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ESTIMATION OF FUEL COST ECONOMY ON AN AIRLINE OPERATION BY REDISPATCH EN ROUTE

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Abstract. *Fuel represents the biggest operational cost of an airline. In order to optimize its use, companies have been searching for new methods to reduce fuel consumption. An efficient and simple method to be applied is the redispatch en route. This method is widely used, however, there is only a small number of studies relating to its use and impact. This research aims to estimate fuel economy when the redispatch method is implemented by an airline, by understanding how relevant its use is for a company. In addition, a review of studies related to the subject and documentary research, including the consultation of sources such as ANAC that regulates the redispatch in Brazil was undertaken. The result is shown to be similar to other operational methods. The research also takes into account factors such as aircraft payload and flight range, in order to understand how they impact the final result, helping the operator to develop a more efficient flight plan with the redispatch method. Ultimately, the redispatch method was proven to be a method that is capable of increasing fuel economy for an airline throughout the year. In addition, it can also be applied in a diverse number of routes and has more advantages for an airline beyond cost savings.*

Keywords: *fuel consumption, economy, redispatch, flight plan.*

1. INTRODUCTION

Aviation is a very dynamic market that has got its variable costs going through a lot of price fluctuations. According to Ates et al. (2017), fuel represents one of the highest operational costs of an airline and is one of the main challenges faced by them, requiring high adaptability skills. The International Air Transport Association (IATA, 2019) showed that from 2013 to 2019 the airlines member of the association had an average cost with fuel that represented almost 24% of their total costs. On the environmental side, as debated by Lovegren and Hansman (2011), airlines and governments seek ways to reduce fuel consumption due to concerns with the environment and consequently reducing pollution.

Fuel also depicts another challenge due to its high volatility, which makes it hard for airlines to plan their budgets forehand. However, the aviation market is very heterogenic around the world and some countries face more challenges in line with their financial, social and political situation. In Brazil, airlines are exposed to high fuel costs that are uneven around the country, as asserted by Fregnani et al. (2009), with very high taxes represented by two federal taxes that together corresponds to 3% of the fuel price and a state tax called ICMS that varies depending on the state the airline is purchasing the fuel from and it only applies to domestic flights. According to ABEAR (Brazilian Association of Airlines, 2019) this tax averaged 19% of the fuel price in 2018. Another problem is that most of airlines' costs are in U.S. Dollars. With the depreciation of the Brazilian Real front of the U.S. Dollar and volatility in the exchange rate, costs have had their value increased and are still unpredictable.

Methods to optimize fuel consumption and reduce costs become indeed essential for airlines in Brazil and worldwide. There are basically two different types of methods that can be applied to an aircraft focusing on fuel cost optimization: structural and operational. The structural focuses on aerodynamic efficiency improvement, like winglet installation, that can bring good results of about 5% reduction of fuel consumption, however, they are costly, difficult to be implemented and require additional certification. In the meantime, operational methods focus on the fact that, as defined by Jensen et al. (2013), aircraft performance varies with altitude, airspeed and weight to create a flight plan that optimizes these factors resulting on a lower consumption. These methods are easier to be implemented, are not as expensive and does not require additional certifications. According to Trincheiras (2016), a well implemented optimization plan can help reducing fuel cost from 2% to 5%, therefore being able to have similar results to the structural ones.

ATR (2011) and Airbus (2004) suggest different methods that can be used as operational methods namely cost index, fuel tankering and redispatch en route. This work main goal is to estimate the economy of fuel costs in an airline operation by using the redispatch en route method. Other specific goals are to understand the influence of other flight factors like payload and flight distance on the economy result and compare the economy potential between two aircraft models, focusing on the order of magnitude and percentage of the economy.

