overline{\ln S}\right)\right) \tag{9}$$

We then aggregate aircraft model fuel economy to airline level as before, giving us a size-adjusted fleet fuel economy:

$$E_{it}^A = \sum_{j=1}^{J} \frac{S_{jit}}{S_{it}} E_j^A. \tag{10}$$

Our third measure, size and age adjusted fleet fuel economy, also removes the effect of model age from the fleet economy variable:

$$E_j^B = exp\left(\ln E_j - \gamma_1\left(\ln S_j - \overline{\ln S}\right) - \sum_{k=1}^{K} \gamma_{k+1} d_{kj}\right), \tag{11}$$

We aggregate as before:

$$E_{it}^B = \sum_{j=1}^{J} \frac{S_{jit}}{S_{it}} E_j^B. \tag{12}$$

Wages:

We estimate wages *(w)* based on the available wage data in the ICAO (2015) database. A small number of airlines have wage data in nominal US dollars converted at market exchange

[8] Where data on the year of the first flight was not available, we allocated a decade based on our best guess. These assumptions are documented in the Appendix.

rates for 2015 in the ICAO database. For these airlines we compute an average wage for all staff at the airline. We use mid-year data on staff numbers unless only year-end data were available. Some of this data is clearly anomalous and we deleted obviously incorrect values. This includes all average wages above \$200,000 and \$1,000.[9] For airlines without apparently reliable 2015 data but seemingly reliable wage for earlier years in the database, we used that earlier wage to project the wage in 2015 using the parameters from a within airline regression (i.e. using fixed effects for each airline) reported in Table 2. For Venezuela we used 2013 estimates. We could estimate wages for 491 airlines in this manner. The within regression regresses the logarithm of wages on GDP per capita data both in nominal US dollars converted at market exchange rates. Table 1 presents these results:

	Within Regression		Between Regression
Dependent Variable	ln wage		ln wage 2015USD
ln GDP per capita	0.8317***	ln GDP per capita 2015USD	0.5540***
	(0.0443)		(0.0234)
		Constant	4.9805***
			(0.2357)
N	2480		491
R-squared	0.309		0.598

Heteroskedasticity robust standard errors in parentheses. Standard errors for within regression are clustered by airline.

* p<0.10, ** p<0.05, *** p<0.01

Table 1: Wage Regressions

The regression shows that wages increase by 0.83% for a 1% increase in GDP per capita. This coefficient is significantly less than 1. We project the 2015 wage rate as follows:

$$\ln\widehat{W}_{i,2015} = \ln\widehat{W}_{i,b} + 0.8317\left(\ln G_{i,2015} - \ln G_{i,b}\right) \qquad (13)$$

where $\widehat{W}_{i,2015}$ is the projected wage, $W_{i,b}$ is the wage in the base year, and $G_{i,2015}$ and $G_{i,b}$ are GDP per capita in 2015 and the base year respectively in USD converted at market exchange rates.

[9] We did use a value of \$834 in 2006 for Kyrgyzstan Airways to project the 2015 value.

Where no reliable wage data are available in the ICAO database we use the following regression procedure: first we converted all apparently reliable nominal wages to 2015 US Dollars using the US implicit GDP price deflator. We converted the GDP per capita for the relevant country and year in the same way. We then used the between estimator to estimate a regression of the log of wages on GDP per capita. The results are also in Table 1. A pooled OLS regression on the sample of 2480 original data points produces almost identical results. As we would expect, airline jobs are relatively well paying in poor countries and so the elasticity is substantially less than unity. We then used the between regression results to project wages to the remaining airlines using observations on GDP per capita in 2015 in US dollars converted at market exchange rates in the relevant country:

$$\ln\widehat{W}_{i,2015} = 4.9805 + 0.5540\ln G_{i,2015} \quad (14)$$

where $\widehat{W}_{i,2015}$ is the projected wage and $G_{i,2015}$ is 2015 GDP per capita in USD converted at market exchange rates. Where 2015 data were not available, we used the most recent year from the World Development Indicators. We used the Penn World Table to obtain values for 2014 for Syria and Taiwan. We used a variety of online sources for a number of small island countries such as the Cook Islands, Greenland, and Guam and for North Korea.

Interest Rates

Real interest rates *(r),* which we use as proxy for the cost of capital, were sourced from the World Bank (2017) and the ECB (2017).[10] The World Bank uses the data from the International Monetary Fund, International Financial Statistics and its GDP deflator, to calculate real interest rates. As the World Bank data are missing interest rates for a large number of countries including all countries in the Euro Area, we calculated the real interest rates for a number of European countries, by using the ECB's (2017) composite cost of borrowing on new loans for non-financial corporations and deflating it with the World Bank's (2017) deflator.[11]

[10] "Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. The terms and conditions attached to lending rates differ by country, however, limiting their comparability." (World Bank definition, series: FR.INR.RINR)

[11] "Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency." (World Bank definition, series: NY.GDP.DEFL.KD.ZG).

Output

We approximate output, which measures the effect of economies of scale, as the total seats available to an airline. This assumes that all airlines operate all plane types for the same fraction of available time with the same loading. Obviously, a more direct measure of traffic volume such as passenger-miles flown would be a better measure of output. While the IATA does offer monthly traffic data for some of its member carriers, the reported numbers are voluntary and only cover at most 130 airlines.

The airline industry is highly heterogeneous within and across countries. As we cover 174 countries in our sample, we had to make a number of simplifying assumptions in order to estimate our models. One of the limitations of the estimation is the assumption that airlines use all airplanes with the same loading and for the same fraction of time. In truth, load factors vary significantly across airlines. Due to the very large number of airlines used, such load factors were not available, without reducing our sample size ten-fold.

Aviation Fuel Price

Data on aviation fuel prices are not readily available for our dataset on a country level. While fuel on international flights is untaxed, countries within their jurisdiction may choose to tax domestic aviation fuel. Fuel prices for international flights at international trading hubs vary slightly. Also, airlines might not refuel in their country of origin, but might do so while flying different "legs" of their international routes and fuel prices for domestic and international airlines in some countries may differ. Platts offers jet fuel price comparison on a regional (continental) basis for one day of a year, and daily spot prices for several major trading hubs are only available on a subscription basis. Below is a snapshot of regional jet fuel prices as of 25 April 2017:

	Share in World Index	cts/gal	$/bbl	$/mt	Index value 2000=100%
Platts Global Index	100%	148.69	62.45	492.42	170.71%
Platts Regional Indices					
Asia & Oceania	22%	148.35	62.31	492.23	178.03%
Europe & CIS	28%	148.89	62.53	492.75	168.48%
Middle East & Africa	7%	144.33	60.62	478.28	181.02%
North America	39%	148.78	62.49	493.64	166.12%
Latin & Central America	4%	155.93	65.49	504.28	181.42%

Table 2: Platts Jet Fuel prices: snapshot from: http://www.platts.com/jetfuel, 26 April 2017.

The lowest average jet fuel prices are in the Middle East and Africa, and the highest prices in Latin and Central America. At the same time, the differences are not major, with only 8% difference between the lowest and highest price range. Given all this, we decided to assume that the international fuel price faced by each airline was the same and so in our cross-sectional estimation is absorbed into the constant.

We use different proxies for the domestic aviation fuel price, including the World Bank's (2017) information on road gasoline prices,[12] oil rents as a fraction of GDP,[13] and proven oil reserves per capita (Burke, 2013).

Environmental Factors

The environment, **z,** in which airlines operate has a significant impact on their cost function.

For our simple fleet fuel economy model, which does not remove the effects of aircraft size and model age from estimated fleet fuel economy, we alternatively control for the average seat size within a fleet, and for the estimated maximum age of the fleet. The vintage (V) of

[12] "Fuel prices refer to the pump prices of the most widely sold grade of gasoline. Prices have been converted from the local currency to U.S. dollars." (World Bank definition, series: EP.PMP.SGAS.CD).

[13] "Oil rents are the difference between the value of crude oil production at world prices and total costs of production."(World Bank definition, series: NY.GDP.PETR.RT.ZS.CD)

the fleet is calculated by deducting the year of the first (YF) flight for a specific model from 2015:

$$V_{i,t} = 2015 - YF_{i,t} \tag{15}$$

This gives us the maximum age of a specific aircraft flown in a fleet. We take the seat weighted average of the aircraft age, in a given fleet, giving us effectively the maximum age of a seat in a fleet.

$$V_{it} = \sum_{j=1}^{J} \frac{S_{jit}}{S_{it}} V_j \tag{16}$$

The average seat size within a fleet is calculated in a similar manner:

$$S_{it} = \sum_{j=1}^{J} \frac{S_{jit}}{S_{it}} S_j \tag{17}$$

All models also control for country area and population. These variables control for the fact that larger countries in both population and area might see a higher number of flights between cities and this might not simply be a function of either area or density. A higher average distance between cities would increase the share of domestic travel that takes place by air. While small countries usually would have more international air travel relative to domestic, a large small population country such as Australia might also have relatively more international travel than a large more densely populated country such as China. Country area controls for the increased likelihood of internal flights, which face the domestic fuel price. Both variables are sourced from the WDI (World Bank, 2017).

We control for the general air-traffic activity in a country by using data on the number of passengers carried per country (World Bank, 2017).[14] We also control for unobserved geographical and regional characteristics of the area airlines operate in, using dummy variables for the World Bank's regional classification including, East Asia and Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, and Sub-Saharan Africa. East Asia and Pacific is the default region in our regressions.

[14] "Air passengers carried include both domestic and international aircraft passengers of air carriers registered in the country" (World Bank definition, series: EP.PMP.DESL.CD).

5. Results

5.1. Characteristics of airline fleet fuel economy

Figure 1 presents the relationship between aircraft seat fuel economy, and the first year of flight. The Figure shows that on average the fuel economy of new aircraft models has been improving over the past 70 years, in line with our expectations.

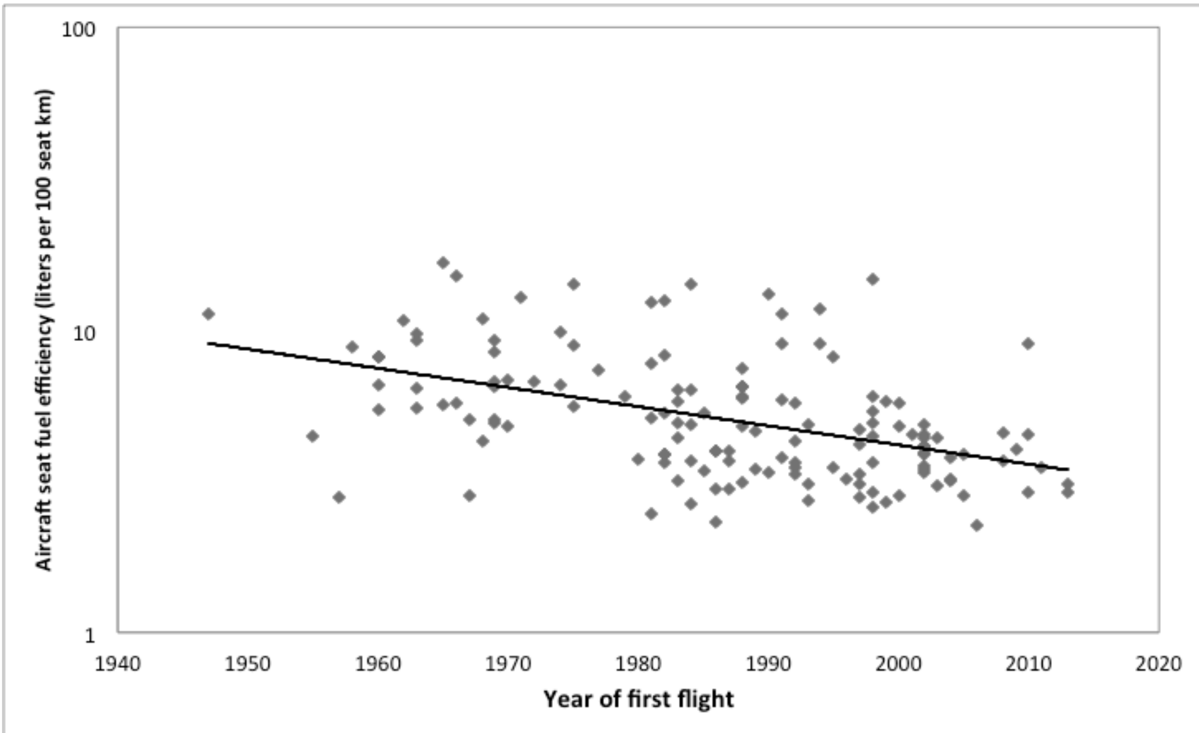

Figure 1: Aircraft fuel economy in the year of first flight for a sample of 143 aircraft models

Aircraft have also become larger over time, which is one of the main drivers of simple fuel economy. Figure 2 depicts the relationship between seat size and aircraft fuel economy. This relationship appears to be linear on a log scale meaning that while fuel economy improvements have progressed at a constant percentage rate, in absolute numbers there have been slowing incremental improvements, despite increases in aircraft size and other independent technical improvements. These findings are in line with the IEA's (2009) report on slowing efficiency gains as new aircraft models get closer to the technologically

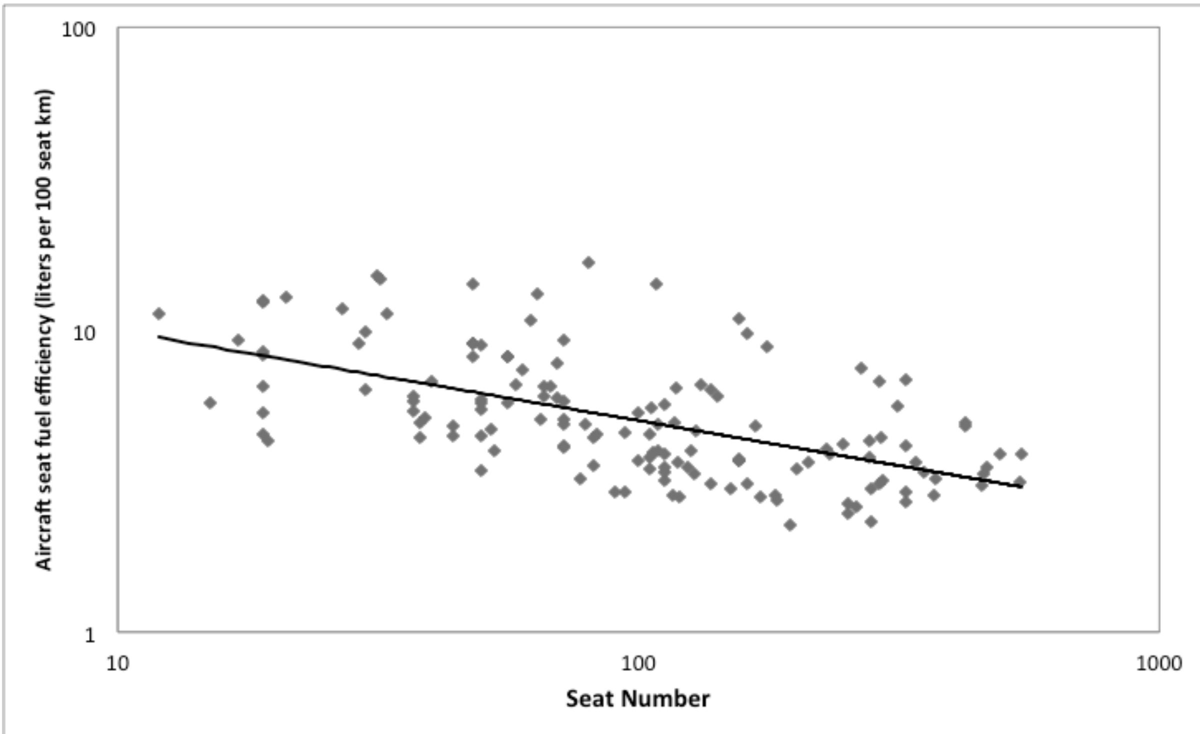

Figure 2: Aircraft fuel economy and seat numbers for a sample of 143 aircraft models.

	ln efficiency 1
Demeaned Log Seats	-0.274***
	(0.0333)
1940s	0.280***
	(0.0971)
1950s	-0.00663
	(0.335)
1960s	0.304**
	(0.138)
1970s	0.537***
	(0.0968)
1980s	-0.00112
	(0.0841)
1990s	0.0121
	(0.0903)
2000s	-0.168**
	(0.0755)
Constant	1.468***
	(0.0648)
N	143
adj. R-sq	0.468

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 3: The effect of seat size and the decade of first flight on aircraft fuel economy.

achievable fuel efficiency levels. Noteworthy, older aircraft sometimes get retrofitted with newer engines and wingtips etc. Our data cannot capture such retrofitting.

