# WIDER ECONOMIC BENEFITS OF AIR TRANSPORT: ESTIMATING CONSUMER SURPLUS FOR GERMANY

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## ABSTRACT

In addition to the direct, indirect, and induced impact of air transport there exist wider economic benefits, also referred to as catalytic impact. Surveys provide data on direct effects. Input-output analysis has been used by a multitude of studies to estimate indirect and induced impact. In contrast, quantifying the wider economic benefits beyond this multiplier impact is considered a difficult task. Obviously, one of the key economic benefits from the transport of passengers and freight by air is consumer surplus, i.e. the difference between the consumer's willingness to pay and the actual airfare and freight rate respectively. In theory, consumer surplus is a convincing monetary measure of the welfare that passengers and shippers gain from air transport. However, a practicable method for implementation is needed. The paper proposes the use of average price elasticities of air transport demand to estimate consumer surplus. The approach also requires the specification of average prices and sales volumes in the air transport markets under consideration.

*Keywords: air transport, economic catalytic impact, consumer surplus analysis*

# 1. INTRODUCTION

Measuring the impact of air transport on economic welfare is relevant for many policy and legislative issues such as further liberalisation of air transport, public investment in airport infrastructure, airport regulation (e.g. night curfews) and governmental decisions to raise the cost of air transport (e.g. increase of airport charges, inclusion of air transport in emissions trading schemes).

In addition to the direct, indirect, and induced impact of air transport there exist wider economic benefits, also referred to as catalytic impact. Direct employment and income for companies in the aviation industry are the immediately visible economic benefits. Input-output analysis is the prevalent method to estimate indirect and induced impact. In contrast, quantifying the wider economic benefits beyond this multiplier impact is considered a more challenging task. The present paper investigates the wider economic benefits of air transport with regard to air transport of passengers to and from Germany.

The economic impact of air transport has been subject of a large number of studies. Many of them have been commissioned by airport authorities, industry associations or governmental institutions. The study by York Aviation for ACI Europe (2004) on the social and economic impact of airports in Europe is an often-cited example of such studies. Further noted reports have been published by MPD Group (2005) and Oxford Economic Forecasting (2005). The study by MPD Group assesses the economic costs of night flight restrictions reviewing the existing literature quite broadly and providing a comprehensive bibliography. The study by Oxford Economic Forecasting (2005) is especially relevant for the present paper as it focuses on the economic catalytic effects of air transport. A recent study by ECAD (Arndt et al. 2009) assesses a number of these effects on a regional scale for Germany by applying a mix of quantitative and qualitative methods. A comprehensive synthesis of airport economic impact methods and models is also provided by Transportation Research Board (2008).

In theory, consumer surplus is a convincing measure for the wider economic benefits resulting from the transport of passengers and freight by air. In the present context it is defined as the difference between the passenger's or shipper's willingness to pay and the actual airfare and freight rate respectively. The present paper proposes the use of average price elasticities of air transport demand to estimate consumer surplus. Various empirical studies on price elasticities of air transport demand exist. Most of them deal with passenger transportation. One exception is the survey of estimates of price elasticities by Oum et al. (1992). A more recent report on elasticities of air travel demand is provided by Gillen et al. (2002). Both studies and other existing research have been reviewed by Ernst & Young (2007) and Intervistas (2007). Intervistas combines a review of the existing literature with own empirical work that highlights the bearings of factors such as degree of aggregation or time horizon on price elasticity estimates.

The next section of the paper contains a brief description of different categories of benefits of air transport highlighting consumer surplus as one of the key economic benefits from the transport of passengers by air. The following section specifies the kind of price elasticity used in this paper. To derive inverse demand functions for air transport to and from Germany, the fourth section provides quantities, prices and price elasticities for different air transport markets and also contains a discussion of the appropriate curvature of demand functions.

The fifth section estimates the revenues and consumer surplus for German air transport markets. The concluding section briefly summarizes the results and points out directions to further refine the proposed methodological approach to estimate the wider economic benefits of air transport.

# 2. BENEFITS OF AIR TRANSPORT

Economic impact studies of air transport typically measure direct, indirect, and induced effects as three separate effects.

- Direct effects include production, added value and employment in the air transport industry.
- Indirect effects represent production, added value and employment generated down the supply chain to the air transport industry.
- Induced effects are secondary effects resulting from the spending of those directly or indirectly employed in the air transport industry throughout the economy.

Information on direct effects is derived by surveys, workplace counts and available statistics. Input-output analysis has been used by a multitude of studies to measure the multiplier impact of indirect and induced effects. This methodological approach relies on input–output tables that show the industrial distribution of inputs purchased and outputs sold for any individual industry sector. Input-output analysis has been criticized for several reasons, e.g. that inputs are assumed to be available with no negative impacts on other industries. Hence, the use of computable general equilibrium (CGE) models has been proposed as an alternative approach to measure the multiplier impact of air transport. CGE models are descended from input-output models but assign a more important role to prices.

