The Cost Impact of EU ‘Fit For 55’ Measures on Passenger Route Levels and Their Effect on Air Travel Demand

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1 Introduction

The European Union’s „Fit for 55” package aims at reducing CO_2-emissions by 55% until 2030 compared to the baseline emissions from 1990. This reduction is sought by a bundle of measures, out of which several affect commercial aviation. This includes a tightening of the EU Emission Trading System (EU ETS), a mandatory blending quota for sustainable aviation fuels (SAF) on European airports, and a minimum taxation on energy (Energy Taxation Directive, ETD).

In this study, we consider the impact of these measures in two ways. First, we provide an in-depth analysis of the price increase which is to be expected in the coming decades. We compare price increases for different geographic domains and, for long distance travel, for transfer at hubs inside and outside Europe. Second, we derive demand elasticities on route level from a discrete choice model. Given these elasticities, we analyse the impact of the measures on passenger demand. This impact is two-fold: On the one hand, the overall number of passengers will grow slower than it would have if no price increases occurred. From an environmental perspective, this is – besides incentivising airlines to reduce fuel consumption – a desired impact of the measures. On the other hand, asymmetric price increases may occur in cases in which different travel routes are asymmetrically impacted by the ’Fit for 55’ measure. In this case, passengers may prefer a route which avoids European airports, leading to so-called Carbon Leakage. Using cross-price elasticities, we analyse the extent to which this will be the case.

This paper is structured as follows. We begin with a review on the ’Fit for 55’ measures and necessary assumption related to them. Next, we describe the model used to calculate the changes in passenger demand. In Section 3 we describe the costs occurring on various routes, and Section 4 analyses the impact on passenger demand.

2 Research Design, Methodology & Assumptions

2.1 Increase in Average Fares

To conduct a route-specific analysis of the cost and demand changes, it is essential to have a comprehensive understanding of the various factors influencing the 'Fit for 55' measures, both broadly and in detail. Therefore, analysing the additional costs to be expected in the coming decades as a result of the 'Fit for 55' measures requires thorough assumptions about the development of the individual regulations. The calculations presented in this article essentially assume that the regulations planned by the EU will be realised in their currently planned form. This will be detailed below. An overview of the inflation-adjusted costs of the individual instruments is shown in Table 1. All of these instruments are subject to more or less active discussions. We will discuss recent developments and their potential impact on results in Section 5.

It is planned to make the blending of sustainable aviation fuels (SAF) mandatory at major European airports [4]. In order to take account of the foreseeably low availability of SAF, the obligation starts with a quota of 2% in 2025, which then increases to 5% in 2030, 20% in 2035 and up to 63% in 2050. Within this study, we assume that the price of SAF will rise until 2035 due to increased demand, only to fall again slightly thereafter due to economies of scale and the learning curve in production. When estimating the costs arising from the addition of SAF, it should be noted that these are largely dependent on the price difference between SAF and conventional fuel. We have assumed a kerosene price of €0.50 per litre, which corresponds to the average of the last 10 years, but is relatively low compared to the current price.

Table 1: Overview of the assumptions used throughout this article

Year	SAF quota	SAF price [€/l]	EU ETS [€/T]	Corsia [€/T]	ETD
2025	2%	€1.49	€80.00	€26.50	€0.07
2030	5%	€1.66	€100.00	€33.00	€0.20
2035	20%	€1.70	€133.00	€40.00	€0.26
2040	32%	€1.49	€166.00	€60.00	€0.23
2045	38%	€1.38	€183.00	€80.00	€0.20
2050	63%	€1.26	€200.00	€100.00	€0.18

The prices assumed here for SAF are in the lower average of other assumptions [23], and refer to a mix of different types of SAF (HEFA, PtL). Furthermore, we assume in our calculations that the blending quota will also apply in the countries of the European Economic Area (EEA), Switzerland and the UK.

In its "IATA Fly Net Zero" initiative, the International Air Transport Association (IATA) forecasts a similar development in blending rates [16]. This would enable a level playing field between European and non-European airlines with respect to this instrument. However, IATA insists that the new fuels must be price-competitive with existing fuels. As this condition does not appear realistic from today's perspective and no binding minimum blending quota is set, the initiative is not taken into account in our study when calculating possible additional costs.

In European Union Emissions Trading System (EU ETS), aircraft operators must submit certificates for CO_2 emissions generated on flights within the European Economic Area (EEA). In this study, we use the version as given in [8]. Therefore, flights to outermost regions of the EU are exempt from this requirement [3]. Currently, airlines receive a significant proportion of allowances free of charge (free allowances). However, the proportion of these free allowances is to be reduced to 0 by 2027 [10] which will significantly increase the costs incurred by the ETS in the next years. Similar systems exist in the United Kingdom and Switzerland. The intention is to link these systems with each other [11].

The expected price development for the EU ETS is given Table 1. It is difficult to forecast due to the interdependence with other sectors. Nevertheless, the figures used in our study are in line with the average of other values from the literature (cf. [27]).

The third instrument of the Fit for 55 measures is a minimum tax on energy in the EU (Energy Taxation Directive – ETD). This rises to a value of €0.37 per litre of conventional aviation fuel in 2033, with reduced rates due on SAF depending on the type of production [9]. Currently, it is unclear when and how this instrument will be implemented. However, it is integrated in this study to guarantee a precise and complete set of assumptions of 'Fit for 55' measures at a specific point in time.

The costs of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) were taken into account in our calculations for flights outside Europe. This system, initiated by the ICAO, aims to achieve CO_2 -neutral growth in aviation by requiring the submission of certificates for emissions that exceed the level of 2019. The certificates are intended to guarantee that the CO_2 emitted has been saved in other projects.

In order to estimate the additional costs incurred when travelling by air, the costs for a single flight were determined initially. For the sake of simplicity, it was assumed that transporting a passenger consumes an average of 3.4 litres per 100 km. In order to reflect inefficiencies in flight routing and increased consumption during take-off and landing, it was assumed that the distance travelled is 95 km greater than the great circle distance between take-off and destination [7]. The consumption figures calculated in this way correspond to average consumption figures, but the actual figures are varying by airlines and deviate from this. For example, RyanAir states an average consumption of 2.6 litres per passenger and 100 kilometres for 2019 [24] while Lufthansa reported 3.67 litres [20]. The reasons for this include different seating arrangements, higher per capita consumption in Business Class and different aircraft load factors.

Several additional assumptions have been done for his study. First, when calculating the increase in average ticket prices, we assumed a 100% pass-through-rate. Although this must not necessarily be the case in the short run and on highly competitive market segments, it is a reasonable assumption for the overall market [1].

Second, in order to take account of further technical developments in aviation, our calculations assume a 1.5% increase in fuel efficiency per annum. Finally, for some cost calculations, prices for 2019 had to be converted between euros and US dollars. Here, we have used an average exchange rate of 1.1.

2.2 Literature Review on Demand Elasticities

Based on the modelled increase in cost due to 'Fit for 55' measures, the following section describes the approach to model the impact on demand and route-specific passenger volumes.

Several studies have analysed the impact of cost and price changes on demand raised by different political measures to reduce the climate impact of flights. Both scenario-based approaches ([5]) and the implementation of demand elasticities ([25]) are used to model the impact of changes in costs due to the EU ETS. However, in our study we study the impact of a set of different measures including EU ETS. Existing studies on the impact of the 'Fit for 55' package model the elasticity of demand. SEO [26] calculates a reduction of 11.6% in global demand compared to the reference scenario with an average cost increase of €65 for flights within the EEA and €105 for flights to destinations outside the EEA. Oxera [22], on the other hand, models a decline in demand of 5 % in 2030 and 6 % in 2050 for European airports with a price increase of 11 % and 13 % respectively compared to a reference scenario.

