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International competition in aircraft market

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Abstract

This thesis investigates aspects of Boeing – Airbus competition on the field of large commercial aircraft. By analyzing action-reaction dynamics in M&A strategies, introductions of new models and trade disputes, namely interactions with regional jet manufacturers and Airbus's reaction on the introduction of 787, we observe that mimicking competitor's strategy does not necessarily guarantee increase of the market share. We collect and analyze data on wide-body aircraft sales and prices from 2004 to 2018 to find the most valuable parameter for customers. The results show the price being the most important and a market segmentation present, while medium and long-range wide-body segments are more sensitive to price changes within the segment than across. From the qualitative attributes of an aircraft, range is a more important factor than seating. Finally, we question the inaccuracies of demand estimations for A380 before its launch. Unpredictable events and factors unobservable by an economic model are found to have a drastic impact on the real demand and the estimations ought to be accepted with caution.

Keywords: Demand for aircraft, commercial aviation, duopoly, market share, demand estimation, market segmentation, wide-body aircraft.

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Abstrakt

Táto práca sa zaoberá aspektami súťaže Boeingu a Airbusu na poli veľkých komerčných lietadiel. Analyzovaním dynamík akcie a reakcie v stratégiách M&A, uvádzaní nových modelov a obchodných sporoch, menovite interakcie s výrobcami regionálnych lietadiel a reakcie Airbusu na uvedenie modelu 787 sledujeme, že napodobňovanie stratégie súpera nezaručuje isté zvýšenie trhového podielu. Analyzujeme dáta predajov a cien širokotrupých lietadiel medzi rokmi 2004 a 2018, aby sme našli parametre najcennejšie pre zákazníkov. Výsledky ukazujú cenu ako najdôležitejší faktor a prítomnú segmentáciu trhu, zatiaľ čo segmenty stredného a ďalekého doletu sú citlivejšie na zmeny cien vo vlastnom segmente ako naprieč. Z kvalitatívnych atribútov lietadla je dolet dôležitejší faktor ako kapacita. Nakoniec diskutujeme o nepresnostiach v odhadoch dopytu pre A380 pred uvedením na trh. Nepredvídateľné udalosti a faktory nesledovateľné ekonomickými modelmi majú drastický dopad na skutočný dopyt a odhady by mali byť brané s rezervou.

Klíčová slova: Dopyt po lietadlách, komerčné letectvo, duopol, podiel na trhu, odhad dopytu, segmentácia trhu, širokotrupé lietadlá.

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Acronyms

AB Appelate Body
2SLS Two-stage least squares
CARES Coronavirus Aid, Relief, and Economic Security Act
COMAC Commercial Aircraft Corporation of China
COVID-19 Coronavirus disease 2019
DoC U.S. Department of Commerce
EADS European Aeronautic Defence and Space Company
EU European Union
GATT General Agreement on Tariffs and Trade
GE General Electric
ILFC International Lease Finance Corporation
LCA Large commercial aircraft
MA Mergers and acquisitions
MPE Markov perfect equilibrium
MRO Maintenance, Repair and Overhaul
MTOW Maximum takeoff weight
OLS Ordinary least squares
SCM Agreement on Subsidies and Countervailing Measures
S.D. Standard deviation
TLCA Agreement on Trade in Large Civil Aircraft
US United States
USITC United States International Trade Commission
WTO World Trade Organization

1 Introduction

The specificity of commercial aircraft industry makes it very hard to find another area where similar dynamics and characteristics are present. While not being the only oligopoly present in the manufacturing sector, extremely high barriers to entry, its unpredictability and sensitivity to fluctuations in the world's economy make it somehow stand out from other oligopolies on the market. Aircraft industry is a major contributor to the growth of world trade and economic prosperity, directly creating tens of thousands of jobs and some countries' economies being reliant on the industry. Without commercial aviation, countries dependent on tourism would be in a very unfavorable situation.

The market was valued at $96.8 billion in 2021 and despite the worldwide devastating effects of COVID-19 pandemic, is expected to grow at 5% a year, reaching $173 billion in 2027 (Intelligence n.d.). With the manufacturing sector goes hand in hand the Maintenance, Repair, Overhaul (MRO) market, valued at $87 billion in 2021, expected to be growing by 4.57% yearly until 2030 (Research 2022). Despite the growth of the aircraft industry, the number of large manufacturers was reduced only to two. We saw the decline of one of the oldest aviation manufacturers, McDonell Douglas, even though it was the second to introduce a successful, transatlantic flight capable jet aircraft, the DC-8. Lockheed exited the commercial market after the fiasco of L-1011 TriStar, where even technical progressiveness and revolutionary solutions could not fuel sales numbers. The same goes for the former Soviet manufacturers, which were not able to find any new market possibilities after the union's dissolution and ceased production. At the beginning of the 21st century, we were left only with two relevant manufacturers of large commercial aircraft – the European Airbus and American Boeing.

Some aircraft offer the most modern technologies available or stand out with unique qualities, such as unparalleled capacity. The high hopes of manufacturers for a revolution and a sales hit at launch are often hit with a lack of interest from the market, resulting in financial losses and premature cancellation of aircraft programs (e.g. L-1011, MD-11 or A380). In this thesis, we are looking into the question of what the market really values and what are the airlines' priorities when purchasing an aircraft. Not much research has been done on this topic, with the last relevant work being from 2004 written by Douglas A. Irwin and Nina Pavcnik. The researchers focused on the data from 1969 to 1999. Since then, we have seen many new models introduced, with the industry shifting to a new generation of technology and thinking. We have collected and modelled newer data (2004 to 2018) to have an updated view on the trends on the market.

As there are only two companies present, the tighter is the battle for dominance. Their strategies include mimicking moves of the other player or attempts of inflicting losses or difficulties directly or indirectly, resulting in one of the largest trade wars in history, dragging in the governing bodies of respective countries to the corporate battle. With the pair of manufacturers being busy eating up each other's market shares, there is a third player slowly rising in the background, potentially capable of changing market dynamics. The creation of Chinese COMAC was seen by experts as a serious competition, but with the time passing by and the dynamics remaining unchanged, we investigate the possibility of jeopardizing the position of Boeing - Airbus duopoly.

2 Literature review

There are not many papers and theses discussing the demand for commercial aircraft and none published in the recent years, monitoring the current trends. Probably the most notable paper is the one by Irwin & Pavcnik (2004). The paper investigates multiple questions – estimation of discrete choice, differentiated products demand system for wide-body aircraft and examination of the Boeing – Airbus competition. The structure is then used to evaluate trade disputes in the aircraft market between the EU and the US. The results of the paper suggest 3.7% price increase after the EU-US agreement on limiting subsidies on aircraft development. They find the increase consistent with the subsequent increase of marginal costs of the companies by 5%. The paper also tries to simulate the impact of entry of the Airbus's superjumbo A380, at that time still in development. The simulation looks into the changes in the wide-body segment, most notably the change of demand for the only A380 direct competitor, Boeing 747. 747's share could drop by up to 14.8% (depending on the discounts offered), but introduction of A380 could decrease the market share of other existing Airbus's wide-bodies by more than it lowers 747's. The paper uses discrete random utility framework outlined in the work by Berry (1994).