Table 3 shows the magnitude of the impact of aircraft size on efficiency, while controlling for the fact that technology has been changing over time. We find that planes with more seats are significantly more fuel-efficient independent of the time effect. The numbers indicate that aircraft introduced in the 1940s, 1960s, and 1970s were significantly less fuel-efficient than recent aircraft, *ceteris paribus*. Aircraft introduced in the first decade of the 21st Century were more fuel-efficient.

To remove the significant impact of plane size on efficiency – in order to focus on variables that can be influenced by energy policy rather than technological features -, we created size-adjusted aircraft fuel economy as described in the Data Section. Figure 3 plots seat weighted airline fleet fuel economy against size-adjusted economy.

Less (more) fuel-efficient airlines tend to look relatively more (less) efficient using size adjusted fuel economy than simple fuel economy. Because larger airlines in terms of the total number of seats also tend to use larger aircraft, this correction also means that the relationship between fuel economy and airline size should be less pronounced using size adjusted fleet fuel economy than simple fuel economy. Figure 4 shows the relationship between simple fleet fuel economy and airline size. Larger airlines tend to fly longer legs with larger aircraft, therefore their seat weighted simple fuel economy will be better due to the higher number of large aircraft.

In Figure 5 we show the impact of airline size on size adjusted fleet fuel economy. As expected, the relationship is less strong, but importantly still suggests that there are economies of scale. This means that even after controlling for the efficiency improvements arising from the size of aircrafts, big airlines tend to fly more efficient fleets. This might be either due to the impact of fleet age or a better investment strategy.

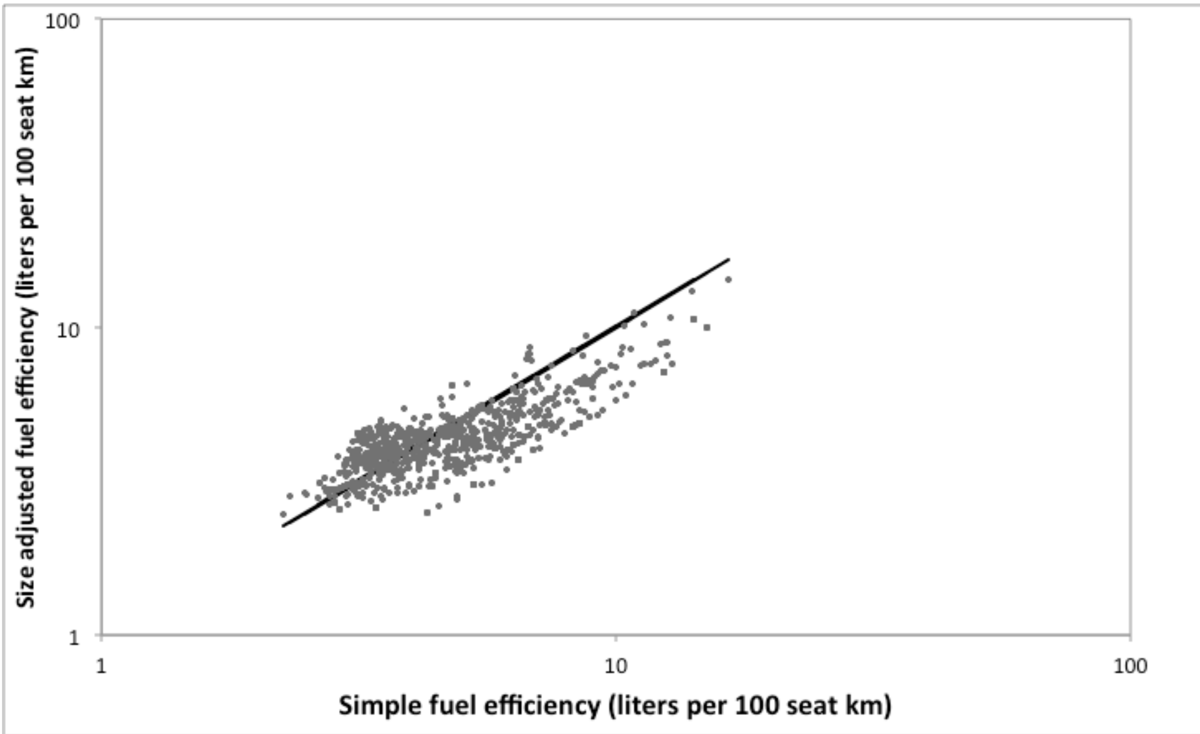

Figure 3: Airline simple fleet fuel economy vs. size-adjusted airline fleet fuel economy for 1267 airlines. The solid line represents a 45 degree line.

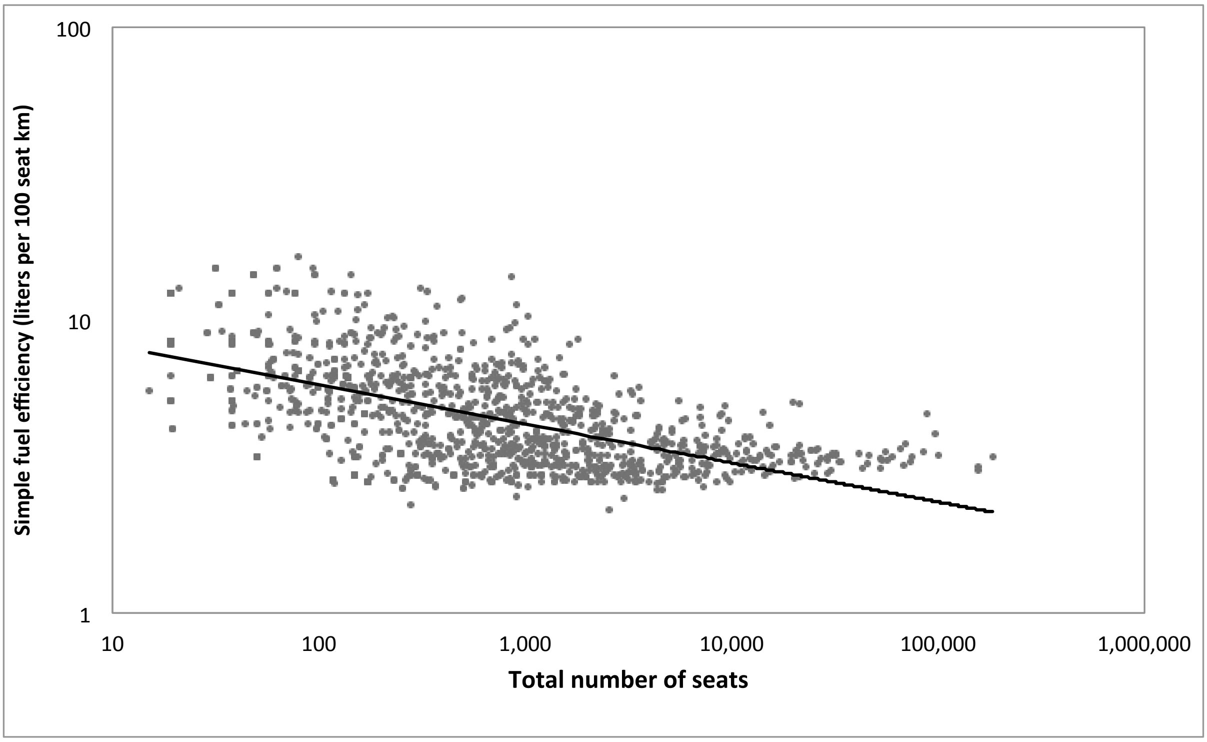

Figure 4: Airline simple fleet fuel economy and total number of seats

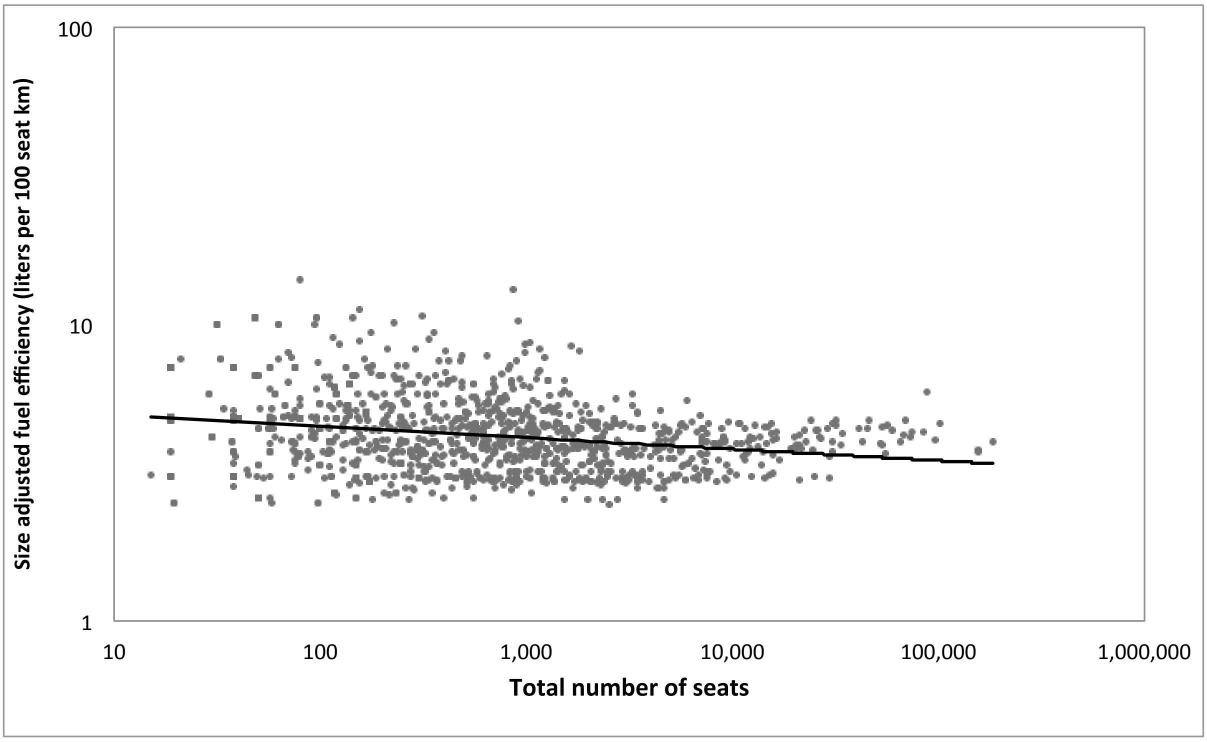

Figure 5: Airline size adjusted fleet fuel economy and total number of seats

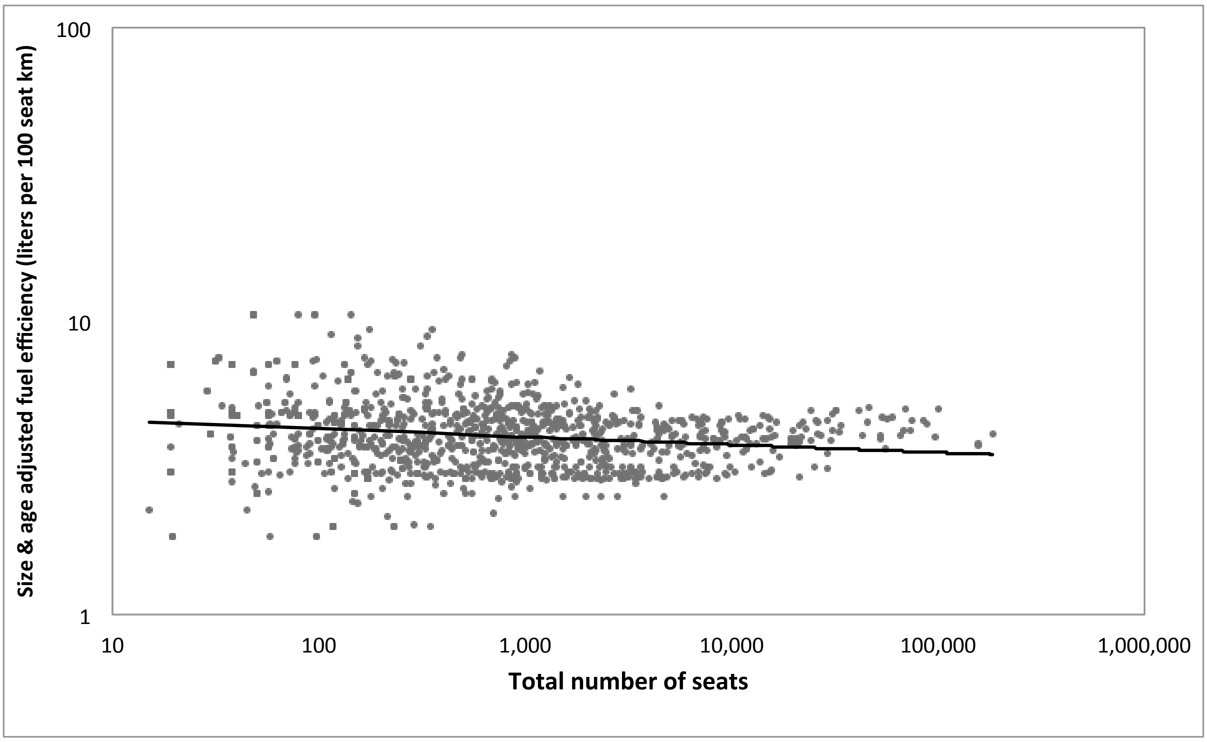

Figure 6: Airline size and age adjusted fleet fuel economy and total number of seats

Among the ten largest airlines in the world (over 70,000 total seats), five airlines (including the first three) are from the United States, two from China, and one from each of the UEA, the UK, and Germany. In our sample, 85 airlines have more than 10,000 total seats, while the majority (65%) of airlines have less than 1,000 total seats. When we rid the efficiency measure both of aircraft size and age, the relationship flattens again, indicating that larger airlines fly both larger and newer types of planes.