- Catalytic impacts

Most impact studies concentrate on the direct, indirect, and induced contributions of air transport. In comparison, catalytic impacts on the economy have received relatively little attention. Figure 1 distinguishes catalytic impacts into consumer surplus that users gain from air transport, economic spillovers and environmental and social impacts. Positive spillover effects on the supply-side of the economy include increased inward investment and productivity improvements. Negative spillovers, environmental and social impacts of air transport are a major issue in the debate on optimal climate change policies.

One of the key economic benefits from the transport of passengers and cargo by air is consumer surplus, i.e. the difference between the consumer's willingness to pay and the actual air fare and cargo rate respectively. In theory, consumer surplus is a convincing monetary measure of the welfare that passengers and shippers gain from air transport. However, a practicable method for implementation is needed. The paper proposes the use of average price elasticities for air transport demand to estimate consumer surplus. The approach also requires the specification of average prices and sales volumes in the air transport markets under consideration.

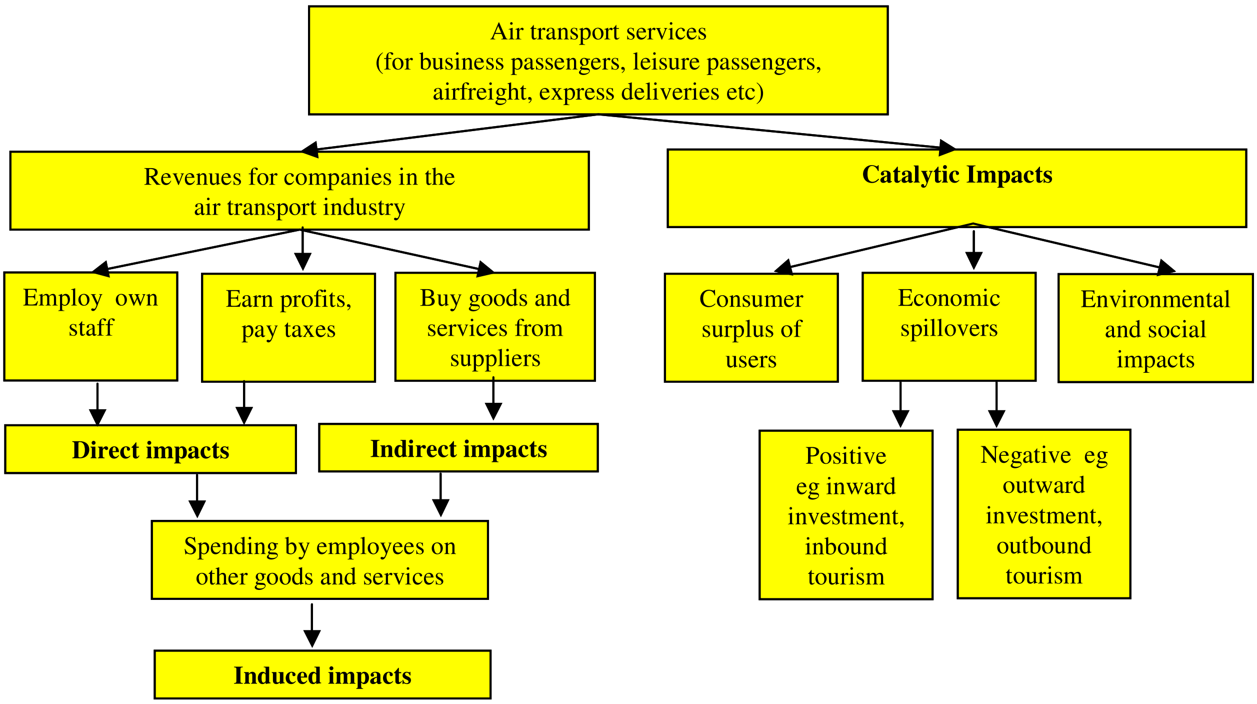


Figure 1 – Benefits (and costs) of air transport

Two examples of air transport markets – low-cost air travel and express air freight – may serve to illustrate the concept of consumer surplus and the influence of different price elasticities of demand. The left diagram in Figure 2 shows a schematic market for express air freight. The market demand for air freight is assumed to be relatively price inelastic leading to a step downward sloping demand curve. Given a supply curve, the demand curve leads to market equilibrium with equilibrium price and equilibrium quantity. In this standard supply and demand diagram, consumer surplus is the triangular area above the equilibrium price level and below the linear demand curve. In comparison, demand for low-cost air travel depicted in the right diagram in Figure 2 is more price elastic leading to a flat demand curve and a smaller triangular area. Hence, relatively price inelastic market demand - assuming all else is held constant - leads to larger aggregated consumer surplus than relatively price elastic demand.