2.3 Implementing Demand Elasticities

The price elasticity of demand indicates the relative change in demand when the price of the good changes. Values between 0 and -1 indicate inelastic demand (the percentage of reduction in demand is lower than the percentage of price increase), while values between -1 and -2 indicate elastic demand (demand reacts more sensitive than the price change). Numerous studies exist on quantifying the price elasticity of demand in air transport, although these are generally based on individual geographical and economic sections. Gillen et al. [14] and Brons et al. [2] carried out meta-studies and were able to identify average values between -1.1 and -1.3, with larger deviations depending on distance and segmentation into, for example, business and leisure travellers.

The sensitivity of demand and, thus, the value of elasticity varies greatly depending on the geographical region, the distance, the absolute ticket price, market-specific variables, competitive pressure within the market, market segmentation and other factors. The aggregation level of the price increase plays a particularly important role. For instance, regulatory instruments may result in more general and far-reaching price increases and, therefore, a higher level of aggregation is considered. If the ticket prices of all routes are increased - due to newly introduced taxes, for example - there are fewer attractive substitutes for passengers and the probability that a passenger will choose a different route or airline is lower. Therefore, the demand is less elastic, which means that the price elasticity of demand is closer to zero.

While the direct elasticity indicates the change in demand when the price of the specific good changes, the cross-price elasticity defines the change in demand when the price of another substitute good changes on the same market. Aggregate elasticity refers to the change in demand with a simultaneous change in the price of both routes. Aggregate elasticity is therefore a coupling of direct elasticity and cross-price elasticity.

Thus, it is absolutely necessary to use an aggregated elasticity to calculate the effects of the 'Fit for 55' measures. In the above-mentioned studies on the effects of the 'Fit for 55' instruments, uniform global price elasticities are assumed (-0.63 in [22] and -1.11 [25]). These are based on various sources ([18] [13], [6], [15]).

2.4 Discrete Choice Model

In the following the term origin-destination market (OD market) or simply referred to as market represents all connections between the same origin and destination airports, for example all connections between Hamburg and Bangkok airport. Individual routes within the market differ according to the airline offering them or by possible transfer airports (route 1 via Frankfurt: HAM-FRA-BKK, route 2 via Helsinki: HAM-HEL-BKK).

A discrete choice model is used to define the elasticity of the market share for an individual passenger route compared to all routes on the same market. The model determines the probability that a passenger will choose a particular route from a set of possible routes on a market. The decision is made dependent on the parameters of the routes, which also include the ticket price. Therefore, the elasticity of the market share is the change in the probability that a passenger will choose a route on the market when the ticket price changes [12]. Kölker et. al [19] calculate a global elasticity of market share of -0.2 with geographical differences between -0.18 to -0.46 (see Table 2).

2.5 Implementation

The numerous factors influencing the level of additional costs from ‘Fit for 55’ measures vary for different routes in the same market. Hence, the resulting price increases vary depending on the route and market specific characteristics. In order to take this effect into account, we consider a different change in demand for each route. This change depends not only on the relative change in the ticket price Δp_r for the specific route (direct elasticity), but also on the change in the price of all other substitution routes Δp_s (cross-price elasticity).

Sufficiently detailed studies on the calculations for cross-price elasticities are not known. Therefore, the following model distinguishes between passengers who do not fly at all due to the price increase (‘no flight’) and passengers who choose a different route within the same market due to the price increase (‘demand shift’ due to ‘spill and recapture’). Both changes taken together result in the route-specific change in demand.

Table 2: Assumption about elasticity values, η values indicate base values, multipliers are multiplied by the base values (InterVista, 2007), elasticities of the market share are added [20]

$\eta_{NoFlight}$ (Base value, global level)	η_{Direct} (Base value, market level)	Multiplier short-haul	Geographical multiplier	Elasticity of market share
-0.6	-1.4	1.1	0.6 - 1.4	-0.18 to -0.48

	Global	Europe	Asia	North America	Asia ↔ North America	Asia ↔ Europe	Europe ↔ North America
Multiplier (geographical)	1	1.4	0.95	1	0.6	0.9	1.2
Elasticity of market share	-0.19	-0.19	-0.18	-0.25	-0.35	-0.28	-0.29

	Europe ↔ Africa	Europe ↔ Caribbean	Europe ↔ Middle East	Europe ↔ Oceania	Europe ↔ South America	Europe ↔ Central America
Elasticity of market share	-0.30	-0.31	-0.30	-0.41	-0.47	-0.48

To model the change in demand for every route the following approach has been implemented. Firstly, the sensitivity of the shift in demand is modelled. This corresponds to the passenger's willingness to choose a different route within the market. Second, based on the remaining number of passengers, the number of passengers who do not fly is calculated. The aggregate elasticity that occurs in the event of a global price increase is used for this. A base value of -0.6 is assumed here, whereby geographical and distance-specific multipliers vary this value resulting in values between -0.36 and -0.84 depending on the route [18].

To calculate the elasticity of demand shift, the elasticities of the market shares must be added to the elasticities at market level [21]. To do so, the elasticity at market level with the base value of -1.4 is reduced by the elasticity of non-flying passengers, then adjusted with the respective geographical multipliers [18] and the elasticity of the market share is added. Hence, values between -0.82 and -

1.31 are assumed for the elasticity of the shift in demand depending on the route. For the Hamburg-Bangkok route, for example, the following value is assumed:

$$\eta_{DemandShift} = \left(-1{,}4 - (-0{,}6)\right) \cdot 0{,}9 - 0{,}28 = -1{,}0$$

To calculate the change in future demand following a change in the ticket price due to 'Fit for 55' measure, the forecasted passenger numbers d_r for each route r and the expected relative changes in the ticket price presented in the previous section are taken as a basis. The absolute change in demand $\widehat{d_r}$ for a route r is given by:

$$\widehat{d_r} = \eta_{NoFlight} \cdot \Delta p_r \cdot d_r + \eta_{DemandShift} \cdot \Delta p_r \cdot d_r - \eta_{DemandShift} \cdot \sum_{s \neq r} \frac{d_r}{\sum_{t \neq s} d_t} \Delta p_s d_s$$

This is divided into the passengers who do not fly at all (first term), the 'spill' passengers who switch to other routes (second term of the equation), and the 'recapture' passengers who switch from other routes s to the route r (third term). The latter is weighted by the size of the destination route.

2.6 Model Discussion

In the following, further noteworthy aspects, assumptions and limitations of the model will be analysed in more detail and discussed.

2.6.1 Return Flights and Asymmetrical Travel Routes

The model assumes that a passenger always books or travels on a return journey at the same time. As the additional costs for the routes in the two directions may be different, the price increases for both routes are considered and added to the total ticket price. In the study, it is assumed that a passenger chooses the same route for both directions.

2.6.2 Assumption Regarding the Elasticity Values

A base value of 0.6 from the study by [18] is assumed the elasticity for passengers who decide not to fly in the event of a price increase. This is sufficient for the definition of a scenario, but it should be stated that the value may be outdated due to a lack of more recent data. Furthermore, in the InterVISTAS study [18] higher elasticities are calculated from other models, which are not used to assume a global elasticity due to a lack of significance.

In addition, the elasticities used here were collected empirically across a wide price range and all passenger segments and, therefore, represent average values. However, elasticity values refer to just one point on the demand curve.

2.6.3 Discrete Choice Model

A discrete choice model is used to calculate the elasticity of the market share. Due to the complexity of the data, a multinomial logit model (MNL) is used, in which the probability that a passenger chooses a particular route is independent of other alternatives (independence of irrelevant alternatives). This property can lead to an underestimation of elasticity, as the attractiveness of possible new routes is underestimated from the passengers' point of view. However, due to the static nature of the airline networks, this effect is less important in our study.