An analysis by Berrittella et al. (2007) shows that the parameters such as maximum take-off weight are relevant in technical consideration, and that speed is not. This explains the strategy adopted by Boeing during the development and production of the 787, where it prefers to satisfy the needs of airlines that require cost effective aircraft, which can connect cities without using congested hubs, and that speed is not a factor for them. The analysis further investigates the conditions under which companies have incentives to create strategic alliances. A stable alliance is possible under the existence of side-payments. The stability is present if the agreement emanates from competition, such as Bertrand duopoly, but is not certain if it comes from monopoly.

Benkard (2000) attempts to model the aircraft industry empirically using a dynamic oligopoly model with fully specified dynamics. Three alternatives of market structure were evaluated – with suggesting single product MPE (Markov perfect equilibrium) to be efficient from a social perspective. He also concludes that an unregulated monopolist producer would create a large loss in social efficiency and should be avoided, but too strict government intervention in restriction of one-firm concentration would reduce the total welfare as well. Benkard considers the aircraft industry to be one of the simpler cases to work with due to small number of firms.

The Airbus - Boeing competition is described in more detail in a thesis by Cook (2008), where he describes the duopolistic behavior of the manufacturers is different from usual models in other industries. Uncertainty, inflexible supply and irrationality (in the form of national pride) limits the tendencies for collusive behavior. Woo et al. (2021) focuses on competitive dynamics, especially the actions taken by Boeing to maintain its position of the leading manufacturer. The risk-taking culture of Boeing was identified as the main factor of Boeing's success, but eventually led to the 737 MAX disaster, where company's profit was preferred to safety. Olienyk & Carbaugh (2011) question the possibility of the duopoly being in jeopardy, most notably after the rulings of the WTO, where the reports confirmed that both manufacturers used illegal subsidies and were obliged to refrain from this in future developments. Other manufacturers, notably Chinese COMAC, capitalize on unregulated subsidies from the Chinese government. At that time, development of COMAC aircraft was still at the outset and was considered a threat to the duopoly. We look into the subsequent development of Chinese aircraft industry further in this thesis.

A report by Lawrence & Abaloufia (2006) published for Morgan Stanley presents opinions from two experts. Lawrence considered rapid urbanization in Asia to fuel demand for routes between megacities and A380 a key factor in countering increasing congestion. He did not consider the competing 747-8 a threat, due to being built on outdated technology and did not expect it to take more than 35% of the market. He estimated the size of market for very large aircraft segment to be around 1400 units up to 2025, with almost 900 A380s delivered. Aboulafia correctly evaluated the very large aircraft market to be shrinking in the future, and that A380 would be profitable only on a small number of routes. He estimated that only about 400 A380s would be delivered by 2025 and that international travel would be better served with A350s, 777s and 787s, all two-engine aircraft. Despite considering A380 to be technologically obsolete and the changes in market dynamics taken into consideration, the final number of delivered A380s is in reality significantly lower than the estimated, pessimistic number.

3 Boeing - Airbus duopoly dynamics

3.1 Market segmentation

The commercial aircraft industry can be divided into three segments, based on the characteristics of usage of an aircraft:

1. Private (jet) aircraft;
2. Regional airliners;
3. Large commercial aircraft (LCA).

Each of these market segments is dominated by different manufacturers and has a different structure. The dominant players in the private jet segment are Learjet, Cessna, Gulfstream or European Dassault. Regional segment, being very strong in North America, is split between Brazilian Embraer and Canadian Bombardier, which has recently exited this segment by selling its CRJ program to Mitsubishi Heavy Industries. Airbus and Boeing are present in this segment too by offering regional versions of their LCAs, like Airbus A318, or by acquiring and manufacturing a running project originally developed by another manufacturer. Instances of this are the Airbus's A220, which was designed and launched by Bombardier as CSeries and later sold to Airbus, or Boeing 717, which is an evolution of McDonell Douglas's MD-80 program from the 1980s, which Boeing inherited by the merger of these two companies in 1997. Regional segment does not play an important role in aviation industry everywhere in the world. As mentioned, the most important location in North America and Europe to some extent, but this segment is almost non-existent in Africa or South America (Insights 2021), where domestic and regional air travel is limited and is usually served by aircraft belonging to LCA segment.

To some extent, there are overlaps between the segments. There are Boeing and Airbus LCAs being sold to private customers for VIP transport and other private uses, or regional aircraft such as Embraer E195, which from some point of view does have LCA characteristics, but is generally regarded as a regional aircraft. These overlaps are in practice minimal and number of sales which may distort the segmentation is negligible, thus we consider the segments to be clearly defined. The LCA segment is in fact not strictly shared between only two manufacturers, Airbus and Boeing. These two companies are the only manufacturers which produce LCAs on a large scale, but e.g., there are still aircraft from defunct Soviet manufacturers in limited active service, though the numbers have been dwindling fast in the recent years. Ilyushin, formerly Soviet and now Russian aerospace company, is currently the only manufacturer in Russia which produces LCAs. With only 30 wide-body Il-96s produced over the last 30 years including government orders, its portion of market share is miniscule and in practice can be ignored.

3.2 Competition from China

Duopolistic character of regional and LCA segments may be threatened by the creation of Commercial Aircraft Corporation (COMAC) – a consortium launched by the Chinese government to develop and manufacture commercial airliners in China. China had some attempts on producing commercial aircraft over the last 50 years, all of them ending unsuccessfully without large-scale operations taking place (notably Xian aircraft). The rapid economic growth of has reflected in increasing demand for domestic air travel and China wants to take advantage of this by developing and producing airliners domestically.

After its creation in 2008, COMAC started working on an already existing project of a regional aircraft – ARJ-21 with capacity of up to 95 passengers. Technical and design-wise, although presented as a completely new development, the aircraft bears a striking resemblance to McDonell Douglas' MD-80 series developed in the 1980s and uses General Electric produced CF34 engine, which is used by regional jets by Bombardier and Embraer. The first flight took place in 2008 as planned and was followed by 240 firm orders by 2010, with intended introduction in 2011 and orders almost solely by Chinese customers. Due to various problems with production and certification of the aircraft, the first delivery took place not until 2016, and only 68 aircraft have been delivered to customers since then.