Average airline fuel economy of the 1267 airlines in our sample, has a mean value of 5.28 (liter/hundred seat-km), while the most efficient airline's efficiency is 2.25 (liter/hundred seat-km), and the least efficient airline's efficiency is at 16.56 liter/hundred seat-km. These are the observed (actual) values. Accounting for differences in aircraft size, the modified efficiency measure shows a hypothetical average of 4.44 liter/hundred seat-km, with the most efficient airlines at 2.46, and the least efficient at 14.18 liter/hundred seat-km. Accenting for both size and age effects, the average is found at 4.27, the minimum at 1.83 and the maximum at 10.58 liter/seat-km. These statistics show that the differences in efficiency in a worldwide sample are far greater than the variation reported by Zhou *et al*. (2014) for the US.

5.2 Factors influencing airlines' choice of fleet fuel economy

Tables 4, 5, and 6 report the results of Eq. (5) for simple, size adjusted, and size and age adjusted fleet fuel economy. The explanatory variables in each table are the same except we control for the average number of seats and the average age of the fleet in Columns 3 and 4 in Table 4, where the dependent variable is simple fuel economy and for average age in Columns 3 and 4 in Table 5, where the dependent variable is size-adjusted fuel economy. These provide an alternative way of removing the effects of size and model age. However, they will remove both the possible effect of these variables on the behavior of airlines as well as the purely technical effect of size and model age on model fuel economy. Therefore, we prefer the estimates in Table Columns 1& 2 to those in Columns 3 and 4 in Tables 4 and 5. The R squared in Table 4, Columns 3 and 4 is high. The variables explain 56% of the variation in simple (or observed) fleet fuel economy. In contrast, the R squared in successive tables is lower, because we removed the effect of plane size and age from the observed fuel economy variable, and from the regressors as well.

The effect of economies of scale is measured by the natural logarithm of the total number of seats, given that the average number of seats in an airline are directly controlled for (Tab.3, Cols 3 and 4), or size-adjusted efficiencies are used (Tab. 4 and 5). The coefficient on the log total number of seats is highly significant and negative in all regressions in Tables 4 to 6. In Table 4 Columns 1 and 2, where the dependent variable is simple fuel economy the coefficient of log total number of seats is largest (in absolute value) at -0.132. However, when we control for the average size and age of plane (Columns 3 and 4) the effect size is much smaller at -0.025 to -0.026. Here though the partial effect of a change in total seat number is equivalent to that of a change in the number of planes the airline operates. In Table 5 (Columns 1 and 2) the returns to scale effect is -0.038. Here the dependent variable adjusts for the technical effect of plane size on fuel economy. In Table 6, where the dependent variable is adjusted for model age, which reduces the variation in fuel economy further, the returns to scale effect is only -0.026, though still statistically significant. There may be various reasons why we find economies of scale. For example, larger firms may get better deals on new aircraft and have more flexible financing opportunities.

As international or domestic aviation fuel prices were not available, we use road gasoline prices, oil rents as a % of GDP, and oil reserves, as proxy variables. The results for gasoline prices are similar for the simple and size-adjusted efficiency measures, with elasticities ranging from -0.09 to -0.132 for simple fleet fuel economy, and -0.087 to -0.11 for size-adjusted fleet fuel economy, when we do not control for fleet model age and significant at the 1 or 5% level. In Table 6, where we adjust fuel economy for the model age of the fleet, the coefficient on the price of gasoline is smaller and not significant at the 5% level. This shows that the response to variations in fuel price is largely addressed by varying the model age of planes employed. Our reported elasticities are somewhat smaller than Li *et al.* 's (2009) and Burke and Nishitateno (2013)'s results on car fleet fuel economy, who respectively find that a 1% increase in fuel prices results in a 0.2% improvement in fleet fuel economy, and to a 0.15-0.2% improvement in new vehicle fleet fuel economy. Of course, cars have a much lower lifespan than aircraft and as we only approximate jet fuel prices these estimates are likely subject to attenuation due to measurement error (Hausman, 2001). We also simultaneously control for oil rents as a percentage of GDP and for oil reserves in a country, both an indicator of fuel prices in general and of subsidies. We do not find the coefficient on either variable significant, after including gasoline prices.

Wages, which constitute one of the largest operating expenses of airlines were not found to be significant in any of the regressions in Tables 4 to 6, though the sign of the effect is as expected. As we estimated wages for many airlines based observations for other airlines and GDP per capita, this is likely the result of measurement error. We would expect that airlines operating in poor vs. rich countries would show differences in their airline fleet fuel economy, although the generally higher interest rates in lower-income countries might be picking up this effect.

Dependent variable: ln simple airline fleet fuel economy

	(1)	(2)	(3)	(4)
ln total seats	-0.132***	-0.132***	-0.0249***	-0.0257***
	(0.00921)	(0.00940)	(0.00725)	(0.00733)
ln wage	-0.0140	-0.0112	-0.0280	-0.0240
	(0.0237)	(0.0240)	(0.0186)	(0.0183)
ln gasoline price	-0.0904**	-0.132***	-0.0655**	-0.0864**
	(0.0432)	(0.0427)	(0.0321)	(0.0329)
ln oil reserves	-0.000831		0.0000740	
	(0.00119)		(0.000958)	
ln oil rents		-0.00703*		-0.000845
		(0.00412)		(0.00326)
ln real interest rate	0.0282***	0.0276**	0.0248***	0.0205**
	(0.0102)	(0.0105)	(0.00912)	(0.0101)
ln land area	0.0102	0.0165*	-0.0145*	-0.0137*
	(0.0101)	(0.00845)	(0.00772)	(0.00688)
ln population	-0.0168	-0.0150	0.0141	0.0152
	(0.0164)	(0.0186)	(0.0106)	(0.0119)
ln passengers	0.0315**	0.0289*	0.0136	0.0129
	(0.0141)	(0.0146)	(0.00901)	(0.00929)
ln average seats per airline			-0.276***	-0.273***
			(0.0130)	(0.0127)
ln average age of fleet			0.192***	0.206***
			(0.0543)	(0.0556)
Europe and Central Asia	0.130***	0.138***	0.119***	0.124***
	(0.0381)	(0.0363)	(0.0272)	(0.0255)
Latin America & Caribbean	0.0935**	0.0952**	0.0217	0.0272
	(0.0386)	(0.0397)	(0.0283)	(0.0279)
Middle East & North Africa	-0.130**	-0.128**	-0.0569	-0.0616
	(0.0561)	(0.0576)	(0.0428)	(0.0456)
North America	0.0862*	0.0803**	0.0380	0.0290
	(0.0440)	(0.0402)	(0.0364)	(0.0315)
South Asia	-0.0564	-0.0677	-0.0876**	-0.0927**
	(0.0525)	(0.0634)	(0.0423)	(0.0456)
Sub-Saharan Africa	0.0503	0.00115	-0.0110	-0.0376
	(0.0543)	(0.0557)	(0.0419)	(0.0441)
Constant	2.089***	1.964***	2.248***	2.138***
	(0.306)	(0.371)	(0.337)	(0.372)
N	890	852	890	852
adj. R-sq	0.375	0.378	0.560	0.564

Robust, country clustered standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 4: Determinants of simple fleet fuel economy. The regional dummy omitted was East Asia and the Pacific. Regressions 3 and 4 do not control for average seats or the average age of the fleet.

Dependent variable: Ln size adjusted airline fleet fuel economy

	(1)	(2)	(3)	(4)
ln total seats	-0.0375***	-0.0380***	-0.0180**	-0.0177**
	(0.00658)	(0.00672)	(0.00766)	(0.00781)
ln wage	-0.0262	-0.0243	-0.0251	-0.0219
	(0.0194)	(0.0198)	(0.0181)	(0.0181)
ln gasoline price	-0.0870**	-0.111***	-0.0660**	-0.0856**
	(0.0365)	(0.0376)	(0.0321)	(0.0331)
ln oil reserves	0.000144		0.000222	
	(0.000941)		(0.000936)	
ln oil rents		-0.00143		-0.000314
		(0.00333)		(0.00310)
ln real interest rate	0.0287***	0.0242**	0.0246***	0.0200**
	(0.00912)	(0.0100)	(0.00907)	(0.0100)
ln land area	-0.0105	-0.00727	-0.0132*	-0.0125*
	(0.00814)	(0.00711)	(0.00753)	(0.00655)
ln population	0.00783	0.00715	0.0137	0.0141
	(0.0119)	(0.0140)	(0.0107)	(0.0121)
ln passengers	0.0164*	0.0150	0.0117	0.0110
	(0.00900)	(0.00933)	(0.00906)	(0.00934)
ln average age of fleet			0.211***	0.224***
			(0.0547)	(0.0560)
Europe and Central Asia	0.129***	0.134***	0.108***	0.113***
	(0.0328)	(0.0314)	(0.0273)	(0.0256)
Latin America & Caribbean	0.0538*	0.0592*	0.0198	0.0244
	(0.0310)	(0.0312)	(0.0287)	(0.0283)
Middle East & North Africa	-0.0654	-0.0696	-0.0595	-0.0641
	(0.0465)	(0.0505)	(0.0433)	(0.0464)
North America	0.0545	0.0445	0.0401	0.0293
	(0.0407)	(0.0371)	(0.0364)	(0.0315)
South Asia	-0.0861**	-0.0844*	-0.0909**	-0.0915*
	(0.0420)	(0.0480)	(0.0434)	(0.0468)
Sub-Saharan Africa	0.00608	-0.0205	-0.00881	-0.0348
	(0.0420)	(0.0456)	(0.0398)	(0.0407)
Constant	1.589***	1.572***	0.782**	0.709*
	(0.261)	(0.325)	(0.327)	(0.363)
N	890	852	890	852
adj. R-sq	0.086	0.091	0.126	0.136

Robust, country clustered standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 5: Determinants of size adjusted fleet fuel economy. The regional dummy omitted was East Asia and the Pacific. Regressions 3 and 4 do not control for the average age of the fleet.

Dependent variable: ln size and age adjusted airline fleet fuel economy		
	(1)	(2)
ln total seats	-0.0248***	-0.0255***
	(0.00517)	(0.00520)
ln wage	-0.0107	-0.00849
	(0.0178)	(0.0177)
ln gasoline price	-0.0202	-0.0476*
	(0.0293)	(0.0284)
ln oil reserves	-0.000170	
	(0.000974)	
ln oil rents		-0.000133
		(0.00311)
ln real interest rate	0.0325***	0.0254***
	(0.00836)	(0.00872)
ln land area	-0.0153**	-0.0161**
	(0.00692)	(0.00618)
ln population	0.0195*	0.0181
	(0.0115)	(0.0125)
ln passengers	0.00690	0.00666
	(0.00950)	(0.00960)
Europe and Central Asia	0.103***	0.106***
	(0.0261)	(0.0244)
Latin America & Caribbean	0.0350	0.0409
	(0.0282)	(0.0272)
Middle East & North Africa	-0.0379	-0.0541
	(0.0388)	(0.0411)
North America	0.0410	0.0347
	(0.0336)	(0.0269)
South Asia	-0.0929*	-0.0882
	(0.0525)	(0.0566)
Sub-Saharan Africa	-0.0138	-0.0413
	(0.0413)	(0.0427)
Constant	1.345***	1.378***
	(0.248)	(0.291)
N	890	852
adj. R-sq	0.040	0.044

Robust, country clustered standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 6: Determinants of size and age adjusted fleet fuel economy. The regional dummy omitted was East Asia and the Pacific. Regressions 3 and 4 were carried out with country clustered standard errors.

Dependent Variable:	ln simple airline fleet fuel economy		ln size adjusted airline fleet fuel economy		ln size and age adjusted airline fleet fuel economy	
	(1)	(2)	(3)	(4)	(5)	(6)
ln total seats	-0.0856***	-0.0856***	-0.0141**	-0.0145**	-0.00103	-0.00143
	(0.0110)	(0.0111)	(0.00710)	(0.00719)	(0.00579)	(0.00582)
ln wage	-0.0239	-0.0236	-0.00432	-0.00594	0.0219	0.0219
	(0.0274)	(0.0284)	(0.0196)	(0.0202)	(0.0180)	(0.0186)
ln gasoline price	-0.0752***	-0.104***	-0.0809***	-0.0932***	-0.0559**	-0.0669***
	(0.0205)	(0.0241)	(0.0228)	(0.0250)	(0.0225)	(0.0237)
ln oil reserves	-0.00126*		-0.000444		-0.000394	
	(0.000750)		(0.000723)		(0.000761)	
ln oil rents		-0.00660*		-0.00167		-0.00127
		(0.00351)		(0.00310)		(0.00281)
ln real interest rate	0.0105*	0.0116**	0.0118	0.0107	0.0154**	0.0141*
	(0.00574)	(0.00564)	(0.00758)	(0.00774)	(0.00671)	(0.00717)
ln land area	0.00893	0.0133**	-0.00632	-0.00294	-0.00882	-0.00758
	(0.00640)	(0.00573)	(0.00585)	(0.00461)	(0.00537)	(0.00501)
ln population	-0.0231*	-0.0205	-0.000428	-0.000109	0.00892	0.00935
	(0.0134)	(0.0147)	(0.0102)	(0.0112)	(0.0100)	(0.0110)
ln passengers	0.0346***	0.0322**	0.00837	0.00654	-0.00240	-0.00274
	(0.0131)	(0.0135)	(0.00995)	(0.0100)	(0.00970)	(0.00990)
Europe and Central Asia	0.0692***	0.0769***	0.0584***	0.0666***	0.0401**	0.0444**
	(0.0210)	(0.0212)	(0.0211)	(0.0198)	(0.0201)	(0.0203)
Latin America & Caribbean	0.0563**	0.0605**	0.00121	0.00612	-0.00893	-0.00451
	(0.0282)	(0.0300)	(0.0234)	(0.0238)	(0.0222)	(0.0225)
Middle East & North Africa	-0.0785***	-0.0738**	-0.0611*	-0.0562	-0.0472	-0.0462
	(0.0285)	(0.0300)	(0.0324)	(0.0351)	(0.0306)	(0.0332)
North America	0.0504*	0.0603**	-0.00243	0.00357	-0.0274	-0.0246
	(0.0295)	(0.0288)	(0.0274)	(0.0255)	(0.0257)	(0.0239)
South Asia	-0.0615**	-0.0722**	-0.0893***	-0.0884**	-0.0894***	-0.0895**
	(0.0298)	(0.0335)	(0.0335)	(0.0361)	(0.0315)	(0.0342)
Sub-Saharan Africa	0.0874**	0.0607	0.0312	0.0217	0.0184	0.00616
	(0.0415)	(0.0437)	(0.0346)	(0.0384)	(0.0351)	(0.0385)
Constant	1.979***	1.876***	1.487***	1.473***	1.161***	1.137***
	(0.295)	(0.326)	(0.237)	(0.267)	(0.222)	(0.254)
N	890	852	890	852	890	852
adj. R-sq	0.305	0.303	0.026	0.029	0.009	0.008

Robust, country clustered standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 7: Determinants of fleet fuel economy: Weighted least squares estimates with the square root of total seats used as weights.