2.6.4 Attractiveness and Competition Between the Routes

Passengers who choose a different route due to a ticket price increase (spill passengers) are distributed to the other routes according to the size of the destination routes. This has the effect that routes with more passengers also attract more passengers from other routes (recapture passengers). Thus, it reflects the fact that such routes are more attractive without directly measuring their attractiveness. However, this neglects the aspect that there are routes that are more likely to be substituted against each other, for example if these routes are offered by airlines participating in the same frequent flyer program. Due to the complexity of the study and the fact that it is a global model, this aspect was not considered.

2.6.5 Substitutes in Other Markets, Airport Selection

In reality, it is quite common for passengers to change markets or airports, meaning that passengers choose a different origin airport and/or a different destination airport, possibly even in a different country. This is particularly the case for journeys by more flexible tourists or leisure travelers. In this model, it is assumed that the market is a closed system. Because the change in demand within the market is primarily analysed here, any other sufficient modelling at the aggregation level of this study is not feasible and also not necessary.,.

2.6.6 Capacity

Furthermore, no airport or aircraft capacity restrictions are taken into account. It is assumed that the capacity is sufficient to accommodate passengers from other routes or that the airline can create the possibility of transporting these additional passengers by changing its services. Accordingly, no network effects within an airline's network are considered, as these differ significantly depending on the location and airline.

3 Results Regarding Fare Increases

In this section, we discuss the development of average additional costs over time in various markets. The data only refers to one direction of travel in each case.

We assume that the airlines pass on the resulting additional costs in full to the passengers. Based on the previous average ticket prices in the market segment, we thus calculate the percentage price increase as a result of the additional costs. It should be noted that the average price increase is stated here. How airlines pass on these costs, e.g. differentiating between economy and business class, is a business decision of the respective airline and cannot be modeled here

3.1 German Domestic Connections

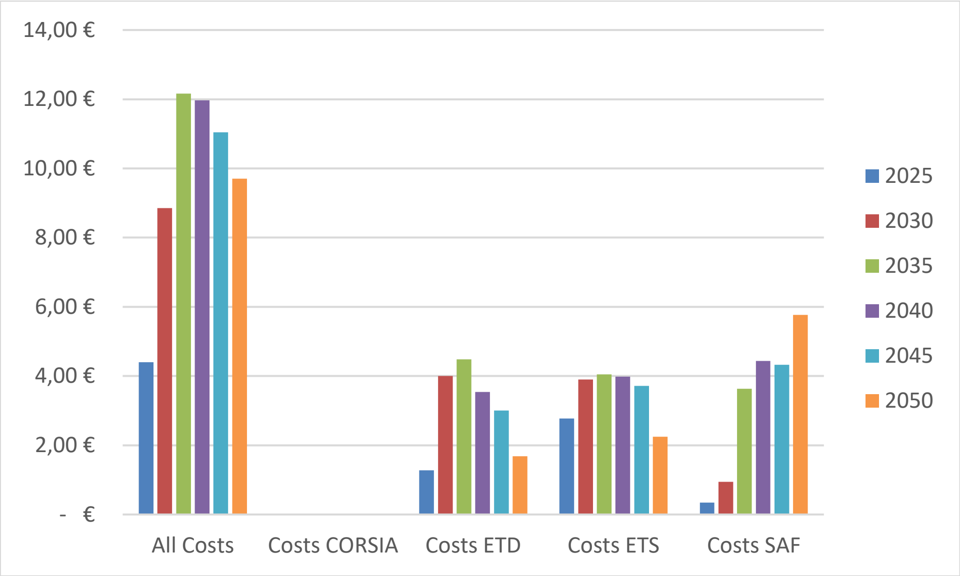

Figure 1: Additional costs on domestic German Flights

Figure 1 shows the additional costs on domestic German flights. Starting at €4.40 in 2025, the total costs of the regulatory instruments analysed rise to €12.16 in 2035 and then fall again. Assuming that the airlines pass these costs on in full to passengers, this corresponds to a maximum price increase of 6.8% in 2035. To be able to understand this trend, the individual components of the regulatory costs were also specified. In 2030, no more free certificates will be issued for EU emissions trading. In addition, the energy tax will reach significant levels, resulting in significant additional costs. The blending quota for SAF increases from 5% in 2030 to 20% in 2035, which will then lead to a further price increase. The costs for SAF blending will continue to rise in the further course of time, but we assume that prices for sustainable aviation fuels will fall during this period. As lower taxes are due on these and these are not taken into account in emissions trading, the total costs of the regulatory instruments fall again.

Corsia plays no role in these market segments, as the emissions are covered by the EU ETS.

3.2 Transport between Germany and other EU countries

The next market segment is consisting of all travel routes between Germany and other EU countries, e.g. Hamburg - Frankfurt - Rome.

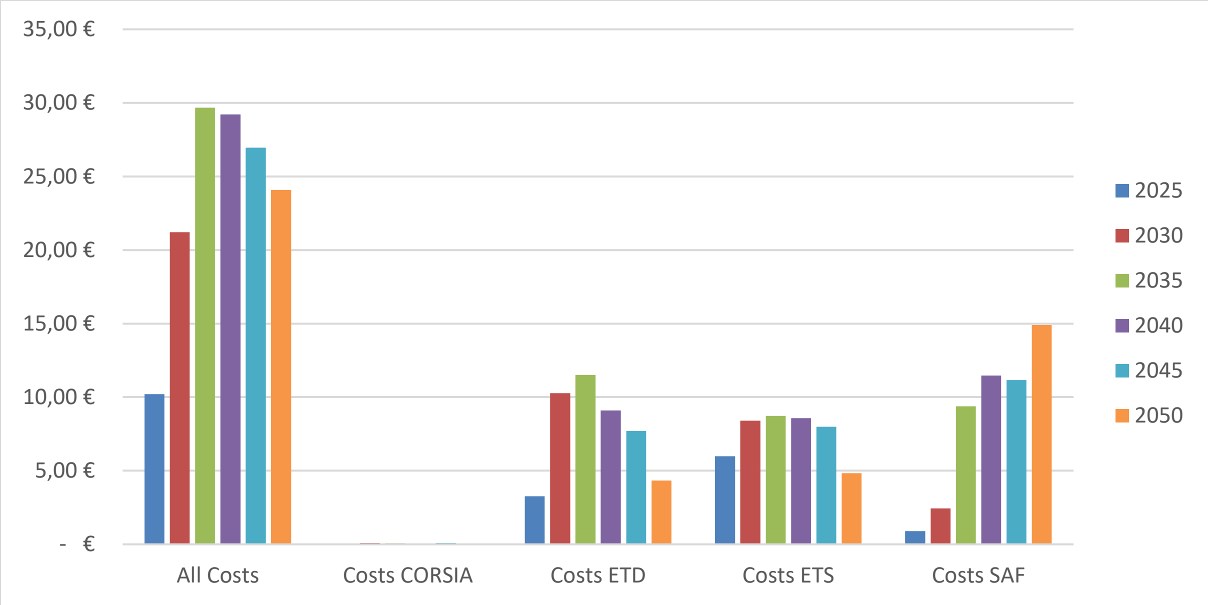

Figure 2: Additional costs when travelling between Germany and other EU countries

As the distances travelled are longer than for domestic German journeys, fuel consumption and consequently the costs incurred by the 'Fit for 55' measures are also higher. This is shown in Figure 2. The additional costs here reach over €29.70 in 2035, which corresponds to a cost increase of 21%. This high relative increase - compared to domestic German travel - is partly due to the higher absolute additional costs, but also to the lower price level on intra-European flights. This is due to various reasons, such as the different market structure - more holidaymakers and fewer business travellers - but also to the 19% VAT, which is only levied on domestic German traffic.