While ARJ-21 did not prove as a real competition to Bombardier and Embraer in the regional segment, the Boeing-Airbus duopoly is more likely to be threatened by C919 in the LCA segment. This COMAC-developed narrow-body airliner has capacity of up to 190 passengers and was created to compete with Boeing 737 and Airbus A320 family. With the creation of the C919 family, COMAC has ambitious plans of taking 20% of global narrow-body market and one-third of Chinese market by 2035, expecting 2000 sales by 2037 (Jiang 2017). Though the designers estimate the aircraft to be 12 to 15 percent more fuel efficient than the competitors, it still falls behind Boeing and Airbus in operating range (about 6500 km vs maximum of 5600 km). Bland (2017) considers the aircraft to be 10-15 years outdated, but with the magnitude of involvement of politics in business in China, the demand for the aircraft may be inflated even though the customers do not fully appreciate the qualities of the aircraft. Independently estimated number of deliveries (Hashim 2020) is 1209 over the duration of production, with Chinese market accounting for 85% of all deliveries. The market in China would still be big enough to support sales of C919 and its competitors, so we cannot expect a substantial decline and exit of the market by one of the Boeing-Airbus couple (Hashim 2020). Similarly as the ARJ-21 program, C919 was not able to abide by the schedule. The first flight took place in 2017 instead of 2014, and the first aircraft still has not been delivered, although the plans were for the years 2016 and later 2020. Many western aviation firms have been included in the development of the aircraft, either by creating joint ventures or directly suppling technology components, like Honeywell or Eaton corp. These collaborations did not get by allegations of economic espionage by companies like GE Aviation, Safran or Honeywell, where cyber and human intelligence operations took place. By 2019, investigations led to arrest of four people for theft of trade secret and espionage (Lynch & Shepardson 2018). Despite these facts, the order book for C919 holds 815 orders as of May 2022, in forms of firm orders and letters of intent, overwhelmingly from Chinese customers. First deliveries are currently expected in 2022.

3.3 Individual projections of air travel models

The creation of jumbo jet (Boeing 747) was the moving factor behind the spread of hub-and-spoke model, adopted all around the world, mostly in major cities and commercial centers of regions. It replaced the point-to-point model, which despite offering better travel experience, could not compete with economic advantages of hub-and-spoke model. Hub-and-spoke become the core strategy of the manufactures during the 20th century, but Boeing changed back to point-to-point model in the 90s, as it was expecting its return and expansion in the future. Boeing set up 7E7 project to create a mid-size, highly efficient aircraft tailored for the model, where low operating costs and scheduling flexibility are key. The project was finalized as the 787 Dreamliner. Compared to Airbus A380, it uses only two engines, increasing efficiency, reducing fixed costs and burning 20% less fuel than directly competing aircraft (Woo et al. 2021). It was designed to be used mainly in medium-sized cities, enabling airlines to optimize performance in their fleets and networks and open new routes to smaller airports.

A year after launching the 7E7 project, in 2004 Airbus responded with updating the engine option on the already existing A330. This move brought negative reception from lessors and carriers, showing that Airbus did not take the threat of 787 seriously. The update of A330 was put on hold and Airbus came up with a new design project – A350, still a redesign of A330. Airbus committed €4 billion to the changes and hoped to launch the aircraft in 2010, estimating demand for 3100 aircraft over the next 20 years in the 250-300 seat segment with capturing at least 50% (Airbus 2004). The design would include a new horizontal stabilizer, reworked wings and new General Electric engines, improving fuel efficiency by 10% in comparison to A330.

The new design was still not able to compete with the 787. In 2005, Qatar Airways placed an order for 60 A350s, but Emirates was dissatisfied with the design changes and was not willing to order the aircraft, considering Boeing 777-200ER to be a better option. At the time the largest Airbus customer, International Lease Finance Corporation (ILFC), publicly criticized the design and advised Airbus to come with a clean-sheet design. With important customers, such as Singaporean Airlines or Qantas, ordering 787 instead of A350, Airbus started to take the threat of losing market share more seriously and knew that it had to come with another redesign, now with a completely new fuselage. The final design was introduced in 2006 as A350XWB (Xtra-Wide-Body), cancelling the original A350 project. Airbus managed to start and offer the project just in time to catch the increasing interest of the market in such aircraft. As of July 2022, 486 A350s have been delivered with 454 unfilled orders in the backlog. This is a portion of market, which would be otherwise solely controlled by 787. 1006 787s have been delivered to customers and 476 orders have not yet been filled. This means that Airbus was able to cut almost 40% of the market up to this moment.

3.4 M&A strategies with regional manufacturers

Boeing and Airbus became a duopoly in the LCA segment after the merger of Boeing and McDonell Douglas in August 1997. The merger caused the increase of Boeing's market share to 70% at the time (Woo et al. 2021). Airbus, as a response to increase its competitiveness, transformed from a consortium to a corporation by changing its management structure. This was to allow Airbus to have swifter decision-making and easier financing of projects.

After lengthy troubles with designing, launching and certification, Bombardier decided to sell its regional CSeries program to Airbus in 2017, first by giving away 50.01% majority stake, with Airbus paying with utilization of its supply chain. The deal was immediately objected by Boeing. Boeing had been fighting against the launch of the CSeries in the US, as it feared the impact on its market share in regional and short-haul segments. The influential position of Boeing in the US industry led to a ruling by US International Trade Commission in June 2017 that the production of the aircraft in Canada and subsequent operation by US carries may be a threat to

American industry (USITC 2018)). The US Department of Commerce reacted with 80% anti-dumping duty, which together with other duties would result in a total duty of 300%, later adjusted to 292%. Such tariffs would make the production of the aircraft unfeasible, and the US market would become inaccessible for CSeries. The large tariffs could have been avoided by producing the aircraft in the US, but Bombardier, struggling financially, did not have time nor money to build a factory on the US soil for production of a single type. Even though the ruling of the DoC was objected by Canadian government and investigation was started by WTO, Bombardier could not afford to delay the launch of aircraft again when the original launch date was proposed to be in 2013. Bombardier had no other option than to create a partnership with Airbus, so it could utilize its manufacturing plants in Mobile in Alabama.

Eventually, after the investigation by WTO started, the USITC ruling of the threat for US industry was overturned in January 2018 (USITC 2018)), but this happened not before the transfer of controlling interest in the program to Airbus. In January 2020, Bombardier reassessed its role in the program and decided to sell its share to Airbus for $591 million, which now controls 75% of the program. The remaining 25% is in the hands of Investissiments Québec, a holding company owned by the Government of Quebec.

A similar move was made by Boeing – the company proposed to buy 80% share in the commercial aircraft division of the Brazilian manufacturer

Embraer. Memorandum of understanding was announced in July 2018, where Boeing would buy the share for $3.8 billion. The venture would not involve Embraer's defense and executive jet divisions. A revaluation in December 2018 increased the price to $4.2 billion. The asymmetrical shareholder structure caused great worries to Brazilian worker's unions, which feared a possible layoff and relocation of production to the US (Staff 2018). Boeing even had plans to rename the venture to Boeing Brasil-Commercial, omitting the Embraer name from the brand (Rochabrun 2019). Antitrust reviews were expected to be finished by the end of 2018, but the EU investigation was released only in October 2019 and found issues. Further investigation could take up more than five months. The deal was suddenly terminated by Boeing in April 2020, blaming Embraer that it could not comply with the conditions in the mutual agreement. The unofficial cause of the termination may have been the drop of Embraer's value as a result of COVID-19 pandemic, where the value fell to less than $1.1 billion (Team 2020). It was at the same time when Boeing received a loan from the US government under the CARES Act, an economic stimulus bill in response to economic impact of the pandemic. Buying a share in Embraer could make an impression that the money provided from the loan had been used to secure jobs in a foreign country, instead to support jobs in the US. On the other side, Embraer blamed Boeing that it overestimated its financial condition and could not in fact afford to close the deal, after the damage caused by 737 MAX groundings and other business problems.