2. METHODOLOGY

When it comes to fuel supply, an airline needs to comply to its country's aviation authority. In Brazil, the Brazilian Regulation of Civil Aviation (RBAC) number 121 paragraph 645, issued by the National Agency of Civil Aviation (ANAC) lists the fuel requirements for an airline offering public transport of passengers for over 19 passengers and was followed in this work. According to the regulation (ANAC, 2020a), on a normal flight dispatch an aircraft must carry enough fuel for the planned flight, plus a reserve that is composed by enough fuel to fly to the furthest listed airport on the initial dispatch, plus 30 minutes in holding speed at 1,500 feet altitude, plus the equivalent to fly 10% of the total flight time, considering standard atmosphere conditions.

Flying with this amount of extra fuel is a challenge for airlines, mainly in long flights, as the reserve can represent an extra weight that increases consumption, fueling costs and even preclude the airline to carry a larger payload. For this reason, the same regulation allows airlines to use redispatch en route, where the contingency fuel, represented by the extra 10% of the total flight time, can be substituted by 10% of the total flight time between the initial airport and a point of redispatch, defined over an intermediate airport along the route. This way less contingency fuel is required, reducing fueling costs and making the aircraft lighter, which reduces consumption in flight. To use this method, operators need to follow the decision point procedure, as explained by ATR (2011) and exemplified on Fig. 1. When flying over the point of redispatch, which is the decision point, the fuel supply is checked and the aircraft must have the contingency fuel needed for the rest of the flight equivalent to 10% or more of the remaining flight time, otherwise the crew must divert to the intermediate airport.

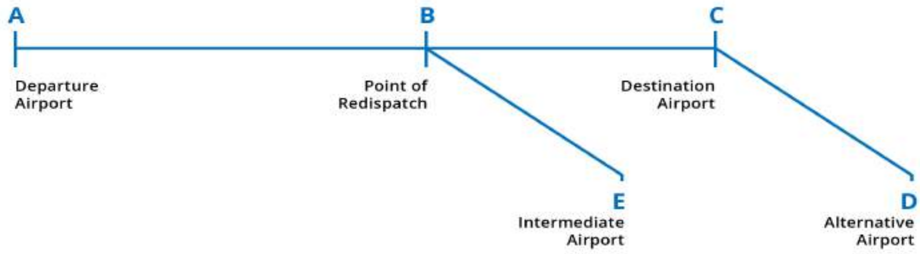

Figure 1. Decision point procedure for a flight with redispatch en route

Some simplifications were made to make the analysis possible: aircraft consumption data from public domains were used, as real data are usually restricted, wind was not considered and standard atmosphere conditions were assumed. Fuel prices given on SkyVector (2020) at different airports were used even though, as affirmed by Morrell (2007), airlines usually hedge fuel to protect themselves from volatility risks, but these prices are also most of the times not available publicly. The simplifications can make results differ from reality, but the discordance of results obtained and real ones will not affect the main goal of the work as it aims to estimate the order of magnitude and percentage of the economy.

2.1 Tools and data

FlightRadar24 (2020) was used to find flight data. It is an online flight tracking platform that gathers flight data from the ADS-B (automatic dependent surveillance-broadcast), a recent technology that allows positioning information received from the aircraft GPS and other data like speed and altitude to be sent from its transporder ADS-B to in land receptors that forwards them to the platform, showing this information in their platform and making it easier for data of commercial flights worldwide to be obtained.

The second tool used was SkyVector (2020), which is one of the biggest flight plan providers and allows the creation of flight plans, used in this work to sketch the flight plan of each chosen route, and it was also used to gather fuel prices in different airports.

Piano-X (Lissys, 2020) was used to calculate fuel consumption in each flight. The tool has a database of different aircraft models and their performance characteristics to determine, given an input of payload, distance, speed, flight levels and reserves, the total fuel consumption for each phase of a flight and emission of toxic gases. As seen before, finding data of aircraft consumption can be challenging, but Piano-X results are still assertive and it is used by big aviation companies such as Boeing, Rolls-Royce, Textron and Bombardier.