The distribution of costs over time between the various instruments is very similar to the distribution on domestic routes, as the same instruments are applied for all routes (with the exception of the EU ETS).

3.3 Touristic Traffic Between Germany and Spain, Greece and Turkey

In the next analysis, we look at transport between Germany and three popular holiday destinations: Spain (ES), Greece (GR) and Turkey (TR). Here we see clear differences in the areas of application of the individual instruments, and consequently also in the costs incurred.

The energy tax and additional costs for blending SAF are incurred when travelling between Germany and Spain as well as Germany and Greece. This results in similar time trends in the costs incurred for these two instruments, and also similar absolute costs due to the similar distances. There are clear differences in the costs caused by EU emissions trading, which are significantly lower for journeys between Germany and Spain. This is due to exemptions, particularly for the Canary Islands. Overall, prices for travelling to and from Greece and Spain will rise by just under 30% in 2035, after which the additional costs will fall slightly.

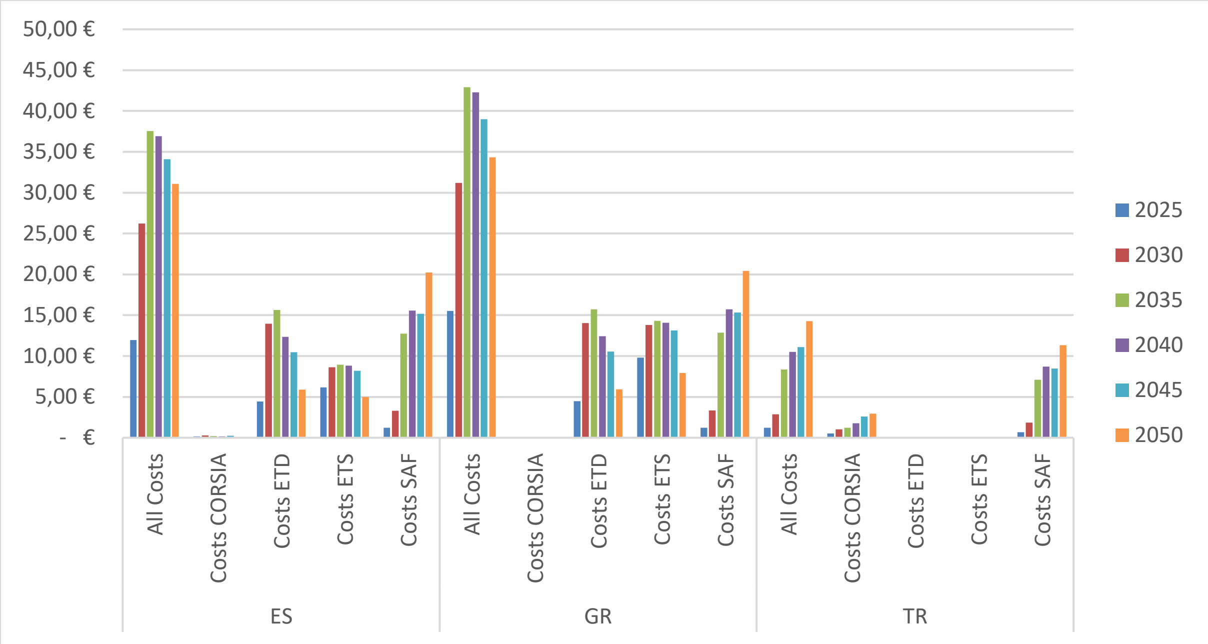

Figure 3: Additional costs when travelling between Germany and Spain/Greece/Turkey

The additional costs for journeys between Germany and Turkey are significantly lower, as neither the EU ETS nor the energy tax are due here. The addition of SAF only leads to increased costs in one direction of travel. This is only compensated for to a small extent by CORSIA. The different effects of the 'Fit for 55' instruments are also visible over time: as the additional costs due to the blending quota of SAF are particularly relevant for trips to Turkey, the costs here will continue to rise after 2035.

3.4 Germany - Asia, South and East Africa

This section analyses routes with long journeys from Germany to the South and East, more specifically to South and East Africa and Asia beyond the Middle East and the Gulf region.

In contrast to the examples discussed above, many passengers travel to these destinations on connecting flights. As the costs of the 'Fit for 55' instruments are incurred on individual travel segments, the costs vary depending on the route. For example, different costs would be incurred on a Hamburg - Frankfurt - Bangkok (HAM-FRA-BKK) journey compared to the Hamburg - Dubai - Bangkok (HAM-DXB-BKK) route. This is shown in detail in Table 3.

Table 3: Illustration of the individual cost components for two different travel routes from Hamburg to Bangkok and back in 2030

	Hamburg-Frankfurt-Bangkok and return				**Hamburg-Dubai-Bangkok and return**			
	HAM-FRA	FRA-BKK	BKK-FRA	FRA-HAM	HAM-DXB	DXB-BKK	BKK-DXB	DXB-HAM
Corsia	€-	€3.65	€3.65	€-	€2.00	€2.51 €	€2.51	€2.50
ETD	€3.66	€-	€-	€3.66	€-	€-	€-	€-
ETS	€3.56	€-	€-	€3.56	€-	€-	€-	€-
SAF blend	€0.86	€15.23	€-	€0.86	€8.36	€-	€-	€-
Total	€8.08	€18.88	3.65 €	€8.08	€10.36 €	€2.51	€2,51	€2,50

Total amount	€38.69	€17.88

On the route via Frankfurt, the feeder flights between Hamburg and Frankfurt incur costs for the energy tax (ETD), the EU ETS and the addition of SAF. On the long-haul flight FRA-BKK, refuelling must take place in Frankfurt on the outward leg, which is why costs are incurred for the addition of SAF.

For connections via Dubai, certificates for CORSIA must be purchased on all segments. In addition, there are costs for an SAF add-on on the outbound flight from Hamburg to Dubai. The total cost for the connection via Frankfurt is €38.69. Tickets for this route cost an average of €585 in 2019, which corresponds to an increase of 6.6%. For the connection via Dubai, the cost is €17.88, which corresponds to an increase of 4.3% with average ticket prices of €418. Depending on the level, such price differences can potentially lead to a partial shift in passenger flows. We analyse the extent of this shift section 4.

Figure 4 shows the price differences for journeys, broken down by route, instrument and year. The travel routes were summarised as direct connections, transfer connections where the transfer point is within the EU and other transfer connections.

In contrast to the previous considerations, the costs for the SAF admixture play a much greater role here. There are two reasons for this. On the one hand, the costs for energy tax (ETD) and EU emissions trading (ETS) are only incurred on feeder flights within the EU; they do not play a role for direct connections or transfers outside the EU.

In addition, the longer journey segments generally take place outside the EU. As the costs incurred for all the instruments considered here are proportional to fuel consumption, these long segments have a greater impact on overall costs.