3.5 Continuation on the WTO dispute

Origins of the dispute date back into the 1970s, the time of creation of Airbus. The development costs and production of the consortium were funded from multiple governments of Europe, mostly the founding states of Airbus. This became an issue for Boeing after 1988, when Airbus launched its narrow-body A320, a direct competitor to Boeing's bestselling 737. A bilateral treaty named Agreement on Trade in Large Civil Aircraft (TLCA) from 1992 at the GATT (General Agreement on Tariffs and Trade, the predecessor of WTO) regulated the maximum levels of permitted support for the producers of wide-body aircraft, i.e. Boeing and Airbus. Direct support from government was limited to 33% of total development cost in Europe, with interest rates covering at least the cost of the loan for the government. In the US, the maximus aid was limited to 3% of the commercial industry's annual turnover, or to 4% of a company's turnover in civil aviation. The terms for indirect aid were not discussed.

The agreement became an object of dispute in 2004, when talks between the US and the EU were restarted in order to modify the agreement. It was at that time when Airbus was launching the A350 and A380 projects and the dominant position of Boeing was threatened. In 2003, Airbus surpassed Boeing in the number of delivered aircraft for the first time. The talks were unsuccessful, and Boeing unilaterally withdrew from the agreement.

Subsequently, the two manufacturers attacked each other with reciprocal legal actions, with the EU claiming that Boeing had been given over

$19.1 billion in illegal subsidies from multiple government-related sources. Boeing objected the $15 billion received by Airbus in the form of launch aids, which were structured according to the TCLA, but due to US withdrawal, the agreement was not applicable anymore. These two filings became the largest disputes in the WTO history (Wittig 2021). The first panel reports were released in June 2010 for the Airbus case and in March 2011 for the Boeing case, reports from the Appellate Body (AB) were released a year later in both cases.

Findings in the Airbus dispute were generally positive for the manufacturer. It did not find any instances of prohibited export subsidies (most notably in the A380 project), but some subsidies in the form of infrastructure grants, research founding or launch aid may have caused prejudice, but not a serious extent. The total magnitude was not quantified (Wittig 2021). Both reports from the panel and the AB found prohibited subsidies in the Boeing case, which had been received from various sources. At least $5.3 billion of subsidies were found to be specific (i.e. prohibited), whether in a form of tax exemptions and exclusions from the US government, reimbursements of expenses by US states governments or access to NASA's facilities and equipment. Both reports agree on the fact that these prohibited subsidies helped Boeing to launch the 787 in 2004 and helped to create an unfair technological advantage. These actions caused serious prejudice in the 100-200 seat market, where Airbus directly lost sales, and helped Boeing to significantly suppress prices in the 200-300 seat market (Wittig 2021). In contrast to the

Airbus case, where the AB reversed some of the findings of the panel, findings in the Boeing case went further and were stricter than the ones of the panel.

The dispute settlement system of the WTO does not allow retroactive sanctions. Specifically for the case of subsidies, Article 20 SCM implicitly states that retroactive or punitive damage compensations are not allowed under the WTO system. Even though the WTO was appraised for its handling of the cases, both the panel and the AB can only recommend the respondent to take appropriate steps, i.e. to withdraw the subsidies or to remove the adverse effects caused by the use of the subsidies. The battle continued by compliance panel and AB reports in 2016, essentially confirming previous findings. Finally, on 2 October 2019, permissions for countermeasures on exports were given both to the EU and US, \$7.49 billion of European and \$3.99 billion of annual worth of American export (arbitration decisions WT/DS316/ARB, 2019 and WT/DS353/ARB, 2020). This translated to 10% tariff on LCA imports to the US, increased to 15% in March 2020 and 25% on certain other products, targeting the member states of Airbus consortium. The EU mirrored these duties in November 2020 with the same 15% tariff on LCAs and 25% on some agricultural products, or coal and videogames among others. The combined value, around \$11.5 billion annually, is the largest in the history of WTO disputes.

4 Deciding factors in demand for wide-body aircraft

Aircraft in the LCA segment are divided into two categories: wide-body and narrow-body aircraft. Narrow-body aircraft can be distinguished by a single aisle and shorter range – usually up to 6000 km. The main competitors in this segment are Airbus A320 and Boeing 737, but there are aircraft, such as Boeing 757 or Airbus A321LR, which are capable of transatlantic flights. Wide-body aircraft have two aisles and, in some cases, two decks. They serve medium and long-haul routes, usually up to 14000 km, and have capacity well above 200 passengers. The category can be further divided into medium and long-range market, with multiple aircraft from each manufacturer in both categories. The competing aircraft in the medium-range market are Boeing 767, Airbus A330 and some variants of Boeing 777 and 787. The long-range market currently consists of Airbus's A330neo, A340, A350 and A380, complemented with Boeing's 747, 777 and 787. As each aircraft is usually designed to serve a single market, we can see aircraft in respective categories as imperfect substitutes for each other. In this thesis we focus our research primarily on the wide-body segment, as it is more differentiated, experiences continuing growth for the past decades and is the subject of the trade dispute between the US and the EU. Wide-body segment was the first market Airbus entered with A300 in 1974, with the first entry in the narrow-body segment only in 1988 with A320. The volumes sold in the wide-body segment are usually lower, thus creating more intense competition, while both 737 and A320 narrowbodies sold over 10,000 units over their lifespans.

Table 1: Order-weighted average statistics of aicraft offered every year

Year	Capacity	Price (mil. $)	Range (km)	MTOW (t)	Oil price ($)	GDP growth (%)
2004	325	128.25	13837	313.0	36.86	4.49
2005	294	158.87	13801	281.6	50.53	4.04
2006	324	199.59	13919	307.8	59.65	4.48
2007	313	194.39	14299	288.8	66.56	4.48
2008	317	218.13	13992	290.9	94.22	2.07
2009	322	233.80	14059	305.5	58.25	-1.32
2010	360	257.36	14491	334.3	74.64	4.53
2011	371	274.61	13677	352.5	96.30	3.32
2012	346	278.54	13824	327.6	94.63	2.71
2013	350	299.43	14098	313.3	96.09	2.82
2014	334	201.94	13929	301.5	87.71	3.06
2015	304	273.86	13614	265.1	44.31	3.08
2016	315	289.36	14307	278.9	37.77	2.80
2017	310	288.14	13883	276.3	47.95	3.38
2018	320	302.65	14195	291.3	61.02	3.28