2.2 Primary analysis

For the primary goal of this present work, three routes involving airports in Brazil were chosen. The criteria used was to choose routes that are relevant for the Brazilian market, which have evident difference on fuel prices between airports and are probably suitable to the redispatch method. Thus, the routes chosen were:

- São Paulo (GRU) x Dubai (DXB) flown by Emirates with the A380-800, it is the main route to connect Brazil to Asia and fuel prices in DXB are much lower than in Brazil, which can result a high fuel economy.
- São Paulo (GRU) x Boston (BOS) flown by Latam Airlines with the B767-300ER, it is the only direct flight from Brazil to the city with the biggest Brazilian population in the USA.
- São Paulo (GRU) x Belém (BEL), the route is flown by different airlines, but for the analysis it was considered the B767-300ER used in some flights by Latam Airlines. It was chosen to understand the relevance of redispatch in domestic flights and to compare a short/medium-haul flight to the previous long-haul flights.

Having defined the routes for the primary analysis it is possible to move forward the analysis itself. Figure 2 shows the step-by-step guide followed.

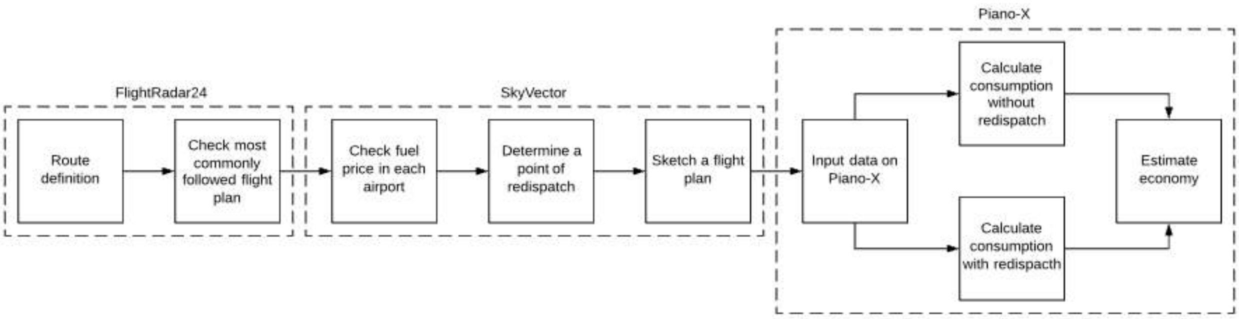

Figure 2. Step-by-step guide to estimate the economy with fuel economy using redispatch en route.

As demonstrated by Fig. 2, once the route is defined, the most commonly followed flight plan is checked by analyzing flights over a period of 20 days in the same route to find a trend, that will later on help to determine how the flight plan should be sketched. Once this flight plan is determined, prices of fuel in both airports are obtained on SkyVector (2020) to decide in which direction the redispatch should be applied. The initial point is always the airport with more expensive fuel, thus, in all the flights of the analysis this airport was GRU.

The next step is to determine a point of redispatch along the route. This point needs to be around an airport as close as possible to 50% of the route so it will bring the best results of economy, which can be difficult as some flights fly over the ocean or inhabited areas for a long time. It is also important to see if the airport around the point of redispatch is suitable to receive the aircraft, by checking if the pavement classification number (PCN) of the airport is higher than the aircraft classification number (ACN) for the runway pavement type and most critical weight condition for the aircraft. With this, it is possible to sketch a flight plan on SkyVector (2020) that will give the total range and distance to the point of redispatch, important to determine the amount of fuel that should be supplied as the contingency fuel. Fig. 3 shows the flight plan sketched for the GRU x DXB route, Fig. 4 for the GRU x BOS route and Fig. 5 for the GRU x BEL route. It can be noted that waypoints along the route were selected to shape the flight plan according to the most common one from FlightRadar24 (2020).