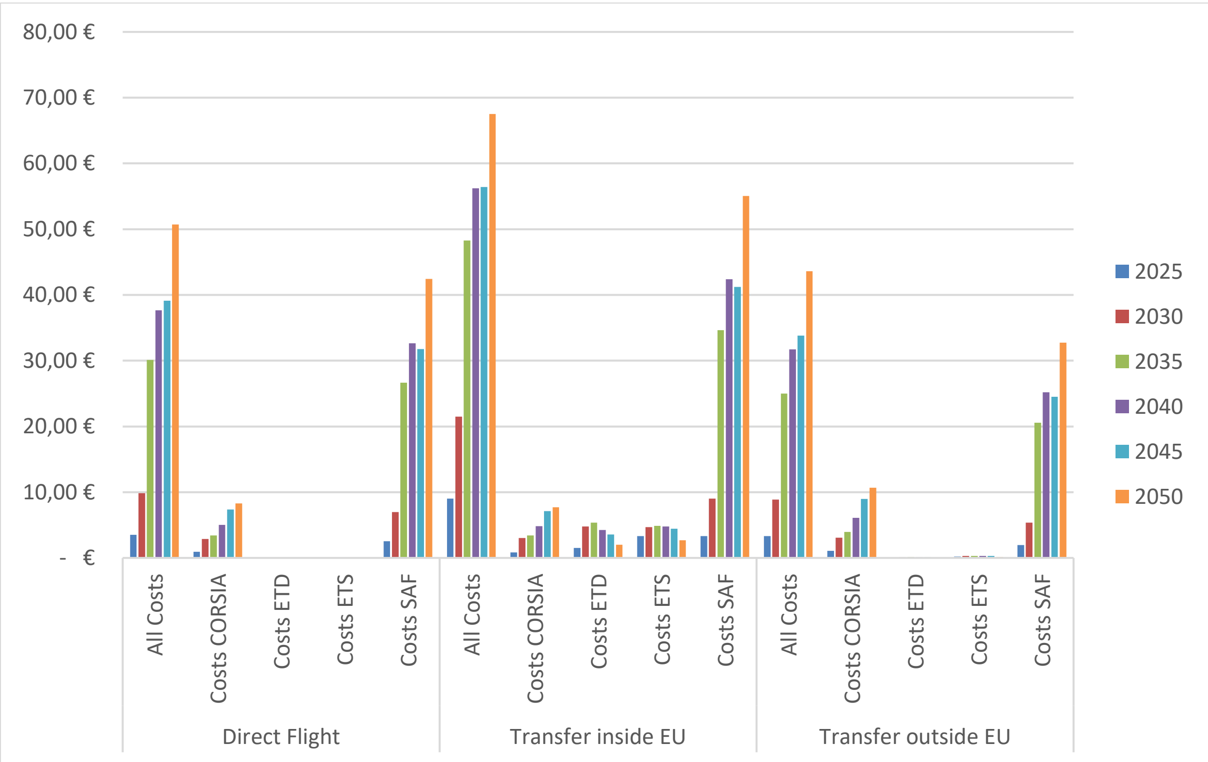

Figure 4: Additional costs when travelling between Germany and South/East Africa and Asia, broken down by transfer point

The different composition of costs depending on the route is also evident over time. In 2030, the average additional costs for a direct flight in this market segment will be €10, €9 for transfers outside the EU and €21 for transfers within the EU.

By 2035, the cost of direct connections will rise to €30. Transfer connections outside the EU will be €25 more expensive on average, transfers within the EU €48 more expensive. Transfer connections where the transfer takes place in the EU will therefore become more expensive overall than other connections in this travel direction. In addition, this increase in price occurs earlier.

However, due to the relatively high price level in this market segment the relative price increases are lower than on domestic connections: connections with a transfer in the EU will become 6.6% more expensive in 2035, whereas the price increase for connections with other transfer destinations will be 4.7%. Direct flights will become 5.5% more expensive.

3.5 Germany - North America

The last target market analysed here is travel between Germany and North America, broken down into direct connections, connecting flights in the EU, connecting flights in Iceland and other connecting flights. Iceland was included in the analysis as a transfer point, as Icelandair in particular offers transfer connections between Europe and North America via Keflavik Airport. In addition, this transfer point illustrates the influence of long flight segments within the EU/EEA on the composition of the additional costs and the total costs incurred by the Fit for 55 package.

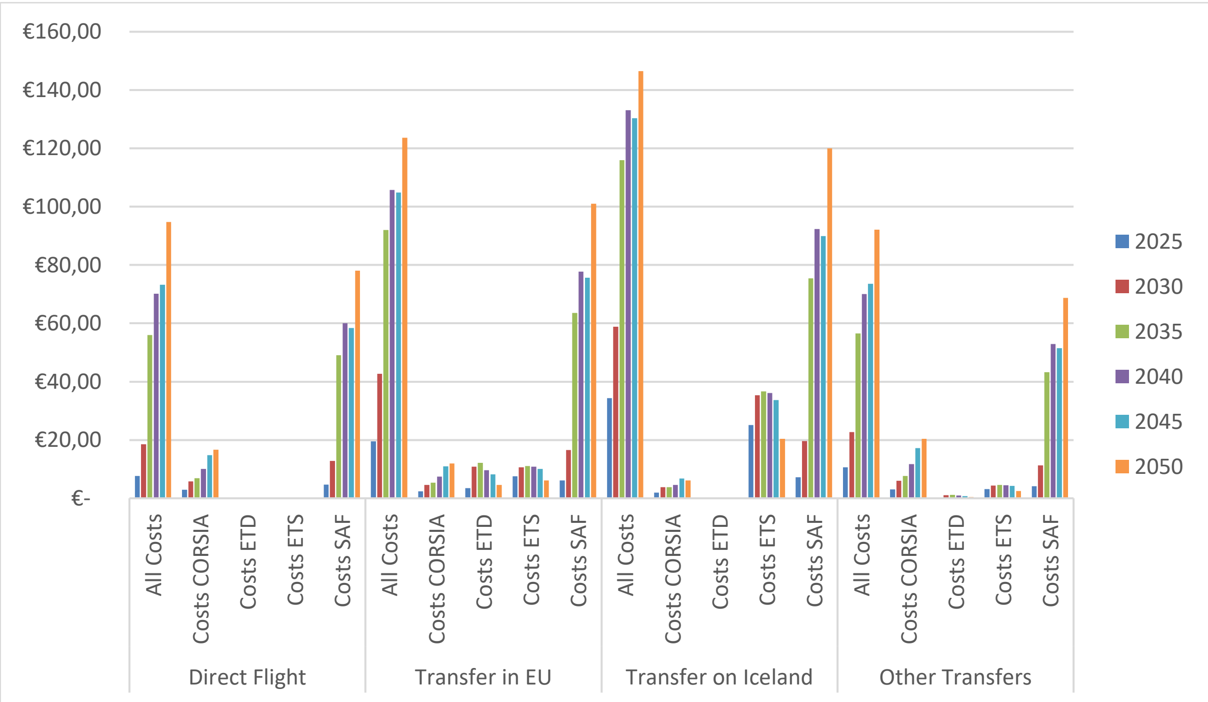

Figure 5: Additional costs when travelling from Germany to North America

In 2025, the additional costs for direct connections will increase by an average of €4 (0.5%), for connections within the EU by €9 (1%), for other connecting flights by €5 (0.7%), but for connecting flights via Iceland by just under €17 (3.5%). This trend will continue in 2030, with price increases of between €10 (1.2%) for direct connections and €28 (6%) for transfer connections via Iceland.

Iceland's competitive disadvantage is made up of two components: Firstly, a large part of the flight route is within the scope of the EU Emissions Trading Scheme. This accounts for a large part of the cost premium, particularly in 2025. In addition, the blending quota applies to both intra-European flights and flights from Iceland to North America.

3.6 Analyses for selected airlines

In addition to the analyses for individual target markets, we also analyse the difference in impact of the Fit for 55 instruments on various airlines. These were selected in such a way that various airline business models are covered: Ryanair (FR) as a low-cost airline, which operates a large proportion of its flights within the EEA and is therefore particularly affected by instruments that have an impact within this region. Condor (DE) as an airline operating in the tourism segment, which offers connections both within Europe and long-haul connections to other continents. Lufthansa and Turkish Airlines were selected to analyse the effects on network Airlines with hubs inside and outside the EEA, respectively.