We find that real interest rates are significant at the 1% to 5% level in all specifications, and have a positive coefficient as expected. This means that a 1% increase in interest rates (for example from 1.0 to 1.01% in levels), will result in the worsening of long-run fleet fuel economy between 0.02 to 0.033 %. Higher interest rates not only mean a higher cost of capital for purchasing aircraft, but are also incorporated in lease-rates, effectively increasing the cost of renting an aircraft. Therefore, higher interest rates are likely to result in less investment into newer, efficient technologies.

Finally, we consider the environmental variables. We find that greater land area is associated with better fuel economy only when we adjust or control for model age. This indicates that even though we control for the size of the aircraft and the size of the airline, airlines based in larger countries fly more technically efficient aircraft. Population and passenger numbers were not found to be a significant driver of fleet fuel economy.

We find compared to the base region of East Asia and the Pacific that Europe and Central Asia has significantly worse fleet fuel economy. This result is remarkably robust in all three specifications, and is not only driven by airlines in Russia and the USSR successor states, but also by airlines in the European Union. The results are not attributable to the age of the fleets or to the size of the aircraft, but potentially to different technology used in planes of the same age and seat size. These planes are often manufactured by smaller companies. Compared to the base region, South-Asia also shows significantly higher efficiency in some specifications including our central estimates in Columns 3 and 4 in Table 5. In the simple fleet fuel economy regressions without the fleet age and average seat size controls, a number of regional dummies are significant. Most of these inferences disappear however, once we adjust or control for seat size and age.

We present weighted least squares estimates in Table 7 focusing on the size adjusted estimates in Columns 3 and 4. These are broadly similar to those in Table 5. The returns to scale effect is smaller here, the dummy for Europe and Central Asia has a smaller effect, and the coefficient of the South Asia dummy is much more significant.

6. Conclusions and Policy Implications

In this paper, we investigated the impact of plane size and age, fuel prices, capital costs, wages and airline size on technically achievable fleet fuel economy. We constructed a dataset from plane-level data for 1267 airlines in 2015. Newer and bigger aircraft are more efficient. We find that, *ceteris paribus*, larger airlines – as measured by total number of seats – have higher fleet fuel economy. This suggests that there are economies of scale in fuel efficiency choice. Larger airlines not only fly larger, and thus more fuel-efficient planes, but they use more fuel-efficient aircraft independent of the size (and also model age) of aircraft. One of the explanations is that larger airlines potentially have better access to financing or lower capital costs and are willing to invest in more fuel-efficient aircraft. We also find that the elasticity of fleet fuel economy with respect to the price of fuel is between -0.07 to -0.13, depending on specification, where a negative sign indicates an improvement in fleet fuel economy with higher fuel prices. This value is only a little lower than previous studies have reported for road vehicle fleet fuel economy. Higher interest rates are, on the other hand, associated with worse fleet fuel economy. Wages were not found to have a significant effect. We find that, despite a wide range of controls, some regional differences persist, which are independent of the age or the size of the aircraft or the other controls. These differences are best explained by the evolution of different technological designs for aircraft of the same size and age throughout the world.

Looking into the future, our findings confirm that airline fleet fuel economy is significantly though very inelastically responsive to changes in fuel prices as well as credit costs and availability. The policy implications of these findings are twofold: We see that higher taxes on domestic aviation fuel, the removal of fuel subsidies, or taxes on aircraft GHG emissions would in fact result in some improvement of fleet fuel economy through change in the composition of the fleet. Our estimate of the fuel economy elasticity treats the current price of aircraft of varying fuel efficiency as an implicit given. Induced technical change could increase the long-run response by lowering the cost of fuel-efficient aircraft. On the other hand, there could also be some leakage (Jacobsen and van Benthem, 2015) if global fuel price increases lowered the price of less fuel-efficient aircraft.

As international agreements on aircraft emissions standards are consistently delayed, and the introduction of carbon pricing has been limited to regional initiatives, the removal of fuel subsidies would seem the most plausible course of action. While some states may keep subsidizing fuel in order to support their national flagship carriers, we have seen several successful examples of fossil fuel subsidy removal. Long-run efficiency gains may translate to long-run profits for firms, and the economy, result in cleaner skies and a pathway to emission reductions of the aviation sector.

References

Adrangi, B., Gritta, R. D., Raffiee, K. (2014). "Dynamic interdependence in jet fuel prices and air carrier revenues", *Atlantic Economic Journal* 42: 473–474.

Alcott, H. Wozny, N. (2014). "Gasoline prices, fuel economy and the energy paradox", The *Review of Economics and Statistics* 96(5): 779-795.

Anger, A. Koehler, J. (2010). "Including aviation emissions in the EU ETS: much ado about nothing? A review", *Transport Policy* 17(1): 38-46.

Babikian, R., Lukachko, S. P., Waitz, I. A. (2002). "The historical fuel efficiency characteristics of regional aircraft from technological, operational, and cost perspectives", *Journal of Air Transport Management* 8: 389–400.

Barreto L., Kemp, R. (2008). "Inclusion of technology diffusion in energy-system models: some gaps and needs", *Journal of Cleaner Production* 16S1: 95-101.

Benmelech, E., Bergman, N. (2011). "Vintage capital and creditor protection", *Journal of Financial Economics* 99: 308–332.

Berry, S. Jia, P. (2010). "Tracing the woes: an empirical analysis of the airline industry", *American Economic Journal: Microeconomics* 2: 1–43.

Borenstein, S. (2011). "Why can't US airlines make money?" *American Economic Review* 101(3): 233–237.Burke, P. J. (2013). The national-level energy ladder and its carbon implications, *Environment and Development Economics* 18(4): 484–503.

Burke P. J., Nishitateno, S. (2013). "Gasoline prices, gasoline consumption, and new-vehicle fuel economy: Evidence for a large sample of countries", *Energy Economics* 36: 363–370.

Caves, D. W. Christensen, L. R., Tretheway, M. W. (1984). "Economies of density versus economies of scale - why trunk and local-service airline costs differ", *Rand Journal Of Economics* 15(4): 471-489.

Coelli, T., Perelman, S., Romano, E. (1999). "Accounting for environmental influences in stochastic frontier models: With application to international airlines", *Journal of Productivity Analysis* 11(3): 251-273.

Economist, The (2012). "Buy or rent?", http://www.economist.com/node/21543195, print edition: Jan 21st, 2012.

EASA/EEA/EUROCONTROL (2016). *European Aviation Environmental Report*, DOI: 10.1007/s11293-013-9388-9, ISBN: 978-92-9210-197-8

Eisfeldt, A., Rampini, A. (2006). "Capital reallocation and liquidity", *Journal of Monetary Economics* 53(3): 369–399.

ECB (2017). European Central Bank data*: Corporates' cost of borrowing,* %: https://sdw-wsrest.ecb.europa.eu/service/data/MIR/M.AT+BE+CY+DE+EE+ES+FI+FR+GR+IE+IT+LT+LU+LV+MT+NL+PT+SI+SK+U2.B.A2I.AM.R.A.2240.EUR.N?startPeriod=2003

Flightglobal (2015). *World Airliner Census 2015*. https://www.flightglobal.com/asset/3480

GAO- United States Government Accountability Office (2014). Report to Congressional Committees, Aviation, Impact of Fuel Price Increases on the Aviation Industry, GAO-14-331.

Gavazza, A. (2011). "Leasing and secondary markets: theory and evidence from commercial aircraft", *Journal of Political Economy* 119(2): 325-377.

Gillen, D. W., Oum, T. H., Tretheway, M.W. (1990). "Airline cost structure and policy implications: a multi-product approach for Canadian airlines", *Journal of Transport Economics and Policy* 24(1): 9-34.

Greve, H. R., Seidel, M-D. L. (2015). "The thin red line between success and failure: Path dependence in the diffusion of innovative production technologies", *Strategic Management Journal* 36: 475-496.

Hausman, J. (2001). "Mismeasured variables in econometric analysis: problems from the right and problems from the left", *Journal of Economic Perspectives* 54(4): 57-67.

ICAO - International Civil Aviation Organization (2016). Assembly — 39th Session, Agenda Item 22: Environmental Protection – International Aviation and Climate Change – Policy, Standardization and Implementation Support, Working Paper: A39-WP/207, EX/77, 18/8/16

IEA – International Energy Agency (2009). *Transport, Energy and CO2, moving towards sustainability*, IEA/OECD 2009, (61 2009 25 1P1) ISBN: 978-92-64-07316-6.

IEA (2014). *World Energy Outlook 2014*, International Energy Agency.

IEA (2016). *World Energy Outlook 2016*, International Energy Agency.

Inglada, V, Rey, B, Rodriguez-Alvarez, A, Coto-Millan, P. (2006). “Liberalisation and efficiency in international air transport”, *Transportation Research Part A-Policy and Practice* 40(2): 95-105.

Jacobsen, M.R., van Benthem, A.A. (2015). “Vehicle Scrappage and Gasoline Policy”, *American Economic Review* 105(3): 1312–1338

Jaffe, A., Stavins, R. (1994). “The energy paradox and the diffusion of conservation technology”, *Resource and Energy Economics* 16: 91–122.

Kahn, M. E., Nickelsburg, J. (2016). „An economic analysis of U.S. airline fuel economy dynamics from 1991 to 2015”, NBER Working Paper 22830.

Keen, M. Strand, J. (2007). “Indirect taxes on international aviation”, *Fiscal Studies* 28(1): 1–41.

Klier, T., Linn, J. (2010). “The price of gasoline and new vehicle fuel economy: evidence from monthly sales data”, *American Economic Journal: Economic Policy* 2: 134–153.

Lee, J. J., Lukachko, S. P., Waitz, I. A., Schafer, A. (2001). “Historical and future trends in aircraft performance, cost, and emissions”, *Annual Review of Energy and the Environment* 26: 167–200.

Lee, J. J. (2010). “Can we accelerate the improvement of energy efficiency in aircraft systems”? *Energy Conversion and Management* 51: 189–196.

Li, S., Timmins, C., von Haefen R. H. (2009). “How do gasoline prices affect fleet fuel economy?” *American Economic Journal: Economic Policy* 1(2): 113–137.

Murphy, F., Li, N. Murphy, B., Cummins, M. (2013). “The link between jet fuel prices, carbon credits and airline firm value”, J*ournal of Energy Markets* 6(2): 83-97.

Naumann, N., Suhl, L. (2013). “How does fuel price uncertainty affect strategic airline planning?” *Operational Research* 13 (3): 343–362.

Nava, C. R., Meleo, L. Cassetta, E. Morelli, G. (2017). “The impact of the EU-ETS on the aviation sector: competitive effects of abatement efforts by airlines”, *Department of*

Economics and Statistics "Cognetti de Martiis" Campus, Working Paper 10/17. http://econpapers.repec.org/paper/utodipeco/201710.htm

Oum, T. H., Yu, C. Y. (1998). "Cost competitiveness of major airlines: An international comparison", *Transportation Research Part A-Policy and Practice* 32(6): 407-422.

Peeters, P. M., Middel, J., Hoolhorst, A. (2005). "Fuel efficiency of commercial aircraft An overview of historical and future trends", *National Aerospace Laboratory (NLR) Report*: NLR-CR-2005-669.

Romano, J. P., Wolf, M. (2017). "Resurrecting weighted least squares", *Journal of Econometrics* 197: 1–19.

Rosskopf, M., Lehner, S., Gollnick, V. (2014). "Economic -environmental trade-offs in long-term airline fleet planning", *Journal of Air Transport Management* 34: 109-115.

Scheelhaase J., Grimme, W., Schaefer M. (2010). "The inclusion of aviation in the EU greenhouse gas emissions trading scheme – impacts on competition between European and non-European network airlines", *Transportation Research Part D: Transport and Environment* 15(1): 14-25.

Sims R., Schaeffer R., Creutzig, F., Cruz-Núñez, X., D'Agosto, M., Dimitriu, D., Figueroa Meza, M. J., Fulton L., Kobayashi, S., Lah, O., McKinnon, A., Newman, P., Ouyang, M., Schauer, J. J., Sperling, D., Tiwari, G. (2014). Transport. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T., Minx, J. C. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Verdolini, E., Galeotti, M. (2011). "At home and abroad: an empirical analysis of innovation and diffusion in energy technologies", *Journal of Environmental Economics and Management* 61(2): 119-134.

Vespermann, J., Wittner, A. (2011). "Financial, ecological and managerial impacts of emission trading schemes: the case of Lufthansa", *Business Strategy and the Environment* 20(3): 174-191.

World Bank (2017). *World Development Indicators*. http://data.worldbank.org/data-catalog/world-development-indicators

Zou, B., Elke, M., Hansen, M., Kafle, N. (2014). "Evaluating air carrier fuel efficiency in the US airline industry", *Transportation Research Part A* 59: 306–330.

Zou, B., Kwan, I., Hansen, M., Rutherford, D., Kafle, N. (2016). Airline Fuel Efficiency: Assessment Methodologies and Applications in the U.S. Domestic Airline Industry, *Advances in Airline Economics*, edited by Peoples, J., Bitzan, J., Emerald Group Publishing.