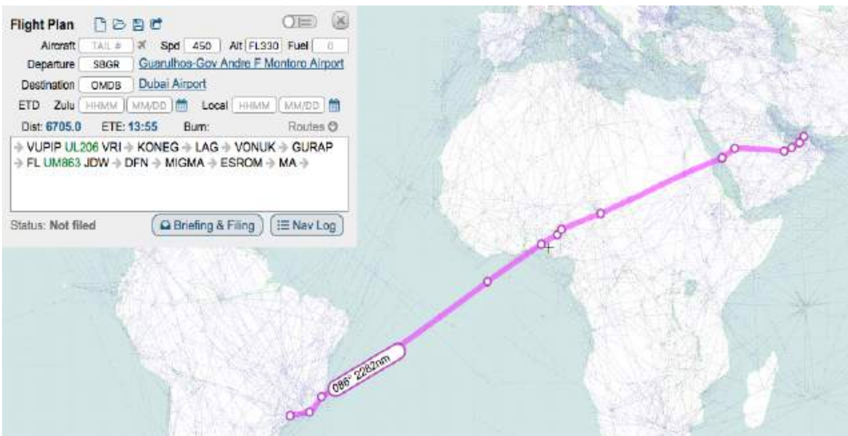

Figure 3. Sketch of GRU x DXB flight plan using SkyVector.

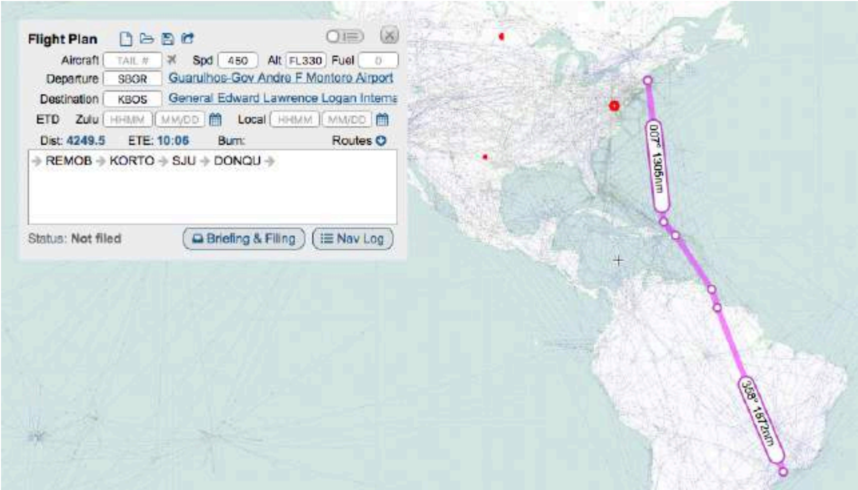

Figure 4. Sketch of GRU x BOS flight plan using SkyVector.

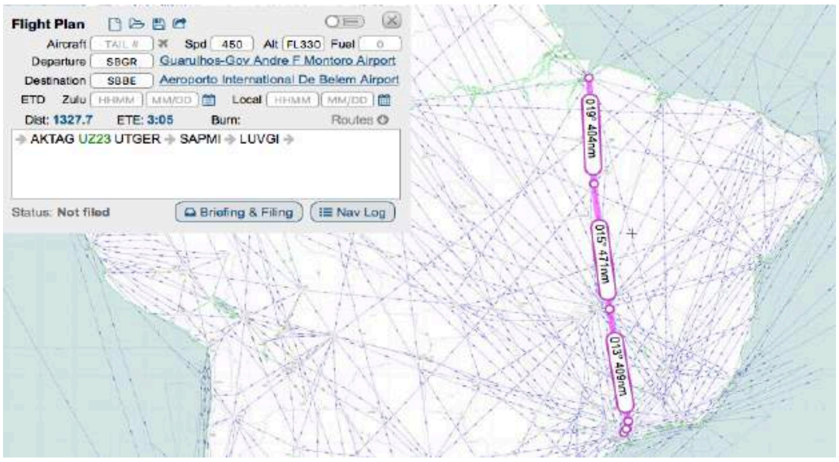

Figure 5. Sketch of GRU x BEL flight plan using SkyVector.

The following step is to input the gathered data into Piano-X. The tool provides basic design weight information for some aircrafts such as zero fuel weight and maximum take off weight. The database from ANAC (2020b) provides monthly occupation of flights regarding both passenger and cargo, so the payload was chosen as the average number of passengers and cargo per flight in 2019, assuming 80 kg per passenger plus 8 kg of luggage. Flight levels were taken from FlightRadar24 (2020) and all flights followed a step climb cruise, where the aircraft goes one level up along the cruise as it gets lighter with fuel burn to reduce consumption, as explained by Airbus (2004).