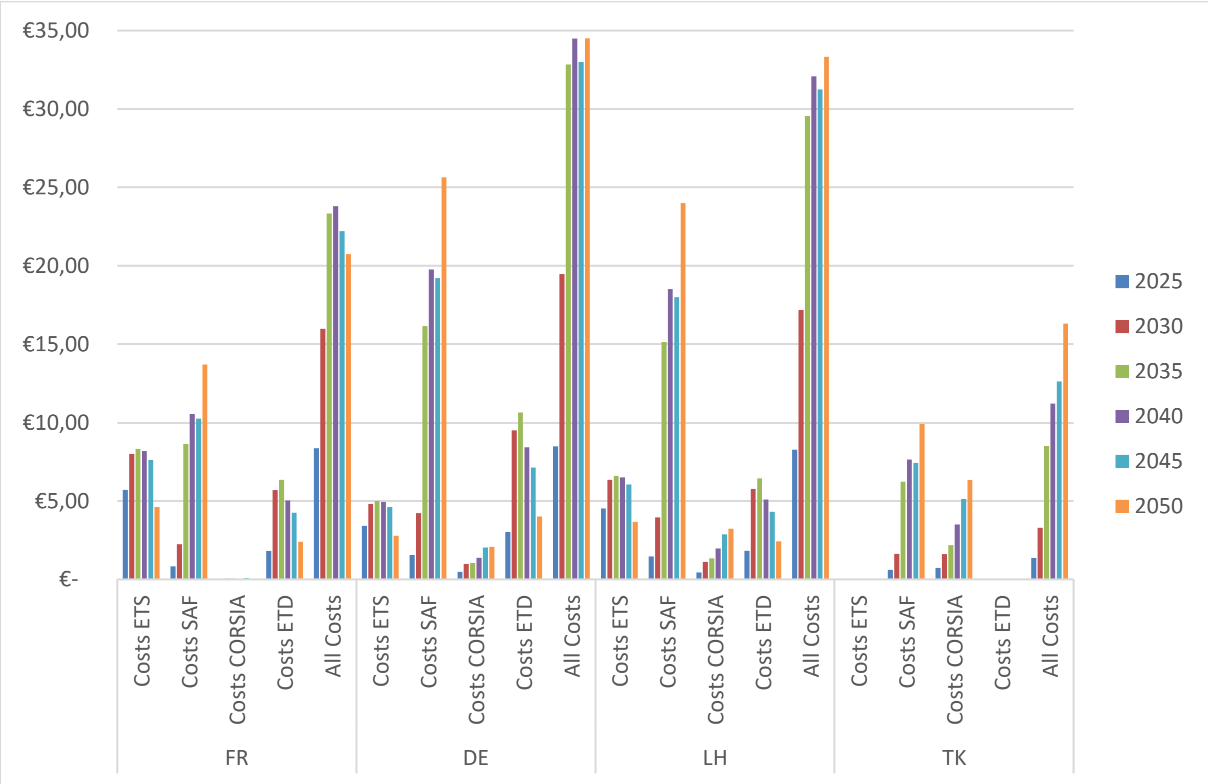

Figure 6: Additional costs per passenger, by airline

In all cases, only routes with at least one airport in the European Economic Area, UK or CH were considered. The different network structures are reflected in the cost structures: for Ryanair, the EU ETS and ETD will result in a price increase of over €8 from 2025, rising to just under €16 in 2030. This corresponds to a price increase of 10% and 20% respectively. For the airlines Condor and Lufthansa, which operate both intra-European and intercontinental flights, the impact of the costs resulting from the addition of SAF is higher. For Lufthansa, the expected price increases are €8 (2025), €17 (2030) and €30 (2035). Due to the higher price level in this market segment, however, the percentage increase in prices is significantly lower: 2% (2025), 4% (2030) and 7% (2035). However, it should be noted that Lufthansa competes on long-haul routes with other airlines such as Turkish Airlines, which are less affected by the Fit for 55 measures due to their hubs outside the EEA. For example, tickets for flights with TK will increase in price by just over €1 (2025, equivalent to 0.4%), €3 (2030, equivalent to 1.1%) and €9 (2035, equivalent to 2.8%).

4 Results

Based on the results from Section 3, the changes in demand due to the indicated cost increases are assessed based on the proposed methodology. Selected results of this model are presented below. For this purpose, passenger numbers for all flights with at least one stop in Europe are compared in a base scenario for the years 2025 to 2050 with a scenario with increased prices and changed demand through 'Fit for 55' measures. For this purpose, annual passenger growth of 2.9% is assumed in the base scenario, which corresponds approximately to the growth rates of the ICAO's post-COVID-19 forecast scenario [17]. In the 'Fit for 55' scenario, the growth in demand is dampened by the additional costs, whereby nevertheless there continues to be an increase in absolute passenger numbers. To simplify matters, comparisons are only made within a base scenario of the same year.

As a result, the aggregate demand elasticity for the 'Fit for 55' measures is -0.61 on average for all routes across the entire scenario. The specific effects and detailed changes are presented below.

4.1 Change in demand for a locally limited passenger flow

The following chart visualises the effects of the change in demand using the example of all routes on the Hamburg-Bangkok market in 2035.

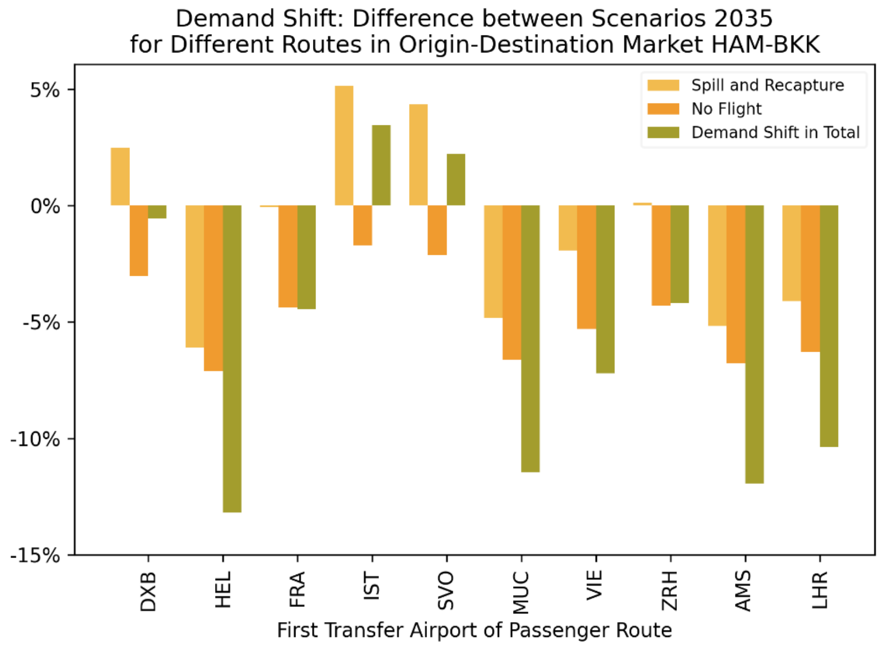

Figure 7: Change in demand for various routes in the example of the HAM-BKK market

The price increases range between 3.0% for the route via Istanbul (IST) and 14.0% for the route via Helsinki (HEL). The highest relative change in demand compared to the base scenario is also on the route with a transfer in Helsinki. With the price increase of 14.0%, a decrease of 13.7% is expected. This includes 6.1% of passengers switching to other routes, where all others choose not to fly. Routes with transfers in Munich (MUC), Frankfurt (FRA) and Dubai (DXB) show a lower relative decline. As already mentioned in the model description, this is due to the different characteristics of the routes.