4.1 Data

The data for wide-body passenger aircraft orders (net in the year of order) and prices were collected over the period from 2004 to 2018. The starting point of the period was chosen on the basis of the year of publication of the original article by Irwin & Pavcnik (2004). Furthermore, 2004 is the year of an important change in the industry – launch of the 787 program, the first clean-sheet design of a wide-body aircraft in the 21st century, making the year 2004 the first year, when an aircraft purposefully designed for point-to-point travel was available. Data for years 2020, 2021 and 2022 were not collected due to impact of COVID-19 pandemic on the demand for wide-body aircraft and aircraft in general. The decline in demand was not caused by intrinsic deterioration of aircraft qualities or spontaneous loss of interest in flying, but rather by the exogenic factor of lockdowns, restrictions on travel, shortage in labor and difficulties in the supply chain. These factors could not be properly incorporated in the model and the sudden change in dynamics could bias results for the non-pandemic years. The year 2019 was not incorporated due to Boeing's sharp decline of new orders (down 77% from 2018) caused by the worldwide grounding of 737 MAX. The sudden loss of reputation, increased cost and disruption in manufacturing process, unique for the year, could have caused withdrawal of customers or their shift to Airbus aircraft, making the decision solely on the fact that Boeing is in peculiar situation and not because they started to value the characteristics of Airbus's aircraft more.

List prices of aircraft were obtained from the official price list published by the respective manufacturers every year. Boeing decided not to update the prices for the years 2009 and 2016, when the prices were kept the same as in 2008 and 2015, respectively. Data for historical orders were obtained from the official order summaries of the manufacturers. Data for the average oil price and GDP growth were obtained from the World Bank database.

Table 2: Descriptive statistics

Variable	Mean	S.D.	Max	Min
Typical seating	326	81.9	575	174
MTOW (t)	304.4	88.14	575	179.2
Range (km)	13559	1799	16670	9700
Net orders	15.9	33.2	213	0
Price (mil.$)	246.16	41.61	445.6	114
Oil price ($)	67	21.25	96.3	36.85
GDP Growth (%)	3.23	1.142	4.523	-1.32

4.2 Methodology

We employ the same structure of aircraft demand system as in the work by Irwin & Pavcnik (2004), which is based on the discrete choice random utility framework proposed by Berry (1994). The following description of the used model infers from the description in the Irwin & Pavcnik work. Without observing individual customers and their purchases, we can use the data on total sales, prices and other factors to estimate the demand. Consumers (airlines) are presented two options: purchasing a wide-body aircraft or an outside good, which consists of used wide-body and new narrow-body aircraft. Thus the total market is composed of all new aircraft and used wide-body aircraft. Utility from the outside good is normalized at zero.

Characteristics valued by airlines include typical seating, MTOW, price and range. Each wide-body model is modeled as a bundle of these characteristics. Apart from these, there may be some other characteristics that an airline values, like availability of service or ease of use, which cannot be observed directly, but our framework allows that. The utility of an airline i purchasing product (aircraft) j can be expressed as:

$$u_{ij} = x_j\beta - \alpha p_j + \xi_j + \tau_{ij} \tag{1}$$

where x_j is a vector of aircraft j characteristics and $_j$ it the aircraft price. Two terms cannot be obsereved: ξ_j, which captures characteristics valuable for airlines, and τ_{ij}, which represents airline i's specific taste for aircraft j.

The mean utility level yielded by an aircraft j is denoted by:

$$\delta_j \equiv x_j\beta - \alpha p_j + \xi_j. \tag{2}$$

In this model, the different valuation of each aircraft across consumers originates from the additive term τ_{ij}.

The term can be rewritten as:

$$\tau_{ij} \equiv \upsilon_{ig}(\sigma) + (1-\sigma)\epsilon_{ij}, \tag{3}$$

when by using a nested logit demand model we allow to correlate specific tastes of consumers across individual aircraft. The aircraft are grouped into two categories g, representing medium-range and long-range market segments, and the consumers having an option to buy the outside good. Identically and independently distributed consumer tastes are captured by the term ε_{ij}. The common taste of an airline i for a market segment g (covering

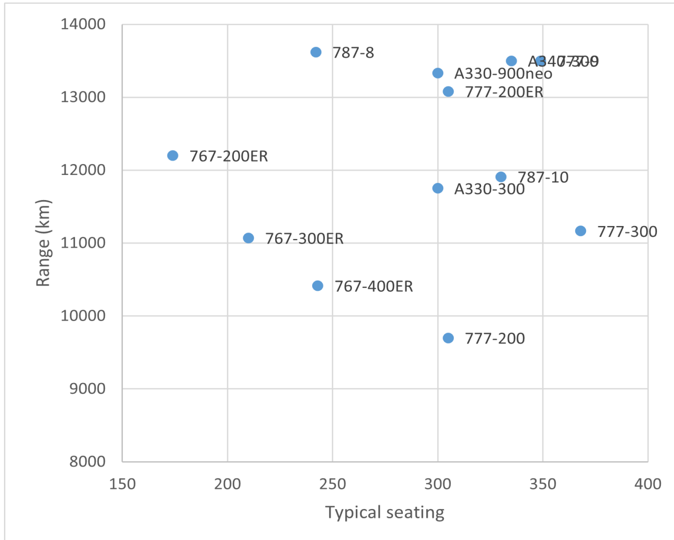

Figure 1: Typical seating and range of aircraft in the medium-range segment

all aircraft in the segment) is captured by the term v_{ij}. σ represents distribution parameter with values between 0 (included) and 1 (excluded), upon which is the common taste term dependent. For σ=0, no market segmentation is present and consumer tastes are independent. σ determines the level of substitutability within a segment, with values getting closer to 1 resulting in higher correlation of consumer tastes for aircraft in the given segment. Aircraft within become a more serious competition to each other and are less competitive with aircraft from different segments.

We assume an airline to select the aircraft yielding the highest utility. Even though airlines usually purchase multiple aircraft in one order, in this framework we do not observe particular purchases and the number of aircraft ordered, and we allow only one aircraft to be purchased at a time.

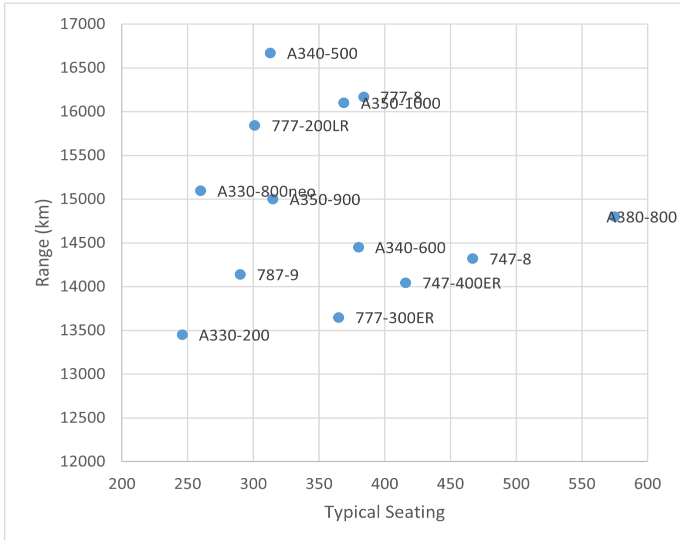

Figure 2: Typical seating and range of aircraft in the long-range segment

The predicted market share s_j of aircraft j can be denoted as:

$$s_j(\delta, \sigma) = \frac{e^{\delta_j/(1-\sigma)}}{D_g} \frac{{D_g}^{1-\delta}}{\sum_g {D_g}^{1-\delta}}, \tag{4}$$

where

$$D_g \equiv \sum_{j \in g} e^{\delta_j/(1-\sigma)}. \tag{5}$$

Aircraft j's market share in the market segment is expressed by the first term, the second term represents market segment g's market share in the total aircraft market. By inversion of the market share expression we can describe mean utility level δ_j with demand function and the parameter σ:

$$lnS_j - \sigma lnS_{j|g} - lnS_0 = \delta_j(S, \sigma) \equiv x_j\beta + \alpha p_j + \xi_j. \quad (6)$$