For cruise speed, Piano-X allows to choose between 4 options: a fixed Mach speed; “economy”, which is the maximum range cruise speed (MRC) providing the lowest fuel burn rate; “long range cruise” (LRC), which is the MRC with a decrease of 1% in terms of distance travelled per kilogram of fuel burned; “high speed”, which is the maximum speed for each cruise level and "max”, which is the maximum speed considering only one cruise level (Lissys, 2008). According to Roberson et al. (2007), the 1% range decrease of the MRC speed can result on a 3 to 5% higher speed, and as time also has a cost for airlines, the LRC is most commonly used and approximates more to the cost index usually followed by airlines, trading of range for a higher speed. Therefore, the long cruise is the speed used in all flights of this work.

The last information to be input is related to fuel reserve. The diversion distance is calculated on SkyVector (2020) as the distance to a diversion airport in the area, the holding time is set as 30 minutes and the contingency fuel as 10% for a flight without redispatch and a percentage according to the distance to the point of redispatch for the flight with redispatch. Finally, both cases can be calculated and the estimation of economy can be found by comparing both results. Table 1 summarizes the input data for each flight of the primary analysis.

Table 1. Input data on Piano-X for fuel consumption calculation.

Input Data	GRU x DXB	GRU x BOS	GRU x BEL
Payload (kg)	51,768	28,729	19,193
Range (km)	12,417	7,871	2,459
Flight Levels	350, 370, 390	340, 360, 380	340, 360
Cruise Speed	Long range	Long range	Long range
Diversion Distance (km)	185	370	518
Contingency Fuel without redispatch/with redispatch	10%/5.2%	10%/6.5%	10%/6.2%
Point of redispatch location	Lagos (LOS)	San Juan (SJU)	Palmas (PMW)

2.3 Secondary analysis

The redispatch method can be used in any type of flight, regardless of flight factor such as range and payload. However, there is a risk involved in its operation, which is having to divert to an intermediate airport in case the fuel supply is under its minimum required when flying over the point of redispatch. In order to help airlines to perceive better which flights can bring higher results, help planning them more efficiently and understand for which ones it is more interesting taking the risk, the secondary analysis was made to study the influence of these flight factors on the economy result. The procedure for this analysis is to redo the calculations for both B767-300ER and A380-800. First it was done for different values of flight distance keeping payload, flight levels and reserve configurations for GRU x BOS and GRU x DXB flights, respectively. Later on it was done for different values of payload keeping each flight distance and respective flight configuration.

Another analysis was also undertaken to compare results of two different aircraft models on a same route. Some airlines have been replacing old models of wide-bodies aircrafts for newer and more efficient models. Based on this, the fuel economy for the GRU x BOS and GRU x DXB routes were also calculated with the B787-800 using the same previous configurations, but with payload corresponding to the occupation the flight, that means, if the payload on the GRU x BOS primary analysis with the B767-300ER corresponded to 80% of its maximum payload, it will be used a payload that refers to 80% of the B787-800 maximum payload.

3. RESULTS

The results for the primary analysis are presented on Table 2. It also shown the estimation of economy for each route within a year, considering fuel prices from February 2020, with a more optimistic scenario where 90% of the flights could follow the method and a less optimistic one, with 30% of the flights.

Table 2. Main results from the primary analysis.

Flight	Economy on fuel burned during flight	Economy on reserve fuel	Total fueling cost economy	Estimation of fuel cost economy in a year, 90% of the flights scenario (USD)	Estimation of fuel cost economy in a year, 30% of the flights scenario (USD)
GRU x DXB	1,78%	29,27%	4,89%	4,253,400	1,417,800
GRU x BOS	0,95%	16,09%	3,23%	454,680	151,560
GRU x BEL	0,26%	7,59%	2,51%	226,337	75,446

Based on Tab. 2, it becomes clear the relevance of the method, even on a less optimistic scenario. The economy of fuel costs was indeed between 2% and 5%, confirming the assumption of Trincheiras (2016). Regarding the influence of flight distance in the final result, it becomes clear that as the longer the range, the higher the economy, which got confirmed by the secondary analysis and shown in the Figure 6 for the B767-300ER and in the Figure 7 for the A380-800.