The intra-European share of the flight connection and, thus, the price increase is higher for a transfer in Helsinki than for other routes This is why less price increase is to be expected in Dubai with 5.4 % or in Frankfurt and Munich with 8.2 % and 12.9 % respectively. The absolute ticket price for the route via Helsinki is also lower, which is why the relative price increase is higher.

Growth in demand is evident for the routes via Istanbul (3.5 %) and Moscow (SVO, 2.3 %), although a slight decline can be seen here due to passengers not flying. (This study is based on data and structures from 2019 and therefore cannot take recent developments into account). However, this decline is more than compensated for by passengers switching from other more expensive routes. On the routes via Dubai, Frankfurt and the rather infrequently flown route via Zurich (ZRH), a shift in demand due to changing passengers is also to be expected. In contrast to Moscow and Istanbul, however, the price increase for these routes is higher such that passengers who do not fly will cancel out the effect.

4.2 Passenger Flows Between Germany and Other Countries

Figure 7 shows the change in demand for all routes to and from Germany, broken down by various origin and destination countries. The absolute passenger numbers will grow significantly for all routes by 2050, which is due to the exogenously assumed growth rate. However, the 'Fit for 55' measures lead to a negative change in demand compared to the base scenario. As in the analysis of cost changes, with ticket prices the highest relative change in demand is expected for routes with origins or destinations in Spain and Greece. Due to the large passenger flow, the difference in absolute passenger numbers compared to the scenario without 'Fit for 55' measures is greatest for domestic routes. For international connections, routes with destinations in Spain show the greatest absolute difference in demand when comparing the scenarios. For routes with origin and destination in the USA, demand will increase less strongly by 2050 due to the additional influence of CORSIA, whereas the influence of the 'Fit for 55' measures is expected to decrease for European countries from 2035 and 2040 due to the expected lower price of sustainable aviation fuel.

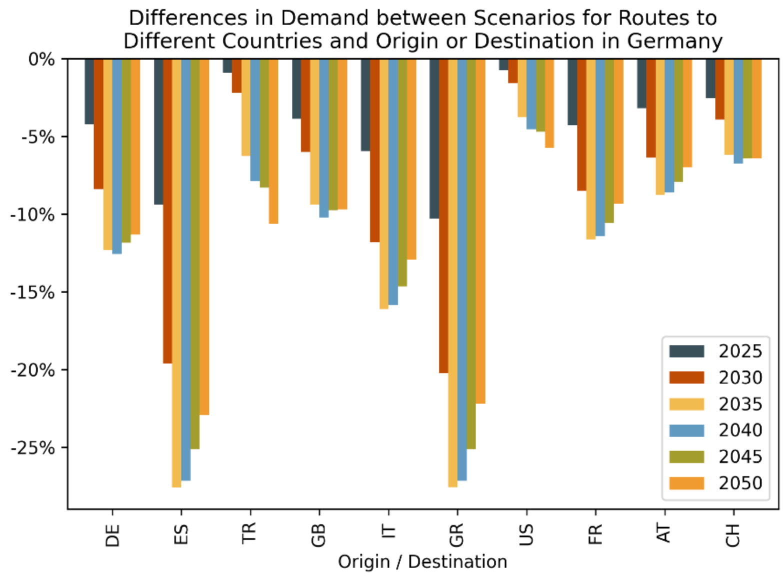

Figure 8: Differences in passenger demand in scenario with 'Fit for 55' measures compared to the base scenario for the ten largest passenger flows

4.3 Results Differentiated By Airline

In the above results the differences in demand between the two scenarios aggregated by different airlines have been shown. However, it should be noted that routes differentiated by airlines are not sufficiently comparable in detail in the demonstrated approach. Due to different business models, the network and price structures differ, which means that the airlines not only have different route lengths but also varying cost structures, ticket price levels, pricing and revenue management systems as well as different flexibility in the operational system. For example, an airline with a high proportion of intra-European flights is charged relatively more considering the costs of the ‘Fit for 55’ measures than an airline with long-haul flights, which has to pay only EU ETS and EU ETD costs on the feeder flight. These systemic differences result in different relative ticket price changes and, thus, also different changes in demand in response to the additional costs.

Similarly, airlines operate on different markets with varying average price levels, resulting in varying degrees of demand shifts to other routes. Additionally, only flights that take off, land or have a transfer in Europe are considered. Therefore, it is only possible to show the changes for varying proportion of an airline's flights. Furthermore, the different flexible reactions of the airlines are not shown. For example, the point-to-point networks of low-cost carriers are more flexible, which is why they react more quickly to changes and can compensate for some of the loss of demand more effectively. This aspect cannot be depicted in the model due to the definition of static scenarios. On the other hand, low-cost carriers primarily serve the markets in which many leisure travellers fly having a more elastic demand. Hereby, a price change could have a greater impact than on markets with many business travellers. However, on our model an average elasticity across all travellers can only be modelled.

Given the above restrictions, Ryanair's demand in the ’Fit For 55’ scenario is 27% lower than in the base scenario. As the airline mainly operates flights within Europe, additional costs are higher on average for all flights. Furthermore, Ryanair has a comparatively low price level, which is why the relative share of additional costs is higher in the model. Therefore, also the relative change in demand based on elasticities is higher in the model.

When comparing the scenarios, the demand for Lufthansa is 4% lower in the ‘Fit For 55’ scenario than in the base scenario. The smaller change in demand compared to Ryanair is due to the greater proportion of long-haul flights and the higher price level in general. Furthermore, the markets served by Lufthansa have a more homogeneous pricing structure, which is why there is less shift in demand to other routes because the ticket price increases for all routes on the market.

4.4 Results Differentiated by Transfer Airports

A better comparison is given for passenger flows limited to geographical regions. In the following, we show the change in demand between the two scenarios based on the passenger routes between Germany and Asia or Africa, broken down by transfer airports. The airports are sorted according to the number of absolute passengers.

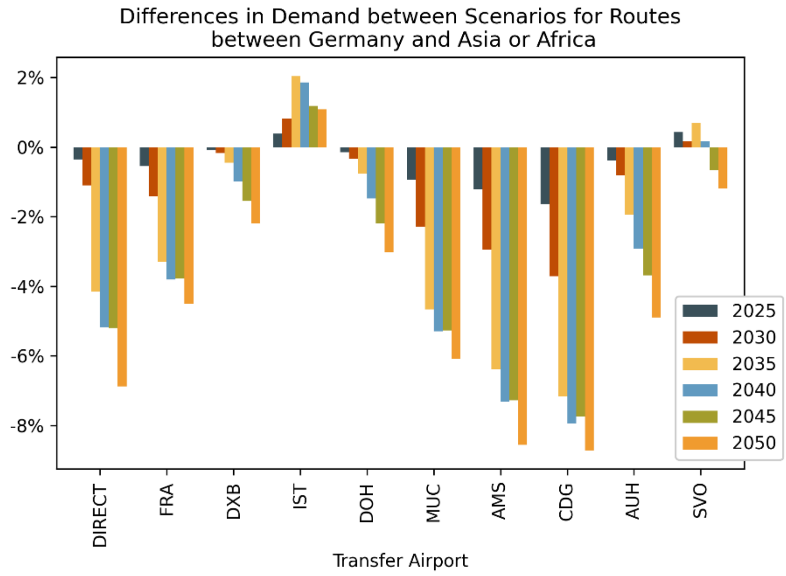

Figure 9: Impact on transfer airports for traffic between Germany and Asia and Africa by transfer airport

Direct flights are subject to higher additional costs by 'Fit for 55' measures, as the connecting flight is less burdened with additional costs depending on the location of the transfer airport. In 2050, routes with transfer in Frankfurt and Munich airports have 4.5 % and 6.1 % fewer transfer passengers respectively than in the base scenario. It is noticeable that the change in demand for other European transfer airports is significantly higher for these data. This is due to the fact that the feeder flights to other European airports are longer and therefore more expensive for passengers from Germany. This effect is no longer present when all European airports would be considered.