Appendices:

- List of aircraft types used and technical data
- Sources of technical information

Appendix 1: Technical Data

Aircraft Model	Seat	Fuel Capacity	Maximum Range	First Flight
AIRBUS A300 B1	290	43,478	2,222	1972
AIRBUS A300 B4600	294.5	62,000	6,670	1983
AIRBUS A310	233	61,070	6,800	1982
AIRBUS A318	107	24,210	5,750	2002
AIRBUS A319	124	30,190	6,950	1995
AIRBUS A320	150	27,200	6,100	1987
AIRBUS A321	185	30,030	5,950	1993
AIRBUS A330 200	247	139,090	13,450	1997
AIRBUS A330 300	277	139,090	11,750	1992
AIRBUS A340 200	341.5	155,040	12,408	1992
AIRBUS A340 300	277	140,640	13,500	1991
AIRBUS A340 500	293	215,260	16,668	2002
AIRBUS A340 600	326	195,520	14,450	2002
AIRBUS A350 900	325	141,000	15,000	2013
AIRBUS A380	544	320,000	15,200	2005
ANTONOV AN-72/74	60	13,075	2,975	1977
ANTONOV AN140	52	5,627	2,300	1997
ANTONOV AN148	77.5	8,328	3,367	2004
ANTONOV AN158	94	7,595	2,800	2010
ANTONOV AN24	50	6,522	2,400	1960
ANTONOV AN26	40	6,875	2,550	1969
ANTONOV AN28	17	1,957	1,250	1969
ANTONOV AN3	12	1,624	1,200	1947
ANTONOV AN38	27	2,860	900	1994
ATR 42 300	48	5,754	845	1984
ATR 42 400	48	5,754	1,470	1995
ATR 42 500	48	5,754	1,326	1994
ATR 42 600	48	5,754	1,326	2010
ATR 72 200	66	6,394	1,615	1988
ATR 72 210	66	6,394	1,491	1988
ATR 72 500	68	6,394	1,454	1988
ATR 72 600	70	6,394	1,528	1988
BAE (HS) 748	58	6,546	1,715	1960
BAE ATP	72	6,360	1,740	1969
BAE AVRO 146RJ 200	109	11,728	2,222	1984
BAE AVRO 146RJ 300	100	11,728	2,222	1985
BAE BAE146 100	70	11,728	2,174	1981
BAE JETSTREAM 31	19	1,850	1,185	1982
BAE JETSTREAM 41	29	3,300	1,263	1991
BAE SYSTEMS AVRO RJ 100	128	11,701	2,760	1992
BAE SYSTEMS AVRO RJ 85	112	11,701	2,965	1992
BEECHCRAFT 1900C	19	2,520	1,070	1982
BEECHCRAFT 1900D	19	2,520	2,500	1982

BEECHCRAFT B99	15	1,430	1,665	1966
BOEING 717 200	117.5	13,904	2,408	1998
BOEING 727 100	106	29,069	5,005	1963
BOEING 727 200	118.5	30,620	4,021	1963
BOEING 737 200	116.5	16,176	4,899	1967
BOEING 737 300	138	20,102	2,300	1984
BOEING 737 400	167.5	20,102	2,500	1988
BOEING 737 500	128.5	20,102	3,400	1989
BOEING 737 600	119	26,022	5,982	1998
BOEING 737 700	138	26,022	6,112	1997
BOEING 737 800	172	26,022	5,417	1997
BOEING 737 900	183	26,022	5,052	2000
BOEING 737 900ER	196	26,025	5,900	2006
BOEING 747 100	423	178,700	8,556	1969
BOEING 747 200	423	198,380	9,780	1970
BOEING 747 300	496	198,380	10,360	1982
BOEING 747 400	538	210,590	12,435	1988
BOEING 747 8	467	243,400	14,800	2011
BOEING 747 SP	314	189,890	10,840	1975
BOEING 757 200	212.5	42,680	5,550	1982
BOEING 757 300	261	43,400	6,400	1998
BOEING 767 200	253	58,902	9,401	1981
BOEING 767 200ER	253	82,143	12,200	1984
BOEING 767 300	280	63,216	9,700	1986
BOEING 767 300ER	280	91,380	11,000	1986
BOEING 767 400ER	326	91,370	10,400	1999
BOEING 777 200ER	372.5	171,170	14,260	1996
BOEING 777 200LR	370.5	181,280	17,370	2005
BOEING 777 300	459	171,100	11,140	1997
BOEING 777 300ER	457.5	181,200	12,995	2003
BOEING 787 8	230	126,200	13,620	2009
BOEING 787 9	290	126,370	14,140	2013
BOEING MD-11	354	146,170	12,270	1990
BOMBARDIER CRJ 1000	100	11,114	3,004	2008
BOMBARDIER CRJ100/200	50	5,300	1,800	1991
BOMBARDIER CRJ700	72	10,990	2,650	1999
BOMBARDIER CRJ900	83	10,990	2,950	2001
BOMBARDIER DASH 8 Q100	38	3,160	1,900	1983
BOMBARDIER DASH 8 Q200	38	3,160	1,700	1983
BOMBARDIER DASH 8 Q300	53	3,160	1,500	1987
BOMBARDIER DASH 8 Q400	90	6,530	2,500	1998
CONVAIR 580	56	7,950	1,750	1960
CONVAIR 640*	56	7,950	1,750	1960
DE HAVILLAND CANADA DHC7	50	5,757	1,296	1975
DE HAVILLAND CANADA TWIN OTTER	19	1,450	1,690	2010

DORNIER 228	19	2,441	1,037	1981
DORNIER 328	33	4,290	1,150	1991
DORNIER 328JET	32	8,040	1,700	1998
EMBRAER 135 ER	37	5,336	2,409	1998
EMBRAER 135 LR	37	6,480	3,243	1998
EMBRAER 140 LR	44	6,480	3,058	2000
EMBRAER 145 LR	50	6,396	2,873	1998
EMBRAER 170 AR	72	11,625	3,982	2002
EMBRAER 170 LR	72	11,625	3,889	2002
EMBRAER 170 ST	72	11,625	3,334	2002
EMBRAER 175 LR	82	11,625	3,982	2002
EMBRAER 175 ST	82	11,625	3,241	2003
EMBRAER 190 AR	105	16,153	4,445	2002
EMBRAER 190 LR	105	16,153	3,426	2002
EMBRAER 190 ST	105	16,153	4,074	2004
EMBRAER 195 AR	112	16,153	4,260	2002
EMBRAER 195 LR	112	16,153	3,704	2002
EMBRAER 195 ST	112	16,153	4,537	2004
EMBRAER EMB-110 BANDEIRANTE	19.5	1,670	2,000	1968
EMBRAER EMB-120 BRASILIA	30	3,325	1,750	1983
FAIRCHILD METRO/MERLIN	19	2,450	2,000	1969
FOKKER 100	109	13,360	3,100	1986
FOKKER 27	44	5,069	2,593	1955
FOKKER 28	65	9,640	2,957	1967
FOKKER 50	50	5,140	3,000	1985
FOKKER 70	79	13,360	3,470	1993
ILYUSHIN IL114	64	8,360	1,000	1990
ILYUSHIN IL18	120	23,700	7,100	1957
ILYUSHIN IL62	162	105,300	6,700	1963
ILYUSHIN IL96	267.5	150,400	7,500	1988
INDONESIAN AEROSPACE 212	21	2,000	740	1971
LET L-410	19	1,675	1,040	1969
MCDONNELL DOUGLAS DC10 10	327	82,376	3,704	1970
MCDONNELL DOUGLAS DC8 43	177	88,552	5,713	1958
MCDONNELL DOUGLAS DC9 10	80	13,980	1,055	1965
MCDONNELL DOUGLAS DC9 30	112	13,900	2,200	1965
MCDONNELL DOUGLAS DC9 50	132	16,100	1,850	1974
MCDONNELL DOUGLAS MD81	142	22,129	2,575	1979
MCDONNELL DOUGLAS MD82	156	22,100	3,800	1980
MCDONNELL DOUGLAS MD83	156	26,350	4,600	1984
MCDONNELL DOUGLAS MD87	126.5	22,100	4,400	1986
MCDONNELL DOUGLAS MD88	156	26,350	4,600	1987
MCDONNELL DOUGLAS MD90	162	22,130	4,400	1993
NAMC YS11	62	7,270	1,100	1962
SAAB 2000	50	5,980	2,100	1992

SAAB 340	37	3,220	1,500	1983
SHORTS 330	30	2,550	870	1974
SHORTS 360	39	2,180	1,100	1981
SUKHOI SUPERJET 100	94.5	13,135	3,050	2008
TUPOLEV TU134	72	18,414	2,770	1963
TUPOLEV TU154	155.5	47,000	2,780	1968
TUPOLEV TU204	202	30,812	4,400	1989
XIAN MA60	56	5,153	1,600	2000
YAKOVLEV YAK40	31.5	5,665	1,200	1966
YAKOVLEV YAK42	108	23,300	1,530	1975

Table A.1: Technical information of aircraft used in the dataset. Due to lack of data, the following substitutions were assumed: For Convair 640, data from Convair 590 was filled. For Embraer 145 LU, LI, EP, ER, EU, MP, and XR, the technical data of Embraer 145 LR was assigned. For Embraer 170 SU, the technical data of Embraer 170 ST was assigned, for Embraer 190 SE, Embraer 190 ST was used. The year of first flight was assumed as 2002 for Embraer 170 LR/AR ,175LR, 190 LR/AR, 195LR/AR.

Appendix 2

Aircraft Model: A300 B1
Aircraft Version: B1
Seats: Average between single-class and three-class seating capacity.
Source: http://www.aerospaceweb.org/aircraft/jetliner/a300/
Fuel Capacity: Source: EASA (2016) pp.8
The original data was 34000, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Maximum Range:
First Flight: Source: http://www.actforlibraries.org/all-about-the-a300-airbus/

Aircraft Model: AIRBUS A300 B2
Aircraft Version: 100
Seats: Source:
http://www.airbus.com/fileadmin/media_gallery/files/tech_data/AC/AC_A300_20091201.pdf
Fuel Capacity:
http://www.airbus.com/fileadmin/media_gallery/files/tech_data/AC/AC_A300_20091201.pdf
Maximum Range: http://www.actforlibraries.org/all-about-the-a300-airbus/
First Flight: http://www.airbus.com/newsevents/news-events-single/detail/the-first-airbus-setting-new-standards-together/

Aircraft Model: AIRBUS A300 B2
Aircraft Version: 200
Seats: Average between single-class and three-class seating capacity.
Source: http://www.airliners.net/aircraft-data/airbus-a300b2b4/17
Fuel Capacity:
Source: http://www.airbus.com/fileadmin/media_gallery/files/tech_data/AC/AC_A300_20091201.pdf
Maximum Range:
Range with maximum passengers and reserves.
Source: http://www.airliners.net/aircraft-data/airbus-a300b2b4/17
First Flight:
Source: https://en.wikipedia.org/wiki/Airbus_A300

Aircraft Model: AIRBUS A300 B4
Aircraft Version: 100
Seats: Average between single-class and three-class seating capacity.
Source: http://www.airliners.net/aircraft-data/airbus-a300b2b4/17
Fuel Capacity:
Source: http://www.airbus.com/fileadmin/media_gallery/files/tech_data/AC/AC_A300_20091201.pdf
Maximum Range: Source: https://en.wikipedia.org/wiki/Airbus_A300
First Flight: Source: https://en.wikipedia.org/wiki/Airbus_A300

Aircraft Model: AIRBUS A300 B4
Aircraft Version: 200
Seats: Average between single-class and two-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A300.html
Fuel Capacity:
Source: http://www.airbus.com/fileadmin/media_gallery/files/tech_data/AC/AC_A300_20091201.pdf
Maximum Range: Assuming maximum number of passengers and reserves.
Source: http://www.airliners.net/aircraft-data/airbus-a300b2b4/17
First Flight: Source: https://en.wikipedia.org/wiki/Airbus_A300

Aircraft Model: AIRBUS A300 B4
Aircraft Version: 600
Seats: Seating information is for 600R: Seating capacity usually remains the same as the base when a long-range version is created.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A300.html
Fuel Capacity: Hyperlinked source (pp. 18) specifies 62000-76400 l depending on the engine used.
Maximum Range:
First Flight: http://www.airbus.com/company/history/the-interactive-timeline/

Aircraft Model: AIRBUS A310
Aircraft Version: 200
Seats: Average between single-class and three-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A310.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A310.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A310.html
First Flight: Source: http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/a310-200-first-flight/

Aircraft Model: AIRBUS A310
Aircraft Version: 300
Seats: Average between single-class and three-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A310.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A310.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A310.html
First Flight: http://www.airbus.com/company/history/the-interactive-timeline/

Aircraft Model: AIRBUS A318
Aircraft Version: A318
Seats: Typical seating capacity. Source: Airbus Family booklet (2016)
Fuel Capacity: Source: Airbus Family booklet (2016)
Maximum Range: Source: Airbus Family booklet (2016)
First Flight: Source: http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/a318-takes-off-on-maiden-flight/

Aircraft Model: AIRBUS A319
Aircraft Version: A319
Seats: Typical seating capacity. Source: Airbus Family booklet (2016)
Fuel Capacity: Source: Airbus Family booklet (2016)
Maximum Range: Source: Airbus Family booklet (2016)
First Flight: Source: http://www.dailypost.co.uk/business/business-news/airbus-a319-celebrates-20th-anniversary-9930148

Aircraft Model: AIRBUS A320
Aircraft Version: A320
Seats: Typical seating capacity. Source: Airbus Family booklet (2016)
Fuel Capacity: Source: Airbus Family booklet (2016)
Maximum Range: Source: Airbus Family booklet (2016)
First Flight: Source: http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/a320-roll-out-and-first-flight/

Aircraft Model: AIRBUS A321
Aircraft Version: A321
Seats: Typical seating capacity.
Source: Airbus Family booklet (2016)
Fuel Capacity: Source: Airbus Family booklet (2016)
Maximum Range: Source: Airbus Family booklet (2016)
First Flight: Source: http://www.airliners.net/aircraft-data/airbus-a321/24

Aircraft Model: AIRBUS A330
Aircraft Version: 200
Seats: Typical seating capacity. Source: Airbus Family booklet (2016)
Fuel Capacity: Source: Airbus Family booklet (2016)
Maximum Range: Source: Airbus Family booklet (2016)
First Flight: Source: http://www.airliners.net/aircraft-data/airbus-a330-200/26

Aircraft Model: AIRBUS A330
Aircraft Version: 300
Seats: Typical seating capacity. Source: Airbus Family booklet (2016)
Fuel Capacity: Source: Airbus Family booklet (2016)
Maximum Range: Source: Airbus Family booklet (2016)
First Flight: Source: http://www.airbus.com/company/history/the-interactive-timeline/

Aircraft Model: AIRBUS 340
Aircraft Version: 200
Seats: Average between single-class and three-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Airbus-A340-200.html
Fuel Capacity: Standard fuel capacity.
Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-200/
Maximum Range: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/
First Flight: Source: http://www.airbus.com/company/history/the-interactive-timeline/

Aircraft Model: AIRBUS 340
Aircraft Version: 300
Seats: Typical number of seats.
Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-300/
Fuel Capacity: Alternative source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-300/
Maximum Range:
Alternative source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-300/
First Flight: Source: http://www.airliners.net/aircraft-data/airbus-a340-200300/27

Aircraft Model: AIRBUS 340
Aircraft Version: 500
Seats: Typical number of seats.
Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-500/
Fuel Capacity: Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-500/
Maximum Range: Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-500/
First Flight: Source: http://www.airliners.net/aircraft-data/airbus-a340-500600/28

Aircraft Model: AIRBUS 340
Aircraft Version: 600
Seats: Typical number of seats.

Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-600/
Fuel Capacity: Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-600/
Maximum Range: Source: http://www.airbus.com/aircraftfamilies/previous-generation-aircraft/a340family/a340-600/
First Flight: Source: http://www.airliners.net/aircraft-data/airbus-a340-500600/28

Aircraft Model: AIRBUS A350
Aircraft Version: 900
Seats: Typical number of seats.
Source: http://www.airbus.com/aircraftfamilies/passengeraircraft/a350xwbfamily/a350-900/
Fuel Capacity: Source:
http://www.airbus.com/aircraftfamilies/passengeraircraft/a350xwbfamily/a350-900/
Maximum Range: Source:
http://www.airbus.com/aircraftfamilies/passengeraircraft/a350xwbfamily/a350-900/
First Flight: Source: https://en.wikipedia.org/wiki/Airbus_A350_XWB

Aircraft Model: AIRBUS 380
Aircraft Version: A380
Seats: Typical seating capacity. Source: Airbus Family booklet (2016) pp. 11
Fuel Capacity:
http://www.airbus.com/fileadmin/media_gallery/files/brochures_publications/aircraft_families/Airbus-Family-figures-booklet-March2016.pdf
Maximum Range:
http://www.airbus.com/fileadmin/media_gallery/files/brochures_publications/aircraft_families/Airbus-Family-figures-booklet-March2016.pdf
First Flight: Source: https://airwaysmag.com/airchive/flashback-friday-10th-anniversary-of-airbus-a380s-maiden-flight/

Aircraft Model: ANTONOV
Aircraft Version: AN-72/74
Seats: Average of 72 and 74 seating capacity.
Source(s): (72) http://www.airliners.net/aircraft-data/antonov-an-7274/39; (74) http://www.antonov.com/aircraft/passenger-aircraft/an-74
Fuel Capacity: Average of 72 and 74 fuel capacities.
Source: http://www.dutchops.com/AC_Data/Antonov/Antonov_74/Antonov_An72_74.htm
Maximum Range: Average of 72 and 74 given maximum fuel and reserves.
Source: http://www.airliners.net/aircraft-data/antonov-an-7274/39
First Flight: Refers to 72.Source: http://www.airliners.net/aircraft-data/antonov-an-7274/39

Aircraft Model: ANTONOV
Aircraft Version: AN-140
Seats: Source: http://www.airliners.net/aircraft-data/antonov-an-140/405
Fuel Capacity: The original data was 4400, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: https://www.airlines-inform.com/commercial-aircraft/An-140.html
Maximum Range: Average of AI-30s and PW127s (both with 52 passengers).
Source: http://www.airliners.net/aircraft-data/antonov-an-140/405
First Flight: Source: http://www.airliners.net/aircraft-data/antonov-an-140/405

Aircraft Model: ANTONOV
Aircraft Version: AN148
Seats: Average of three variation types (-100A, -100B, and -100E).
Source: https://www.airlines-inform.com/commercial-aircraft/An-148.html
Fuel Capacity: Doesn't specify aircraft variation, we took -100B.

Source: https://www.aircraftcompare.com/helicopter-airplane/Antonov-An-148/388
Maximum Range: Average of three variation types (-100A, -100B, and -100E) assuming maximum payload. Source: https://www.airlines-inform.com/commercial-aircraft/An-148.html
First Flight: Source: http://www.antonov.com/aircraft/passenger-aircraft/an-148

Aircraft Model: ANTONOV
Aircraft Version: AN-158
Seats: Average of two different class layouts on offer.
Source: http://www.antonov.com/aircraft/passenger-aircraft/an-158
Fuel Capacity: The original data was 11900, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
NB: Variations are -200, whereas most sources reference -100.
Source: http://www.antonov.com/media/archive/FAMILY%20OVERVIEW.pdf
Maximum Range: Average of two different class layouts on offer.
Source: http://www.antonov.com/aircraft/passenger-aircraft/an-158
First Flight: Source: http://www.antonov.com/aircraft/passenger-aircraft/an-158

Aircraft Model: ANTONOV
Aircraft Version: AN-24
Seats: Source: http://www.airliners.net/aircraft-data/antonov-an-24263032-xian-y-7/37
Fuel Capacity: The original data was 5100, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: https://www.airlines-inform.com/commercial-aircraft/An-24.html
Maximum Range: Maximum range with maximum fuel. Other sources claim 550km with maximum payload. Source: http://www.airliners.net/aircraft-data/antonov-an-24263032-xian-y-7/37
First Flight: Source: http://www.airliners.net/aircraft-data/antonov-an-24263032-xian-y-7/37

Aircraft Model: ANTONOV
Aircraft Version: AN-26
Seats: Source: http://www.antonov.com/aircraft/antonov-gliders-and-airplanes/an-26
Fuel Capacity: Source: http://www.aeromarine.com/An-26.pdf
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/An-26.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/An-26.html

Aircraft Model: ANTONOV
Aircraft Version: AN-28
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/An-28.html
Fuel Capacity: The original data was 1530, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: https://www.airlines-inform.com/commercial-aircraft/An-28.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/An-28.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/An-28.html

Aircraft Model: ANTONOV
Aircraft Version: AN-3T
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/An-2.html
Fuel Capacity: The original data was 1270, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: https://www.airlines-inform.com/commercial-aircraft/An-2.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/An-2.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/An-2.html

Aircraft Model: ANTONOV
Aircraft Version: AN38
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/An-38.html

Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/An-38.html
Maximum Range: NB: alternative sources (i.e., http://www.airliners.net/aircraft-data/antonov-an-38/404) suggest a higher range. Source: https://www.airlines-inform.com/commercial-aircraft/An-38.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/An-38.html

Aircraft Model: ATR42
Aircraft Version: 300
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 4500, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
First Flight: Source: http://www.airliners.net/aircraft-data/atr-atr-42/41

Aircraft Model: ATR42
Aircraft Version: 400
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 4500, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
First Flight: Source: https://www.flightglobal.com/news/articles/atr-42-400-first-flight-25364/

Aircraft Model: ATR42
Aircraft Version: 500
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 4500, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
First Flight: Source: http://airlinergallery.nl/atr42.htm

Aircraft Model: ATR42
Aircraft Version: 600
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 4500, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
First Flight: Source: http://www.ainonline.com/aviation-news/2010-03-04/atr-42-600-completes-first-flight

Aircraft Model: ATR72
Aircraft Version: 200
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 5000, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf

First Flight: Source: http://www.scmp.com/news/china/article/1702538/taiwan-crash-puts-atr-72-600-airliner-back-spotlight

Aircraft Model: ATR72
Aircraft Version: 210
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 5000, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/ATR-72.html

Aircraft Model: ATR72
Aircraft Version: 500
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 5000, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/ATR-72.html

Aircraft Model: ATR72
Aircraft Version: 600
Seats: Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Fuel Capacity: The original data was 5000, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
Maximum Range:
Source: http://www.atraircraft.com/products_app/media/pdf/FAMILY_septembre2014.pdf
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/ATR-72.html

Aircraft Model: BAE (HS) 748
Aircraft Version: HS 148 Series 2A
Seats: Source: http://www.airliners.net/aircraft-data/hawker-siddeley-hs-748/57
Fuel Capacity: Source:
https://www.easa.europa.eu/system/files/dfu/TCDS_EASA.A.397_HS748_Iss_02_20150115.pdf
Maximum Range: Assuming maximum payload and reserves.
Source: http://www.airliners.net/aircraft-data/hawker-siddeley-hs-748/57
First Flight: Source: http://www.airliners.net/aircraft-data/hawker-siddeley-hs-748/57

Aircraft Model: BAE ATP
Aircraft Version: ATP
Seats: Source: http://www.flugzeuginfo.net/acdata_php/acdata_atp_en.php
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/BAe-ATP.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/BAe-ATP.html
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_atp_en.php

Aircraft Model: BAE SYSTEMS AVRO RJ
Aircraft Version: RJ85 / (146RJ 200 – original version)
Seats: Source: http://www.airliners.net/aircraft-data/british-aerospace-avro-rj7085100/47
Fuel Capacity: Source: https://www.regional-services.com/wp-content/uploads/2016/01/Remote-Runway-Operations.pdf

Maximum Range: Source:
http://www.qualitywingssim.com/files/ultimate_146_collection/docs/QualityWings_Ultimate_146_Collection_Users_Manual_SP4.pdf
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_bae1462_en.php

Aircraft Model: BAE SYSTEMS AVRO RJ
Aircraft Version: RJ100 (146 RJ300 – original version)
Seats: Source: http://www.airliners.net/aircraft-data/british-aerospace-avro-rj7085100/47
Fuel Capacity: Source:
https://www.regional-services.com/wp-content/uploads/2016/01/Remote-Runway-Operations.pdf
Maximum Range: Source:
http://www.qualitywingssim.com/files/ultimate_146_collection/docs/QualityWings_Ultimate_146_Collection_Users_Manual_SP4.pdf
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_bae1463_en.php

Aircraft Model: BAE
Aircraft Version: 146-100
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/BAe-146.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/BAe-146.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/BAe-146.html
First Flight: Source:
http://www.qualitywingssim.com/files/ultimate_146_collection/docs/QualityWings_Ultimate_146_Collection_Users_Manual_SP4.pdf

Aircraft Model: BAE
Aircraft Version: JETSTREAM 31
Seats: Source: http://www.airliners.net/aircraft-data/british-aerospace-jetstream-31super-31/55
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Jetstream-31.html
Maximum Range: Assuming maximum passengers and reserves.
Source: http://www.airliners.net/aircraft-data/british-aerospace-jetstream-31super-31/55
First Flight: Source: http://www.airliners.net/aircraft-data/british-aerospace-jetstream-31super-31/55

Aircraft Model: BAE
Aircraft Version: JETSTREAM-41
Seats: Source: http://www.airliners.net/aircraft-data/british-aerospace-jetstream-41/56
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Jetstream-41.html
Maximum Range: Assuming maximum passengers and reserves.
Source: http://www.airliners.net/aircraft-data/british-aerospace-jetstream-41/56
First Flight: Source: http://www.airliners.net/aircraft-data/british-aerospace-jetstream-41/56

Aircraft Model: BEECHCRAFT
Aircraft Version: 1900C
Seats: Source: http://www.airliners.net/aircraft-data/raytheon-beechcraft-1900/329
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Beech-1900.html, with
Maximum Range: Maximum range with full payload, Source: https://www.airlines-inform.com/commercial-aircraft/Beech-1900.html
First Flight: Source: http://www.airliners.net/aircraft-data/raytheon-beechcraft-1900/329

Aircraft Model: BEECHCRAFT
Aircraft Version: 1900D
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Beech-1900.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Beech-1900.html
Maximum Range: Maximum range, Source: https://www.airlines-inform.com/commercial-aircraft/Beech-1900.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Beech-1900.html

Aircraft Model: BEECHCRAFT
Aircraft Version: B99
Seats: Source: http://www.airliners.net/aircraft-data/beech-99-airliner/66
Fuel Capacity: The original data was 1119, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://all-aero.com/index.php/59-planes-b-c/1402-beech-99-commuter
Maximum Range: Assuming maximum cruising speed.
Source: http://www.airliners.net/aircraft-data/beech-99-airliner/66
First Flight: Source: http://www.airliners.net/aircraft-data/beech-99-airliner/66

Aircraft Model: BOEING
Aircraft Version: 707-120
Seats: Source: http://www.boeing.com/history/products/707.page
Fuel Capacity: Fuel capacity for -120B not -120.
Maximum Range: Source: http://www.boeing.com/history/products/707.page
First Flight: Source: http://www.boeing.com/history/products/707.page

Aircraft Model: BOEING
Aircraft Version: 717-200
Seats: Average between maximum one-class seating and two-class seating.
Source: http://www.qantas.com/travel/airlines/aircraft-seat-map-boeing-712/global/en
Fuel Capacity: Source: http://www.qantas.com/travel/airlines/aircraft-seat-map-boeing-712/global/en
Maximum Range: Assuming maximum payload.
Source: http://www.qantas.com/travel/airlines/aircraft-seat-map-boeing-712/global/en
First Flight: Source: http://www.boeing.com/history/products/717-md-95.page

Aircraft Model: BOEING
Aircraft Version: 727-100
Seats: Typical mixed-class. Source:
http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/727.pdf
Fuel Capacity: Source:
http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/727.pdf
Maximum Range: Source: http://www.boeing.com/history/products/727.page
First Flight: Source: http://www.boeing.com/history/products/707.page

Aircraft Model: BOEING
Aircraft Version: 727-200 advanced
Seats: Average between certified and mixed-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/727.pdf
Fuel Capacity:
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/727.pdf
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_727_en.php
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_727_en.php

Aircraft Model: BOEING
Aircraft Version: 737-100
Seats: Average between FAA exit limit and two-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Average of three listed usable fuel capacities.
http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_7371_en.php
First Flight: Source: http://www.boeing.com/history/products/737-classic.page

Aircraft Model: BOEING
Aircraft Version: 737-200
Seats: Average between FAA exit limit and two-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Average of 5 listed fuel capacities.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_7372_en.php
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_7372_en.php

Aircraft Model: BEOING
Aircraft Version: 737-300
Seats: Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Assuming a CFM56-3B1 engine is used.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Maximum Range: Assuming a CFM56-3B1 engine is used and maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-300.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-300.html

Aircraft Model: BOEING
Aircraft Version: 737-400
Seats: Average between FAA exit limit and two-class.
http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Assuming a CFM56-3B2 engine is used. Source:
http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Maximum Range: Assuming a CFM56-3B2 engine is used and maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-400.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-400.html

Aircraft Model: BOEING
Aircraft Version: 737-500
Seats: Average between FAA exit limit and two-class.
http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Assuming a CFM56-3B2 engine is used.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Maximum Range: Assuming a CFM56-B31 engine is used and maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-500.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-500.html

Aircraft Model: BOEING
Aircraft Version: 737-600
Seats: Average between all-economy and two-class.
http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/737.pdf
Maximum Range: Source: http://boeing.mediaroom.com/1998-06-29-China-to-Purchase-10-Boeing-Next-Generation-737-Jetliners
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-600.html