By rearranging we get our final estimating equation:

$$lnS_j - lnS_0 = x_j\beta + \alpha p_j + \sigma lnS_{j|g} + \xi_j. \quad (7)$$

S_j represents market share of aircraft j, S_0 market share of the outside good and share of product j within segment g is represented by the term $S_{j|g}$.

4.3 Results of estimation

As mentioned, the quality parameter ξ_j is not observed, but is very likely to be correlated with the aircraft price. It is presumable that aircraft manufacturers reflect the product quality in the price of aircraft j. Manufacturers are also very likely to adjust the price of aircraft j based on the characteristics of competing aircraft, so the final price of aircraft j is derived not only from subjective and objective qualitative parameters, but strategic interaction is contained as well. We assume that the qualitative parameter ξ_j is not correlated with the vector x_j of product's attributes. Our final demand equation is linear in all parameters and the error term, so we can carry out OLS and two-stage least squares estimations. Relatively low number of aircraft sold each year may cause a sampling error, which may present heteroskedasticity. Therefore standard errors robust to heteroskedasticity are reported in parenthesis.

Table 3: Estimation results

Period	OLS	2SLS
Range	0.029 [0.047]	0.121 [0.079]
Typical seating	0.0030 [0.0019]	0.0111 [0.0069]
MTOW	0.0023 [0.0019]	0.0013 [0.0026]
Price	- 0.0294 [0.0054]	- 0.0502 [0.0128]
Oil price	- 0.008 [0.006]	- 0.014 [0.009]
GDP Growth	- 0.032 [0.021]	- 0.014 [0.023]
σ	0.947 [0.050]	0.497 [0.213]
Adjusted R^2	0.80	0.61

The basic defining parameters of an aircraft (i.e. range, number of seats and MTOW) have all positive impact on the market share in both methods of estimation. The strongest of these parameters is the range, which is in the line with the shift to point-to-point strategy of airlines. Point-to-point means flying longer distances with less passengers, and that is why the coefficient for typical seating is lower. The coefficients of typical seating and range are higher under the two-least squares method, but the order of magnitudes of the three attributes (including MTOW) is preserved. The MTOW coefficient decreases under the method. MTOW is usually not the deciding parameter when airlines choose an aircraft. Even though airlines would prefer lighter aircraft due to fuel efficiency, MTOW tends to increase with the number of available seating (i.e. dimensionally larger aircraft), which is consistent with the seating coefficient, but can be increased specifically by utilizing stronger materials or by ad hoc certification, which cost premium. Airlines usually do not seek increasing MTOW, as air traffic and landing fees are derived from it. As reducing costs is a priority for airlines, in consequence the MTOW coefficient, as proven by the estimations, is the least important when choosing the right model.

The most significant characteristic of an aircraft is the price. Obviously, the coefficient has negative sign, thus increasing price of an aircraft reduces the market share. The products in the market are not qualitatively differentiated enough to be the main deciding element during an aircraft purchase. As the market is dominated by only two manufacturers and the products are relatively similar to each other, consumers have no other parameter than compare the financial offers from each manufacturer and decide on the price. On the macroeconomic factors, increasing oil price has negative impact on the demand. Increased price is reflected in the price of airline tickets, decreasing the potential demand from passengers and reducing the number of aircraft operated by airlines. The magnitude of this coefficient is however small. The negative coefficient of GDP growth can be explained by manufacturers offering better deals for airlines during years of economic downturn. In a challenge for a steady cash flow and staying in the business, manufacturers are more likely to offer discounts, notably on bulk purchases. Another factor may be the A350 and 787 being introduced during the years of economic crisis, and aircraft usually receive the large orders around the launch periods (e.g. 2008 is the fourth most successful year for A350-900 and the third for A350-1000).

The high values of σ in both estimations suggest aircraft within each segment being highly substitutable mutually and less substitutable with aircraft from different segments. This implies that aircraft within a segment are more sensible to introduction of a new model in the segment, instead of losing sales to a model competing in a different segment. Same goes for a price increase of an aircraft, when the consumers are more likely to buy a different aircraft from the same segment instead from another. This is important for the manufacturers to be aware of this, as they cannot easily substitute the potentially lost sales due to price increase with sales of a model from different segment. Consumers would rather choose an aircraft from a competing manufacturer if the price-increasing company does not offer a reasonable alternative within the segment.

To have a better look on the substitutability, we can employ the estimated coefficient α and the parameter σ in the following equations to calculate own and cross-price elasticities. We distinguish three cases of elasticity η:

1) Own price:

$$\eta_{j,j} = \frac{\partial s_j}{\partial p_j}\frac{p_j}{s_j} = -\alpha p_j s_j + \alpha p_j \left(\frac{1}{1-\sigma} - \frac{\sigma}{1-\sigma} s_{j|g}\right) \tag{8}$$

2) Cross-price for products from different segments:

$$\eta_{j,k} = \frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j} = -\alpha p_k s_k \qquad j \neq k; k \notin g; j \in g \tag{9}$$

3) Cross-price for products from the same segment:

$$\eta_{j,k} = \frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j} = -\alpha p_k s_k\left(\frac{\sigma}{1-\sigma}\frac{s_{k|g}}{s_k} + 1\right) \qquad j \neq k; j,k \in g \tag{10}$$

for aircraft *j,k* and market segment *g*. The results are presented in Table 4 as means weighted by number of orders and averaged into three time periods. We look into the 2004 - 2008 period of introductions of new types, 2009 – 2013 period of the financial crisis and the remaining period of 2014 – 2018.

Table 4: Calculated price elasticities

Period	Own price elasticity	Cross-price elasticity own segment	Cross-price elasticity different segment
2004-2008	-7.353	1.583	0.066
2009-2013	-8.664	2.101	0.082
2014-2018	-7.729	1.722	0.073

The magnitude of the own and cross-price elasticities increased during the crisis period, suggesting the airlines cared about their financial more and the market became more price sensitive. The lower magnitude of cross-price elasticities across segments compared to elasticities within segment confirms our deduction, that the aircraft in one segment are bigger competition to each other than across. A cross-price elasticity larger than 1 means that 1% increase in price means for the competitors gains in the market share larger than 1%. Within-segment elasticities are larger than 1 for every period, while cross-segment elasticity ranges between 0 and 1.