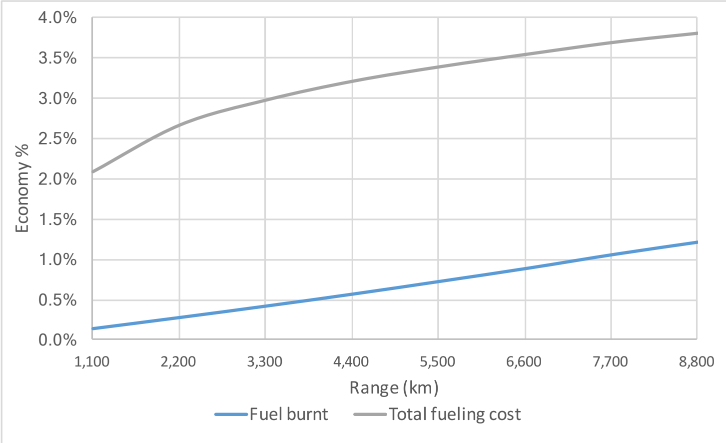

Figure 6. Influence of flight range in the economy percentage for the B767-300ER.

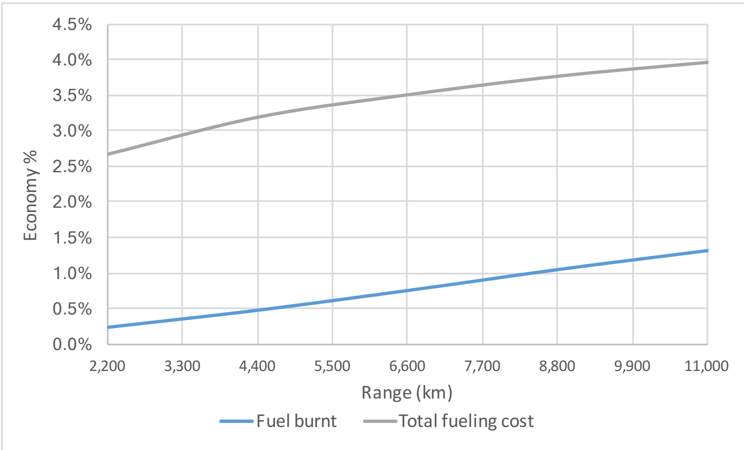

Figure 7. Influence of flight range in the economy percentage for the A380-800.

It is also noticeable that until around 2,200 km for the B767-300ER and 4,000 km for the A380-800 the curve has a higher growth rate of fueling cost economy. Thus it can be assumed that the economy in shorter flights is more sensitive to the increase of flight range. However, the economy percentage showed not to be very sensitive to different payloads, as shown in the Figure 8 for the B767-300ER and Figure 9 for the A380-800.

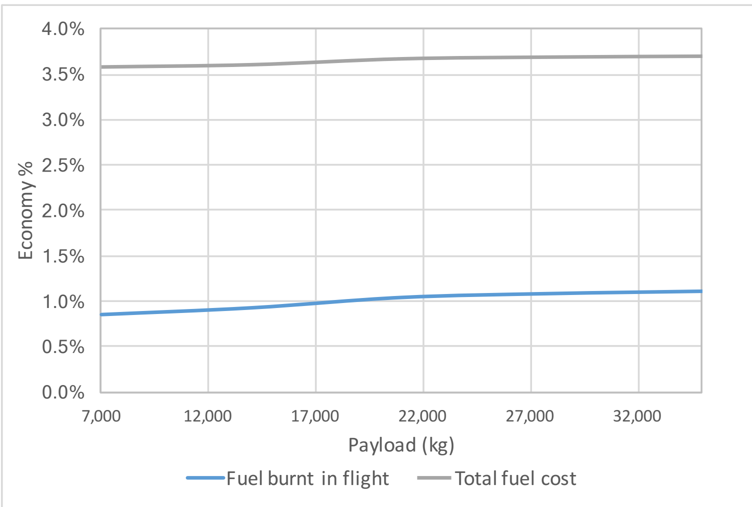

Figure 8. Influence of payload in the economy percentage for the B767-300ER.