Aircraft Model: BOEING
Aircraft Version: 737-700
Seats: Average between all-economy and two-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/737.pdf
Maximum Range: Source: http://boeing.mediaroom.com/1998-06-29-China-to-Purchase-10-Boeing-Next-Generation-737-Jetliners
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-700.html

Aircraft Model: BOEING
Aircraft Version: 737-800
Seats: Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/737.pdf
Maximum Range: Source: http://boeing.mediaroom.com/1998-06-29-China-to-Purchase-10-Boeing-Next-Generation-737-Jetliners
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-800.html

Aircraft Model: BOEING
Aircraft Version: 737-900
Seats: Average between all-economy and two-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/737.pdf
Maximum Range: Source: http://boeing.mediaroom.com/1998-06-29-China-to-Purchase-10-Boeing-Next-Generation-737-Jetliners
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-737-900.html

Aircraft Model: BOEING
Aircraft Version: 737-900ER
Seats: Average between FAA exit limit and two-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/737.pdf
Fuel Capacity: Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/737.pdf
Maximum Range: Source: http://boeing.mediaroom.com/2006-05-31-Boeing-Begins-Assembling-the-First-737-900ER
First Flight: Source: https://en.wikipedia.org/wiki/Boeing_737

Aircraft Model: BOEING
Aircraft Version: 747-100
Seats: Average between all-economy and three-class.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_7471_en.php
Fuel Capacity:
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/747_123sp.pdf
Maximum Range: Source:
http://www.boeing.com/resources/boeingdotcom/company/about_bca/startup/pdf/historical/747-100_-200_-300_-SP_passenger.pdf
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-100.html

Aircraft Model: BOEING
Aircraft Version: 747-200B
Seats: Average between all-economy and three-class.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_7472_en.php
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-200.html
Maximum Range: Assuming maximum payload. (Range may differ with engine type).
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-200.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-200.html

Aircraft Model: BOEING
Aircraft Version: 747-300
Seats: Average between one-class and three-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-300.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-300.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-300.html

First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-300.html

Aircraft Model: BOEING
Aircraft Version: 747-400
Seats: Average between one-class and three-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-400.html
Fuel Capacity: (Fuel capacity may differ with engine type)
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-400.html
Maximum Range: Assuming maximum payload. (Range may differ with engine type)
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-400.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-400.html

Aircraft Model: BOEING
Aircraft Version: 747-8I
Seats: Source: Typical seating capacity.
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-8.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-747-8.html
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_boeing_7478_dt.php

Aircraft Model: BOEING
Aircraft Version: 747-SP
Seats: Average: class-type not specified.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_boeing_747sp_dt.php
Fuel Capacity: Average between two engine types: RB211-524C2 and CF6-45A2/B2.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/747_123sp.pdf
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_boeing_747sp_dt.php
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_boeing_747sp_dt.php

Aircraft Model: BOEING
Aircraft Version: 757-200
Seats: Average between four-door configuration and two-class.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_7572_en.php
Fuel Capacity:
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/757_23.pdf
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-757-200.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-757-200.html

Aircraft Model: BOEING
Aircraft Version: 757-300
Seats: Average between all-economy and dual-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/757_23.pdf
Fuel Capacity:
http://www.boeing.com/resources/boeingdotcom/company/about_bca/startup/pdf/historical/757_passenger.pdf
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-757-300.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-757-300.html

Aircraft Model: BOEING
Aircraft Version: 767-200
Seats: Average between FAA exit limit and (with second over the wing exit door) mixed-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/767.pdf
Fuel Capacity: Fuel capacity may differ with engine type)
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/767.pdf

Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_7672_en.php
First Flight: http://www.boeing.com/history/products/767.page

Aircraft Model: BOEING
Aircraft Version: 767-200ER
Seats: Average between FAA exit limit and (with second over the wing exit door) mixed-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/767.pdf
Fuel Capacity: (Fuel capacity may differ with engine type)
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/767.pdf
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-767-200.html
First Flight: Source: http://www.airliners.net/aircraft-data/boeing-767-200/103

Aircraft Model: BOEING
Aircraft Version: 767-300
Seats: Average between mid-cabin door and two-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/767.pdf
Fuel Capacity: http://www.boeing.com/assets/pdf/commercial/airports/acaps/767.pdf
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-767-300.html
First Flight: Source: http://www.airliners.net/aircraft-data/boeing-767-300/104

Aircraft Model: BOEING
Aircraft Version: 767-300ER
Seats: Average between mid-cabin door and two-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/767.pdf
Fuel Capacity: http://www.boeing.com/assets/pdf/commercial/airports/acaps/767.pdf
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-767-300.html
First Flight: Source: http://www.airliners.net/aircraft-data/boeing-767-300/104

Aircraft Model: BOEING
Aircraft Version: 767-400ER
Seats: Average between all-economy and three-class.
Source: http://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/767.pdf
Fuel Capacity: http://www.boeing.com/assets/pdf/commercial/airports/acaps/767.pdf
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-767-400.html
First Flight: Source: http://www.boeing.com/history/products/767.page

Aircraft Model: BOEING
Aircraft Version: 777-200
Seats: Average between one-class and three-class.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_7772_dt.php
Fuel Capacity:
Maximum Range: Source: http://www.aerospace-technology.com/projects/boeing777/
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_7772_dt.php

Aircraft Model: BOEING
Aircraft Version: 777-200ER
Seats: 200ER has the same number of passengers as Version 200.
Source: http://www.aerospace-technology.com/projects/boeing777/
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-777-300.html
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_7773_dt.php
First Flight: Source: http://www.skytamer.com/Boeing_777-200.html

Aircraft Model: BOEING
Aircraft Version: 777-300
Seats: Average between one-class and three-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-777-300.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-777-300.html
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_7773_dt.php
First Flight: Source: http://www.skytamer.com/Boeing_777-200.html

Aircraft Model: BOEING
Aircraft Version: 777-300ER
Seats: Average between one-class and three-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-777-300.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-777-300.html
Maximum Range: (Range may vary with different engine type)
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-777-300.html
First Flight: Source: http://www.aerospace-technology.com/projects/boeing777/

Aircraft Model: BOEING
Aircraft Version: 777-200LR
Seats: Average between one-class and three-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-777-200.html
Fuel Capacity: Source: http://www.topspeed.com/aviation/aviation-reviews/boeing/2006-boeing-777-200lr-ar87989.html
Maximum Range: Source: http://www.topspeed.com/aviation/aviation-reviews/boeing/2006-boeing-777-200lr-ar87989.html
First Flight: Source: http://www.aerospace-technology.com/projects/boeing777/

Aircraft Model: BOEING
Aircraft Version: 787-8 Dreamliner
Seats: Average between one-class and three-class.
Source: http://www.aerospace-technology.com/projects/dreamliner/
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-787.html
Maximum Range: http://www.boeing.com/commercial/787/#/by-design
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-787.html

Aircraft Model: BOEING
Aircraft Version: 787-9 Dreamliner
Seats: Typical seating capacity.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_boeing_7879_dt.php
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Boeing-787-9.html
Maximum Range: http://www.boeing.com/commercial/787/#/by-design
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_boeing_7879_dt.php

Aircraft Model: BOEING
Aircraft Version: MD-11
Seats: Average between single- and three-class seating capacities.
Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-md-11/112
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/MD-11.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/MD-11.html
First Flight: Source: http://www.boeing.com/history/products/md-11-commercial-transport.page

Aircraft Model: BOEING
Aircraft Version: MD-81

Seats: Typical (two-class) seating capacity.
Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-md-81828388/109
Fuel Capacity: Usable fuel capacity.
Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/md80.pdf
Maximum Range: Source: http://www.boeing.com/history/products/md-80-and-md-90-commercial-transport.page
First Flight: Source: http://www.boeing.com/history/products/md-80-and-md-90-commercial-transport.page

Aircraft Model: BOEING
Aircraft Version: MD-82
Seats:
Average between single-class and two-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
First Flight: Based on: http://www.airliners.net/aircraft-data/mcdonnell-douglas-md-81828388/109.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html

Aircraft Model: BOEING
Aircraft Version: MD-83
Seats: Average between single-class and two-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
First Flight:

Aircraft Model: BOEING
Aircraft Version: MD-87
Seats: Average between single-class and two-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
First Flight: Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-md-87/278

Aircraft Model: BOEING
Aircraft Version: MD-88
Seats: Average between single-class and two-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-80.html
First Flight: Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-md-81828388/109

Aircraft Model: BOEING
Aircraft Version: MD-90-30
Seats: Average between single-class and two-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-90.html

Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-90.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/MD-90.html
First Flight: Source: http://www.boeing.com/history/products/md-80-and-md-90-commercial-transport.page

Aircraft Model: BOEING
Aircraft Version: MD-90-30ER
Seats: Average between single-class and two-class seating capacity. (Assuming same capacity based on: http://www.boeing.com/assets/pdf/commercial/airports/acaps/md90.pdf)
Source: https://www.airlines-inform.com/commercial-aircraft/MD-90.html
Fuel Capacity: Usable fuel capacity.
Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/md90.pdf
Maximum Range: Source: http://www.boeing.com/history/products/md-80-and-md-90-commercial-transport.page
First Flight:

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ1000ER
Seats: Typical seating capacity.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_bombardier_crj1000_en.php
Fuel Capacity: Source: http://www.flyradius.com/bombardier-crj1000/specifications
Maximum Range: Source:
http://commercialaircraft.bombardier.com/content/dam/Websites/bca/literature/crj/CRJ%20Series_CRJ%201000_Factsheet_201607_EN.pdf
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_bombardier_crj1000_en.php

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ1000EL
Seats: Typical seating capacity.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_bombardier_crj1000_en.php
Fuel Capacity: Source: http://www.flyradius.com/bombardier-crj1000/specifications
Maximum Range: Source:
http://commercialaircraft.bombardier.com/content/dam/Websites/bca/literature/crj/CRJ%20Series_CRJ%201000_Factsheet_201607_EN.pdf
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_bombardier_crj1000_en.php

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ100ER
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/CRJ-family.html
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-200.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-200.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/CRJ-family.html

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ100LR
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/CRJ-family.html
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-200.html
Maximum Range:
Source: https://airwaysmag.com/airchive/flashback-friday-the-bombardier-crj-family/
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/CRJ-family.html

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ200ER
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/CRJ-family.html
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-200.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-200.html
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_crj200_en.php

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ200LR
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/CRJ-family.html
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-200.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-200.html
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_crj200_en.php

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ700
Seats: Average between maximum and dual-class seating capacity. Source: http://commercialaircraft.bombardier.com/content/dam/Websites/bca/literature/crj/CRJ%20Series_Brochure_201607_EN.pdf
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ700ER
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ700LR
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html
First Flight:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-700.html

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ900ER

Seats: Average between maximum and triple-class seating capacity. Source: http://commercialaircraft.bombardier.com/content/dam/Websites/bca/literature/crj/CRJ%20Series_Brochure_201607_EN.pdf
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-900.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-900.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-900.html

Aircraft Model: BOMBARDIER
Aircraft Version: CRJ900LR
Seats: Average between maximum and triple-class seating capacity. Source: http://commercialaircraft.bombardier.com/content/dam/Websites/bca/literature/crj/CRJ%20Series_Brochure_201607_EN.pdf
Fuel Capacity:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-900.html
Maximum Range:
Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-900.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Bombardier-CRJ-900.html

Aircraft Model: BOMBARDIER
Aircraft Version: DASH 8 Q100
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q200.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q200.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q200.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Dash8-family.html

Aircraft Model: BOMBARDIER
Aircraft Version: DASH 8 Q200
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q200.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q200.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q200.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Dash8-family.html

Aircraft Model: BOMBARDIER
Aircraft Version: DASH 8 Q300
Seats: Average between economy-class and standard seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q300.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q300.html
Maximum Range: Average between low, medium, and high.
Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q300.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q300.html

Aircraft Model: BOMBARDIER
Aircraft Version: DASH 8 Q400
Seats: Maximum seating capacity. Source: http://commercialaircraft.bombardier.com/content/dam/Websites/bca/literature/q400/Q%20Series_factsheets_201607_EN.pdf
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q400.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q400.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Dash-8Q400.html

Aircraft Model: CONVAIR

Aircraft Version: CV-580
Seats:
Fuel Capacity:
Maximum Range:
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Convair-580.html

Aircraft Model: CONVAIR
Aircraft Version: CV-640
Seats: Source: http://www.flugzeuginfo.net/acdata_php/acdata_cv640_en.php
Fuel Capacity:
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_cv640_en.php
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_cv640_en.php

Aircraft Model: DE HAVILLAND CANADA
Aircraft Version: DHC7
Seats: Source: http://www.flugzeuginfo.net/acdata_php/acdata_dhc7_en.php
Fuel Capacity: The original data was 4502, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://members.aon.at/~slenz/dash7.html
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_dhc7_en.php
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_dhc7_en.php

Aircraft Model: DE HAVILLAND CANADA TWIN OTTER
Aircraft Version: DHC-6-400 (Viking)
Seats: Source: http://www.aerospace-technology.com/projects/vikingdhc6400/
Fuel Capacity:
Maximum Range: Source: http://www.aerospace-technology.com/projects/vikingdhc6400/
First Flight: Source: http://www.aerospace-technology.com/projects/vikingdhc6400/

Aircraft Model: DORNIER
Aircraft Version: 228
Seats: Source: http://www.airforce-technology.com/projects/dornier-do-228-light-transport-aircraft/
Fuel Capacity: Maximum fuel capacity. Source:
https://www.easa.europa.eu/system/files/dfu/TCDS%20%20EASA%20A%20359%20Dornier%20228%20Issue%205.pdf
Maximum Range: Source: http://www.airforce-technology.com/projects/dornier-do-228-light-transport-aircraft/
First Flight: Source: http://www.airforce-technology.com/projects/dornier-do-228-light-transport-aircraft/

Aircraft Model: DORNIER
Aircraft Version: 328
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Dornier-328.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Dornier-328.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Dornier-328.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Dornier-328.html

Aircraft Model: DORNIER
Aircraft Version: 328JET
Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Dornier-328Jet.html
Fuel Capacity: Source: https://www.airlines-inform.com/commercial-aircraft/Dornier-328Jet.html
Maximum Range: Source: https://www.airlines-inform.com/commercial-aircraft/Dornier-328Jet.html
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_do328jet_en.php

Aircraft Model: EMBRAER
Aircraft Version: EMB-110 BANDEIRANTE
Seats: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Embraer-110-Bandeirante.html
Fuel Capacity: Source: http://www.flugzeuginfo.net/acdata_php/acdata_emb110_en.php
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_emb110_en.php
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_emb110_en.php

Aircraft Model: EMBRAER
Aircraft Version: EMB-120 BRASILIA
Seats: Source: http://www.flugzeuginfo.net/acdata_php/acdata_emb120_en.php
Fuel Capacity: The original data was 2600, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016). Source: https://www.forecastinternational.com/archive/disp_old_pdf.cfm?ARC_ID=329
Maximum Range: Source: http://www.flugzeuginfo.net/acdata_php/acdata_emb120_en.php
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_emb120_en.php