5 The failure of A380

In their work, Irwin & Pavcnik (2004) predicted sales of 760 aircraft during the period of 2002-2022, what they considered a sober, but realistic estimation. In 2021, the A380 program has been terminated, just 14 after the first aircraft was delivered. The total number of aircraft built is 254, including 3 test aircraft paid by Airbus, what is less than the break-even number of 270 estimated even before problems with initial launch appeared (Olson 2006). The number falls far short of not just Airbus's expectations, but even the presumed conservative estimations of Irwin & Pavcnik paper were three times higher than actual sales over the last 20 years. We investigate the events taking place after publication of the work and find factors responsible for the failure. Such factors could not be anticipated and are very hard to include in an economic model, or to quantify their impact in numbers. The failed estimations of demand prove that expectations in the aircraft industry cannot be driven by pure mathematics and have to incorporate human irrationality and changing tastes. After the fiasco on the market of new aircraft, we investigate the situation on the secondary market and whether it even exists.

5.1 Impact of delayed introduction

Airbus was the first commercial manufacturer to apply fly-by-wire technology on its products. The technology does not use mechanical linkages between control surfaces and the cockpit, but rather utilizes computer technology to transfer inputs from pilots. This allowed Airbus to have cockpits across its fleet in the same design, reducing the necessary time to re-train pilots for different Airbus types. In 1999, Airbus for the first time surpassed Boeing in the number of orders for large aircraft, despite the value of its deliveries in that year was just 30% of Boeing's and 33% in quantity (Esty & Ghemawat 2002). Though gaining market share steadily, Airbus did not have a product to compete with Boeing's flagship 747, and Airbus envied its monopoly in the very large aircraft market segment.

The predecessor of the current Airbus company was EADS, a merger of four national aircraft manufacturers of four European countries – German DaimlerChrysler Aerospace, French Aerospatiale Matra and Spanish Construcciones Aeronáuticas complemented with 20% stake of British BAE Systems. Airbus has become a fully integrated company only in 2001 by establishing a new entity with all EADS and BAE assets transferred.

First confirmed news on delay were in October 2006, with deliveries of the aircraft in full scale starting in 2008. This almost two years long delay may have reduced Airbus's revenues by €6.3 billion and profits by €4.8

between years 2006 and 2010 (Naikal 2009). Despite achieving steady growth and ending Boeing's monopoly in the past decades, national rivalry, disputes about leading major projects and questions about appointing key positions had been present in the company all along. Airbus changed four CEOs between 2005 and 2006. These conflicts became evident during development of A380 and played a role in the delay of introduction.

A major battle was ongoing between French and German parts of the organization. Airbus and EADS practiced dual management model, a hampering factor in growth of the company influenced by strong national and individual interests. The conflict eventually resulted in official meeting of French president Sarkozy and German chancellor Merkel in July 2006 at company's headquarters in Toulouse. This came amongst economic troubles for Airbus – in the first two quarters of 2006, the share value of Airbus fell by 23%, while Boeing grew 47% (Scally 2007). The meeting resulted in employment of new rotation-based management structure. With European economies being stable at that time, as a joint company of EU member states Airbus's expenditures are billed in Euros, but US Dollars are used for billing the customers. During the 2006 and 2007 period, value of US Dollar against Euro fell by 20%, what translated to about $1.6 billion off profit for each 10% decrease in dollar value (Naikal 2009) and pushed the necessary number of aircraft to sell to break even to 400. In 2007, Airbus presented its Power8 restructuring program, which enumerated $3 billion of necessary annual cutting cost to counter this fall of value. In addition to this, the program proposed cutting overhead costs by 30% and focused on 20% improvement in productivity without substantial laying off (Airbus 2007).

Initial eighteen-months postponement of A380 delay had an adverse impact not only on aircraft operators, but MRO (Maintenance, Repair and Overhaul) operators as well. Among them were Emirates, Air France Industries or Lufthansa Technik, most important MRO companies in European and Middle East area. The delay except being an inconvenience for flight schedules originally counting with the aircraft being in operation, affected growth strategies of airlines and Airbus as well. Estimated losses on operating profits from A380 program may have reached up to €500 million between years 2007 and 2010 (Naikal 2009). The delay was the primary motivation behind cancellation of Air India's order for 12 aircraft.

5.2 Related logistical issues

The size and unique arrangement of the aircraft created specific logistical problems for airports and operators of aviatic infrastructure. The customization of infrastructure included widening and prolonging of taxiways and runways (requiring 15m more than 747), creating extra gate space and application of dual boarding bridges. The double-deck layout requires multiple gates, so both decks can be reached for boarding. Often one A380 occupies up to four gates at time, two for each deck, to make the boarding process faster. These costly induced investments prevented smaller airports from handling A380, reducing the number of potential destinations for the aircraft. For the duration of A380 operation, the aircraft has been flying mostly between important international hubs, in accordance with hub-and-spoke distribution theory, for which the aircraft was created. Prior to A380 launch, London Heathrow airport spent £450 million to redevelop Terminal 3 (Elliott 2005), including £100 million construction of Pier 6, which can accommodate 4 A380 at the same time. New York's JFK invested $179 million, Moscow's Sheremetyevo airport reconstructed a runway for $114 million. Some smaller airports believed in A380 to be a radical change in the dynamics of aviation and hoped that A380-compliance will enable them to gain more routes and passengers. In 2005, San Bernardino Airport in Los Angeles area invested $37 million in reconstruction of runway to accommodate A380, despite having no scheduled passenger or cargo routes at the time. Since the FAA-paid-for investment, no A380 has landed at the airport (Corporation 2005).

5.3 Failure on the Chinese market

Only five aircraft have been delivered to a single Chinese customer – China Southern, with the first delivery taking place in 2011. At the time of A380 launch in the 00s, Chinese airlines did not have a great reputation, usually providing poor customer service and flying outdated aircraft and cabins. Thus, most of the international connections were provided by European and US airlines.

Airbus hoped for an early order from a Chinese customer, seeing the opening potential and growth of Chinese economy. Chinese airlines employing conservative strategies were not keen on ordering a completely new type of aircraft until it was proven by market introduction (Flottau 2021). The ideal launch customer would be Air China, based in Beijing, considered the country's flag carrier. Instead, Air China became one of few customers in the world which ordered Boeing 747-8, a direct competitor. This implies there was determination and interest in operating ultra-high-capacity aircraft and Air China preferred to stay with the type and manufacturer that it had experience with. Air China's motives might have been not be purely pragmatic, there is rumored a great amount of lobbying from the US and Boeing (Flottau 2021). Airbus either failed with Hong Kong based Cathay, which was at that time considered a role model for Air China in product quality and business strategy.