Furthermore, for transfer traffic in Dubai (DXB), Doha (DOH) and Abu Dhabi (AUH), a change in demand of -2.2 %, -3.0 % and -4.9 % respectively is recognisable in the comparison of the two scenarios. Although these routes show an increase in demand due to a shift from other routes with higher additional costs in the same markets. However, this positive effect is cancelled out by a decline in demand due to an overall increase in ticket prices. An overall positive change in demand for the scenario with the 'Fit for 55' measures of 1.1% can only be seen for routes with transfer traffic in Istanbul. This is because the decline in demand due to passengers not flying at all due to additional costs is less than the additional passengers recaptured from routes via other airports. For Istanbul, the additional costs for transfer traffic are lower compared to the Arab airports, as the feeder flights are shorter. Nevertheless, it can be said that overall across all routes a, significant passenger growth is recognisable for all airports up to 2050.

5 Conclusion

The 'Fit for 55' measures will lead to rising ticket prices. This is intended to achieve two economic policy objectives. First, the costs of global warming as a negative external effect of aviation (as well as many other economic activities) should also be borne by its users. Second, the costs of the regulatory instruments increase the incentive to reduce CO_2 emissions and thus the impact on the climate.

Flights within Europe will become more expensive by 2030, particularly as a result of EU emissions trading system and the taxation of kerosene, whereas the price increase for intercontinental flights will not become significant until 2035 due to the slow increase in blending quotas for sustainable aviation fuels. Compared to the additional costs arising from the European instruments, the costs for CORSIA are relatively low.

In order to analyse the impact of price increases, two scenarios were compared to derive the change in demand through instruments from the ’Fit for 55’ package. The base scenario assumes average annual passenger growth of 2.9 %. In contrast, in the "Fit for 55" scenario, ticket prices are increased by the additional costs of the applicable instruments, which reduces the average annual passenger growth in the scenario to 2.4% (2.1% for intra-European markets). This result is determined by the fact that the relative changes in demand due to price increases for all routes of the same market are on average smaller than the relative ticket price increases and correspond to an average aggregate elasticity of -0.61.

Due to the number of flights and passengers affected, the following assumptions must be made to derive the calculation of the change in demand: A symmetrical cross-price elasticity is defined for all markets due to a lack of data. Furthermore, the same average elasticities are used for all passengers. No distinction is therefore made between leisure and business travellers. Different cost structures and structural adjustment options for different airlines are also not taken into account. Differentiated analyses only make sense for locally limited passenger flows, as this is the only way to ensure comparability in the same markets.

Using the example of the Hamburg-Bangkok passenger flow, the comparison of the scenarios showed how demand is shifted between different routings if these are burdened with different additional costs. This favours hubs in the Middle East over connecting airports within Europe.

Finally, it should be emphasised that this study is a scenario analysis and not an air traffic forecast. The modelled growth rate of air traffic in the base scenario is based on existing forecasts such as those of the ICAO and the DLR. Nevertheless, the difference in various cost and price increases for different routes and market segments is highlighted in our study, and the implications for demand volume and demand shifts in between routes due to ‘Fit for 55’ measures can be adequately and precisely demonstrated.

6 References

[1] Alexander H. Wolter, Thorsten Ehlers, Klaus Luetjens, and Volker Gollnick. 2021. Commodity price pass-through in the US airline industry and the hidden perks of consolidation. *Journal of Air Transport Management* 95, 102100.

[2] Brons, M., Pels, E., Nijkamp, P., and Rietveld, P. 2002. Price elasticities of demand for passenger air travel: a meta-analysis. *Journal of Air Transport Management* 8, 3, 165–175.

[3] DEHST. 2022. *Geographical scope: Which flights are subject to EU ETS?* https://www.dehst.de/SharedDocs/antworten/EN/Aviation/LV_005_scope.html. Accessed 16 August 2022.

[4] Directorate-General for Mobility and Transportation, European Commision, Ed. 2021. *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ensuring a level playing field for sustainable air transport*.

[5] Dray, L. and Schäfer, A. W. 2023. Initial Long-Term Scenarios for COVID-19's Impact on Aviation and Implications for Climate Policy. *Transportation Research Record* 2677, 4, 204–218.

[6] European Comission. 2019. *Taxes in the Field of Aviation and their impact – Final report*.

[7] European Commission. 2018. *COMMISSION IMPLEMENTING REGULATION (EU) 2018/2066*.

[8] European Commission. 2021. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EMPTY*. *'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0550. Accessed 18 August 2022.

[9] European Commission. 2021. *Revision of the Energy Taxation Directive (ETD): Questions and Answers*. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3662. Accessed 18 August 2022.

[10] European Commission. 2021. *Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2003/87/EC as regards aviation's contribution to the Union's economy-wide emission reduction target and appropriately implementing a global market-based measure*.

[11] European Union. 2017. *L 322*. *Official Journal Official Journal of the European Union*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2017:322:TOC. Accessed 16 August 2022.

[12] Garrow, L. A. 2010. *Discrete choice modelling and air travel demand*. *Theory and applications*. Ashgate, Farnham.

[13] Gelhausen, M. C., Berster, P., and Wilken, D. 2020. *Airport capacity constraints and strategies for mitigation*. *A global perspective*. Academic Press, London, England.

[14] Gillen, D. W., Morrison, W. G., and Stewart, C. 2007. Air Travel Demand Elasticities: Concepts, Issues and Measurement. *Advances in Airline Economics, Volume 2, The Economics of Airline Institutions, Operations and Marketing* 2.

[15] IATA. 2009. *IATA Economics Briefing No 9: AIR TRAVEL DEMAND*.

[16] IATA. 2021. *Net-Zero Carbon Emissions by 2050*.

[17] ICAO. 2021. *Post-COVID-19 Forecasts Scenarios*. https://www.icao.int/sustainability/Pages/Post-Covid-Forecasts-Scenarios.aspx.

[18] InterVistas. 2007. *Estimating Air Travel Demand Elasticities*.

[19] Kölker, K., Lütjens, K., and Gollnick, V. 2024. Analyzing global passenger flows based on choice modeling in the air transportation system. *Journal of Air Transport Management* 115, 102530.

[20] Lufthansa Group. 2021. *Factsheet*. *Nachhaltigkeit 2021*.

[21] Oum, T. H., Waters II, W. G., Yong, J.-S. 1992. Concepts of Price Elasticities of Transport Demand and Recent Empirical Estimates: An Interpretative Survey, Journal of Transport Economics and Policy 26, 2, 139–154.

[22] Oxera. 2022. *Assessment of the impact of the Fit for 55 policies on airports*.

[23] Perner, J., Unteutsch, M., and Lövenich, A. 2018. Die zukünftigen Kosten strombasierter synthetischer Brennstoffe. *Agora Energiewende und Frontier Economics*.

[24] RyanAir Group. 2021. *Annual Report 2021*.

[25] Scheelhaase, J., Gelhausen, M., and Maertens, S. 2021. How would ambitious CO2 prices affect air transport? *Transportation Research Procedia* 52, 428–436.

[26] SEO, N. L. 2022. *Aviation Fit For 55 Ticket Prices, Demand and Carbon Leakage*.

[27] van der Sman, E., Peerlings, B., Kos, J., Lieshout, R., and Boonekamp, T. 2021. *Destination 2050*.