Aircraft Model: EMBRAER
Aircraft Version: ERJ145LR
Seats: Source: http://www.embraercommercialaviation.com/AircraftPDF/E145_Cabin.pdf
Fuel Capacity: Maximum useable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E145_Weights.pdf
Maximum Range: Assuming a maximum landing weight.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E145_Performance.pdf
First Flight: Source: http://www.aerospace-technology.com/projects/erj145/

Aircraft Model: EMBRAER
Aircraft Version: ERJ145LU
Seats:
Fuel Capacity: Source: https://en.wikipedia.org/wiki/Embraer_ERJ_145_family
Maximum Range:
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: ERJ145LI
Seats:
Fuel Capacity:
Maximum Range:
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: ERJ145EP
Seats:
Fuel Capacity: Source: https://en.wikipedia.org/wiki/Embraer_ERJ_145_family
Maximum Range:
First Flight:

Aircraft Model: EMBARER
Aircraft Version: ERJ145ER
Seats:
Fuel Capacity: Source: https://en.wikipedia.org/wiki/Embraer_ERJ_145_family
Maximum Range: Range with 50 passengers at long-range cruising speed.
Source: http://www.airliners.net/aircraft-data/embraer-erj-145/198
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: ERJ145EU
Seats:
Fuel Capacity:
Maximum Range:
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: ERJ145MP
Seats:
Fuel Capacity:
Maximum Range: Source:
http://www.embraercommercialaviation.com/AircraftPDF/E145_Performance.pdf
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: ERJ145XR
Seats: Source: http://www.embraercommercialaviation.com/Pages/ERJ-145XR.aspx
Fuel Capacity:
Maximum Range: Source:
http://www.embraercommercialaviation.com/AircraftPDF/E145XR_Performance.pdf
First Flight: Source: http://www.airliners.net/aircraft-data/embraer-erj-145/198

Aircraft Model: EMBRAER
Aircraft Version: ERJ135LR
Seats: Source: http://www.embraercommercialaviation.com/AircraftPDF/E145XR_Performance.pdf
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Embraer-ERJ-135.html
Maximum Range: Assuming full-load of passengers. Source:
http://www.embraercommercialaviation.com/AircraftPDF/E135_Performance.pdf
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Embraer-ERJ-135.html

Aircraft Model: EMBRAER
Aircraft Version: ERJ135ER
Seats: Source: http://www.aerospace-technology.com/projects/erj-135/
Fuel Capacity: The original data was 4173, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: http://www.aerospace-technology.com/projects/erj-135/
Maximum Range: Assuming a full-load of passengers.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E135_Performance.pdf
First Flight: Source: http://www.aerospace-technology.com/projects/erj-135/

Aircraft Model: EMBRAER
Aircraft Version: ERJ140LR
Seats: Source: http://www.embraercommercialaviation.com/AircraftPDF/E140_Cabin.pdf
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Embraer-ERJ-140.html
Maximum Range: Assuming full-load of passengers.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E140_Performance.pdf
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Embraer-ERJ-140.html

Aircraft Model: EMBRAER
Aircraft Version: ERJ170ST
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Cabin.pdf

Fuel Capacity: Maximum usable fuel. Source:
http://www.embraercommercialaviation.com/AircraftPDF/E170_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Performance.pdf
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Embraer-170.html

Aircraft Model: EMBRAER
Aircraft Version: ERJ170LR
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Performance.pdf
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: ERJ170AR
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E170_Performance.pdf
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: E175ST
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E175_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E175_Performance.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E175_Performance.pdf
First Flight: Source: http://www.airliners.net/aircraft-data/embraer-erj-170175190195/406

Aircraft Model: EMBRAER
Aircraft Version: E175LR
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E175_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E175_Performance.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E175_Performance.pdf
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: E190ST
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Weights.pdf
Maximum Range:
Assuming full-load of passengers, long-range cruise speed, and typical mission reserves.

Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Performance.pdf
First Flight: Source: http://www.airliners.net/aircraft-data/embraer-erj-170175190195/406

Aircraft Model: EMBRAER
Aircraft Version: E190LR
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Performance.pdf
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: E190AR
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E190_Performance.pdf
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: E195ST
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Performance.pdf
First Flight: Source: http://www.airliners.net/aircraft-data/embraer-erj-170175190195/406

Aircraft Model: EMBRAER
Aircraft Version: E195LR
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Performance.pdf
First Flight:

Aircraft Model: EMBRAER
Aircraft Version: E195AR
Seats: Average between high-capacity single-class and dual-class.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Cabin.pdf
Fuel Capacity: Maximum usable fuel.
Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Weights.pdf
Maximum Range: Assuming full-load of passengers, long-range cruise speed, and typical mission reserves. Source: http://www.embraercommercialaviation.com/AircraftPDF/E195_Performance.pdf
First Flight:

Aircraft Model: FAIRCHILD
Aircraft Version: METRO/MERLIN

Seats: Source: https://www.airlines-inform.com/commercial-aircraft/Fairchild-Metro.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Fairchild-Metro.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Fairchild-Metro.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Fairchild-Metro.html

Aircraft Model: FOKKER
Aircraft Version: F100
Seats: Typical seating capacity.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_fokker100_en.php
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-100.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-100.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-100.html

Aircraft Model: FOKKER
Aircraft Version: F27 FRIENDSHIP
Seats: Maximum single-class. Source: http://www.mutleyshangar.com/reviews/ag/f27/f27.htm
Fuel Capacity: Maximum capacity. Source: http://www.mutleyshangar.com/reviews/ag/f27/f27.htm
Maximum Range: Assuming a full fuel-load and maximum take-off weight. Source: http://www.mutleyshangar.com/reviews/ag/f27/f27.htm
First Flight: Source: http://www.airliners.net/aircraft-data/fokker-f-27-fairchild-f-27-fh-227/217

Aircraft Model: FOKKER
Aircraft Version: F28 FELLOWSHIP (MK3000)
Seats: Maximum. Source: http://www.airliners.net/aircraft-data/fokker-f-28-fellowship/219
Fuel Capacity:
Maximum Range: Average between high-speed cruise and long-range cruise, both with maximum seating capacity. Source: http://www.airliners.net/aircraft-data/fokker-f-28-fellowship/219
First Flight: Source: http://www.airliners.net/aircraft-data/fokker-f-28-fellowship/219

Aircraft Model: FOKKER
Aircraft Version: 50HP
Seats: Maximum single-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-50.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-50.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-50.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-50.html

Aircraft Model: FOKKER
Aircraft Version: 70
Seats: Maximum single-class
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-70.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-70.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-70.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Fokker-70.html

Aircraft Model: ILYUSHIN
Aircraft Version: IL114

Seats: Maximum single-class.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-114.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-114.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-114.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Il-114.html

Aircraft Model: ILYUSHIN
Aircraft Version: IL62
Seats: Average between single-class and dual-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-62.html
Fuel Capacity: Standard fuel capacity for IL62M.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-62.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-62.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Il-62.html

Aircraft Model: ILYUSHIN
Aircraft Version: IL18D
Seats: Maximum single-class capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-18.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-18.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-18.html
First Flight: Source: http://www.airliners.net/aircraft-data/ilyushin-il-18/249

Aircraft Model: ILYUSHIN
Aircraft Version: IL96-300
We chose the non-stretched version (-400 being the stretched version).
Seats: Average between single-class and three-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-96.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-96.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Il-96.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Il-96.html

Aircraft Model: INDONESIAN AEROSPACE
Aircraft Version: C-212-400 AVIOCR
Seats: Average between given range: seating information not given.
Source: https://www.indonesian-aerospace.com/view.php?m=product&t=aircraft-detil&id=1
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/CASA-212.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/CASA-212.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/CASA-212.html

Aircraft Model: LET
Aircraft Version: L-410-UVP-E20
Seats: Maximum single-class.
Source: https://www.airlines-inform.com/commercial-aircraft/L-410.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/L-410.html

Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/L-410.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/L-410.html

Aircraft Model: MCDONNELL DOUGLAS
Aircraft Version: DC-10CF
Seats: Average between maximum and standard seating capacity. Source:
http://www.boeing.com/resources/boeingdotcom/company/about_bca/startup/pdf/historical/dc10-passenger.pdf
Fuel Capacity: Usable fuel capacity. Source:
http://www.boeing.com/resources/boeingdotcom/company/about_bca/startup/pdf/historical/dc10-passenger.pdf
Maximum Range: Assuming maximum payload.
Source: http://www.boeing.com/commercial/aeromagazine/aero_02/textonly/ps02txt.html
First Flight: Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-dc-10-boeing-md-10/279

Aircraft Model: MCDONNELLL DOUGLAS
Aircraft Version: DC8-43
Seats: Maximum seating capacity (class not specified).
Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/dc8.pdf
Fuel Capacity: Usable fuel.
Source: http://www.boeing.com/assets/pdf/commercial/airports/acaps/dc8.pdf
Maximum Range: Source: http://www.boeing.com/news/frontiers/archive/2008/june/i_history.pdf
First Flight: Source: http://www.boeing.com/history/products/dc-8.page

Aircraft Model: MCDONNEL DOUGLAS
Aircraft Version: DC9-30
Seats: Average between single-class and three-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Douglas-DC-9.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Douglas-DC-9.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Douglas-DC-9.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Douglas-DC-9.html

Aircraft Model: MCDONNEL DOUGLAS
Aircraft Version: DC9-10
Seats: Single-class seating capacity.
Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-dc-9-102030/276
Fuel Capacity: Source: http://planes.axlegeeks.com/l/461/McDonnell-Douglas-DC-9-10
Maximum Range: Assuming maximum payload.
Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-dc-9-102030/276
First Flight: Source: http://www.airliners.net/aircraft-data/mcdonnell-douglas-dc-9-102030/276

Aircraft Model: MCDONNELL DOUGLAS
Aircraft Version: DC9-50
Seats: Average between single-class and coach-class seating capacity. Source:
http://www.boeing.com/resources/boeingdotcom/company/about_bca/startup/pdf/historical/dc9-passenger.pdf
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Douglas-DC-9.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Douglas-DC-9.html
First Flight: Source: http://www.boeing.com/history/products/dc-9.page

Aircraft Model: NAMC
Aircraft Version: YS11A-200
Seats: Single-class seating capacity.
Sources: http://www.airliners.net/aircraft-data/namc-ys-11/287
Fuel Capacity: Source: http://www.airvectors.net/avnamc.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/YS-11.html
First Flight: Source: http://www.worldlibrary.org/articles/namc_ys-11a

Aircraft Model: SAAB
Aircraft Version: 2000
Seats: Maximum single-class capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-2000.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-2000.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-2000.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-2000.html

Aircraft Model: SAAB
Aircraft Version: 340B PLUS
Seats: Maximum single-class capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-340.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-340.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-340.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/SAAB-340.html

Aircraft Model: SHORTS
Aircraft Version: 330-200
Seats: Maximum single-class capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-330.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-330.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-330.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-330.html

Aircraft Model: SHORTS
Aircraft Version: 360-300
Seats: Maximum single-class capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-360.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-360.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-360.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Shorts-360.html

Aircraft Model: SUKHOI SUPERJET 100
Aircraft Version: SSJ-95
Seats: Average between maximum and dual-class seating capacity.
Source: http://www.airliners.net/aircraft-data/sukhoi-superjet-100/408
Fuel Capacity: Source: http://planes.axlegeeks.com/l/336/Sukhoi-Superjet-100-95

Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Superjet-100.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Superjet-100.html

Aircraft Model: SUKHOI SUPERJET 100
Aircraft Version: SSJ-95LR
Seats: Average between maximum and dual-class seating capacity.
Source: http://www.airliners.net/aircraft-data/sukhoi-superjet-100/408
Fuel Capacity: Source: http://planes.axlegeeks.com/l/336/Sukhoi-Superjet-100-95
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Superjet-100.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Superjet-100.html

Aircraft Model: TUPOLEV
Aircraft Version: TU134A
Seats: Average between single-class and dual-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-134.html`
Fuel Capacity: The original data was 14400, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-134.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-134.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Tu-134.htm\

Aircraft Model: TUPOLEV
Aircraft Version: TU154
Seats: Average between maximum single-class and minimum dual-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-154.html
Fuel Capacity: Source: https://en.wikipedia.org/wiki/Tupolev_Tu-154
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-154.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Tu-154.html

Aircraft Model: TUPOLEV
Aircraft Version: TU204-100
Seats: Average between single-class and three-class seating capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-204-100.html
Fuel Capacity: Standard fuel capacity.
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-204-100.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Tu-204-100.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Tu-204-family.html

Aircraft Model: XIAN
Aircraft Version: MA60
Seats: Single-class seating capacity.
Source: http://www.flugzeuginfo.net/acdata_php/acdata_xian_ma60_en.php
Fuel Capacity: The original data was 4030, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: https://www.airlines-inform.com/commercial-aircraft/Xian-MA60.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Xian-MA60.html
First Flight: Source: http://www.flugzeuginfo.net/acdata_php/acdata_xian_ma60_en.php

Aircraft Model: YAKOVLEV

Aircraft Version: YAK40
Seats: Average between single-class variations.
Source: https://www.airlines-inform.com/commercial-aircraft/Yak-40.html
Fuel Capacity: The original data was 4430, but that was measurement was in kg. We converted this number to litres assuming a volume mass of .782 kg/L (number given in EASA, 2016).
Source: https://www.airlines-inform.com/commercial-aircraft/Yak-40.html
Maximum Range: Assuming maximum payload.
Source: https://www.airlines-inform.com/commercial-aircraft/Yak-40.html
First Flight: Source: https://www.airlines-inform.com/commercial-aircraft/Yak-40.html

Aircraft Model: YAKOVLEV
Aircraft Version: YAK42D
Seats: Class that each seating capacity refers to was not specified.
Source: https://www.forecastinternational.com/archive/disp_old_pdf.cfm?ARC_ID=1055
Fuel Capacity: Maximum capacity.
Source: https://www.forecastinternational.com/archive/disp_old_pdf.cfm?ARC_ID=1055
Maximum Range: Assuming normal payload.
Source: https://www.forecastinternational.com/archive/disp_old_pdf.cfm?ARC_ID=1055
First Flight:
Source: https://www.forecastinternational.com/archive/disp_old_pdf.cfm?ARC_ID=1055

Reference:
EASA (2016). EASA, TYPE-CERTIFICATE DATA SHEET: AIRBUS A300, A310 and A300-600, TCDS No. A172, Issue02, 24 November 2016.

Airbus Family booklet (2016).
http://www.aircraft.airbus.com/fileadmin/media_gallery/files/brochures_publications/aircraft_families/Airbus-Family-figures-booklet-March2016.pdf