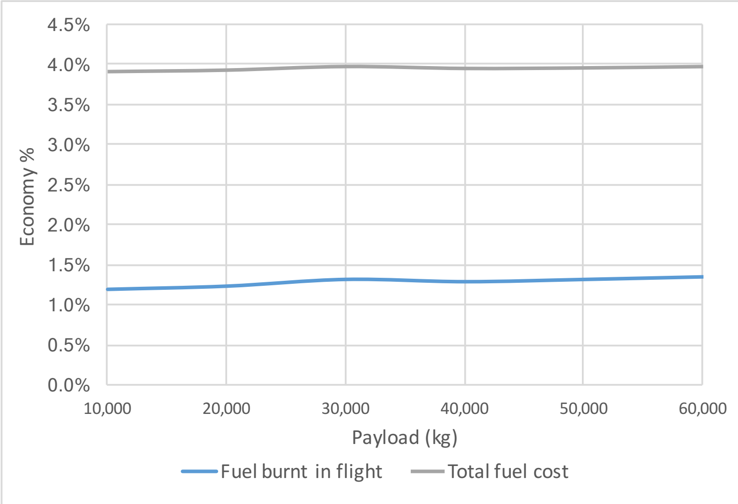

Figure 9. Influence of payload in the economy percentage for the A380-800.

The highest economy increase was of only 0.3% throughout all the different payloads, keeping constant during most of the analysis. Thus, even though the absolute result of economy will be higher with a bigger payload, as a heavier aircraft will have to carry a larger supply of fuel, the percentage of the economy itself will not be affected, as it did with different flight ranges. Regarding the comparison between aircraft models, the B787-800 showed to have achieved subtly higher results of fuel cost economy. Table 3 shows the results from the primary analysis compared to the economy results from the secondary analysis with the B787-800 on each route.

Table 3. Results from the comparison between aircraft models.

Flight	Total fueling cost economy in the primary analysis	Fuel cost per passenger the primary analysis (USD/pax)	Total fueling cost economy in the secondary analysis with the B787-800	Fuel Cost per passenger in the secondary analysis (USD/pax)
GRU x DXB	4.89%	591.42	5.71%	404.21
GRU x BOS	3.23%	291.75	3.58%	263.32
GRU x BEL	2.51%	145.55	2.72%	131.36

The B787-800 showed not only to achieve higher results of economy while using the redispatch method, but also considerably reduced the estimated fuel cost per passenger.

4. CONCLUSION

In this paper it was estimated the redispatch in flight method can bring an economy of between 2% to 5% in fuel costs, confirming the assumption that, if well implemented, it can bring relevant economy results for an airline operation. The importance of studying some flight factors in order to bring better results and understanding the risks involved was also highlighted in this paper. It was then shown that the flight range is the most important aspect to be analyzed before deciding if the method should be used. It was also proven that longer flights can bring higher results while payload does not affect the percentage of the economy result, thus it is not an important aspect for the planning of the method. Finally, it was proven that more modern aircraft can indeed bring higher results of fuel economy, not just by being more efficient themselves, but also when linked to an operational method of fuel optimization.

For future works it is recommended to strike to use real consumption and fuel prices data from airlines to bring even more precise numbers of total economy. It is also recommended to realize the analysis with another method such as fuel tankering, which can together bring more relevant results of economy as they can complement each other. This study can be used by airlines to help choosing the most suitable flight plan and aircraft model for each route and also for aircraft manufacturers on sales support, comparing their aircraft performance with the method to its competitors for potential clients.

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