The only successful deal in China was with China Southern in 2011 for only 5 aircraft. Even this number appeared to be not optimal for the airline and too big. The original plan was to base the aircraft in Beijing instead on its base in Guangzhou, but the airline failed to negotiate a joint A380 operation with Air China (CAPA 2013). China Southern A380 now flies limited routes to Los Angeles, Sydney and Beijing from Guangzhou and plans retiring the aircraft in 2022 (Ch-Aviation 2022).

5.4 Secondary market possibilities

First indications of airlines considering selling the aircraft came around the year 2015, roughly 10 years after the introduction, when first leasing contracts started to expire. At that time, sales of A380 were still far behind Airbus's expectations, and with availability of second-hand units, future sales could potentially be weakened even more. Airbus was publicly optimistic about the outlook, stating that second-hand market of A380 is more attractive for customers looking to buy smaller aircraft, like Boeing 777, and that new and used A380 are not a competition (Rothman & Weiss 2015). In 2016, Malaysia Airlines did not find buyers for all of its six A380s, which they intended to replace with A350s and 787s. Instead, it came with a plan to establish a subsidiary carrier and convert the aircraft to high-capacity layout, with maximum of 712 passengers. These aircraft would be used for pilgrimage flights to and from the Middle East. For the rest of the year, Malaysia Airlines planned to charter the aircraft for tourism and calculated that such business model would be viable for the next 40 years, if the oil price does not rise substantially (Schlappig 2016). As of 2022, Malaysia Airlines has established the subsidiary, named AMAL, but did not convert any of the A380 for this purpose, and continued to try to sell its whole A380 fleet without success. AMAL is using A330-300s for pilgrimage flights instead, with 8500 pilgrims transported so far (Udol 2022).

Portuguese charter airline Hi Fly announced its interest to lease two used A380s for its subsidiary Hi Fly Malta in August 2017, with intended use in airports with limited slot availability and mass demand. It received its first A380 in 2018, a former aircraft of Singapore Airlines, with unaltered three-class configuration and total capacity of 471 passengers. The airline kept only one A380 and did not lease any more, despite its intentions. With the onset of COVID-19 pandemic and rapid drop in passenger numbers, Hi Fly converted the A380 into a freight carrier by removing most of the seats but, keeping the two-deck configuration and no additional cargo door. At the end of 2020, the airline announced that it will not extend the three-year long contract and will retire the aircraft (Boon 2020). The aircraft flew its final voyage on 17 December 2020 to Toulouse for scrapping.

At the time the largest lessor of A380, Amedeo, leasing 22 A380s mostly to Emirates, knew that there would not be much demand for the aircraft after 2022, when most of its leasing contracts expire. They hoped for a possible wet lease model (Schonland 2017), but the pandemic accelerated phasing out the model. The company now leases six A380s. Swiss aircraft trading company Sparfell & Partners planned to convert some of A380s owned by investment firm Dr. Peters, which leased A380s to Singaporean Airlines. The conversion, aimed for VIP or head-of-state transport, at the cost of under $300 million, would be cheaper than a new A330 or 777 manufactured for this purpose (Network 2018). In November 2018, Air France was planning on reducing its A380 fleet, with returning five aircraft to lessors and refurbish interiors of the other five by 2020. In July 2019, they instead decided on retiring the type completely by 2022 (Reld 2019). Ultimately, in January 2020, Air France announced immediate retirement of the aircraft, even before the start of COVID-19 pandemic in Europe, becoming the first operator to scrap the aircraft instead of selling it.

By the end of the 2010s, question of the residual value of a used A380 became very tough to answer. Owners of the type became progressively worried about the existence of a secondary market for the aircraft, and were thinking about scrapping the aircraft, though viability of it became questionable too. In 2018, teardown-specializing firms were not happy with the prices offered by the owners, ranging between $30 and $40 million, due to uncertainty and high risk of the market, and rather estimated that A380 at its half-life has a teardown value between $20 and $30 million (O'Callaghan 2019). Usually the most valuable part of an aircraft, the engines, do not keep the residual value higher, as A380 is the only type to use Rolls-Royce Trent 900. In 2018, Dr. Peters managed to make benefit of upcoming service intervals for many A380s and started its exit strategy for the type, cashing about $45 million for sale of the components alone (Peters 2018). As of June 2022, only 129 A380s were in active service, about a half of all produced units. 95 units are in storage due to demand decline during the COVID-19 pandemic and is hard to predict how many will return. 20 units, or 8% of the total production, have been retired in the last two years (Petchenik 2022). At this rate, we can expect the type to be completely retired at the beginning of the next decade. The low liquidity and sharp drops in residual value show no potential on the secondary market. The obsolescence and inconvenience of

A380 are a burden for airlines even after they stop operating the type. Airbus managed to create an aircraft that cannot find its use in any of existing markets.

6 Conclusion

There was not much attention paid to the aircraft industry on the economic field in the recent years. Studies on demand for aircraft are scarce and we have provided a necessary update with the latest trends included. Even though the manufacturers conduct their own research on demand and this is sometimes complemented with independent analyses, the findings are not guaranteed to be right and the real situation can differ immensely, as was proven with the A380 case. Econometric estimations on demand often cannot observe and predict events after the launch of an aircraft, but at least should take the possible shift of taste of consumers into consideration, what was seriously underestimated by Airbus. An amount of irrationality is included during a development, as aircraft have always been a source of national pride, and if accompanied with internal fights in corporate structure, the real requirements of the market are grossly overlooked. With our research we can confirm that the airlines do not value aircraft capacity more than the range, which is more convenient for the point-to-point strategy they are shifting to use. While the aircraft price is still the most important deciding factor, it becomes even more significant during periods of economic hardships, and the manufacturers must be all the more careful about pricing aircraft, as they are more likely to lose to the competition.

There are no clear strategies for a manufacturer to claim a larger market share. Both companies tried to acquire running programs from other manufacturers due to risk being smaller than developing a new model organically. In this case Airbus succeeded and was able to gain great technology for a relatively small price and introduce the brand into the regional segment. In reaction, Boeing's deal with Embraer did not go through and the company may have closed its door on the M&A market for a considerable time. Airbus's reaction on the Boeing 787 came in the last minute in the form of A350 XWB, which was able to secure some market and the medium-range segment is now not dominated by a single type. Action and reaction are an important element in the industry, but the manufacturers cannot expect success solely by mimicking the competitor's strategy. They resort to illegal measures (i.e. prohibited subsidies) to gain technological and market advantage, only to be than caught in a trade war with consequences extending beyond the limits of aircraft industry.

After the COVID-19 pandemic, the industry is in recovery and is expected to not stop growing. Future dynamics of the market may be changed by the upcoming deliveries of narrow-bodies capable of transatlantic flights (notably A321XLR and 737 MAX 7), what may cause slump in the wide-body segment. Along this, China was still not able to fully present its potential, but the approaching introduction of C919 may present a third competitor on the market, at least in some regions. The aircraft industry will be an interesting subject of study in the forthcoming years.

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