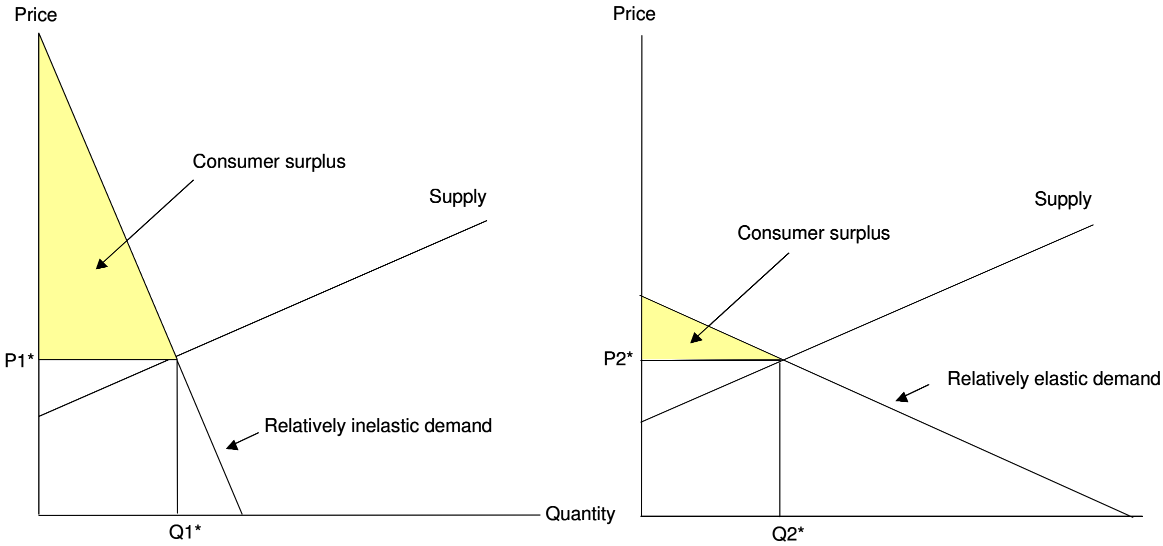


Figure 2 – Consumer surplus in two illustrative air transport markets

The shape of the aggregate demand curve can be convex or concave. In fact, an aggregate demand function cannot be derived except under restrictive and unrealistic assumptions. However, demand relations in a market can be statistically estimated from price, quantity, and price elasticities.

# 3. PRICE ELASTICITIES FOR AIR TRANSPORT

Price elasticity is defined as the ratio between the relative change in demand induced and the relative change in price. Empirical research on own-price elasticity of demand leads to a rather wide range of outcomes (Klophaus, 2009). This largely depends on the specification of price elasticity estimates. In this respect a number of factors determine the elasticity:

- Substitutes: Long-haul air travel is less price-elastic than short-haul air travel because of fewer intermodal substitutes.
- Necessity: Business travel and express freight are less price-elastic than leisure travel and standard cargo respectively.
- Duration: Long-term price elasticities tend to be higher than the respective short-term price elasticties because air transport demand has more time to adjust.
- Aggregation: Demand for airline specific changes of airfares is more price elastic than when all airlines on a given route increase airfares by the same amount.

The present paper considers only aggregated long-term market elasticities of demand for air transport to and from Germany. Route or carrier specific elasticities may differ significantly. In addition, no geographical distinction is made between origin and destination. However, price elasticities for different air transport markets are distinguished according to necessity and distance. The own-price elasticities depicted in Table I are taken from a study by Gillen et al.

(2002, p.4) and show ranges of elasticities (minimum, median, and maximum values) per market segment that have been derived from an extensive literature review.

# 4. DEMAND FUNCTIONS FOR AIR TRANSPORT

Deriving inverse demand functions for air transport to and from Germany for the year 2008 requires market-specific data on quantity and price besides price elasticity of demand. The number of passenger round-trips (RT) is taken from DLR (2009). These round-trips possibly contain several legs.

Regarding the size of specified market segments (e.g. business and leisure passengers) no published source is available. Hence, primary data collection is required. Several interviews with German airlines were completed in order to assess the share of business and leisure passengers on long-haul flights to and from Germany. The same source provided market-specific average airfares. The maximum airfares for round-trip direct flights are ascertained from Lufthansa's internet booking system.

Table I contains the parameter values for quantity, price in Euro (€) and own-price elasticity ranges with regard to the market for inter-continental trips to and from Germany for both business and leisure travellers as well as for intra-European trips to, from, and within Germany, again for both business and leisure travellers.

Table I – Quantities, prices and elasticities for air transport markets to and from Germany 2008

| | **Quantity** | **Price (Euro)** | | **Own-price elasticity** | | |
|---|---|---|---|---|---|---|
| | | Average airfare (RT) | Maximum airfare (RT) | Minimum | Median | Maximum |
| *12.1 m inter-continental trips* | | | | | | |
| Business 20 % | 2.4 m | 4,000 € | 14,000 € | -0.475 | -0.265 | -0.198 |
| Leisure 80 % | 9.7 m | 750 € | 8,000 € | -1.7 | -1.04 | -0.56 |
| *51.2 m continental trips* | | | | | | |
| Business 10 % | 5.2 m | 750 € | 2,200 € | -1.428 | -1.15 | -0.836 |
| Leisure 90 % | 46.6 m | 200 € | 2,000 € | -1.228 | -1.104 | -0.787 |

Inverse demand functions can possess a linear or a non-linear curvature. The consequence of different curvatures of demand functions is exemplified in Figure 3 for intra-continental business travel to and from Germany. The two demand curves intersect at the market equilibrium with 2.4 m passengers, an average fare of € 4,000 and a price elasticity of -0.8.

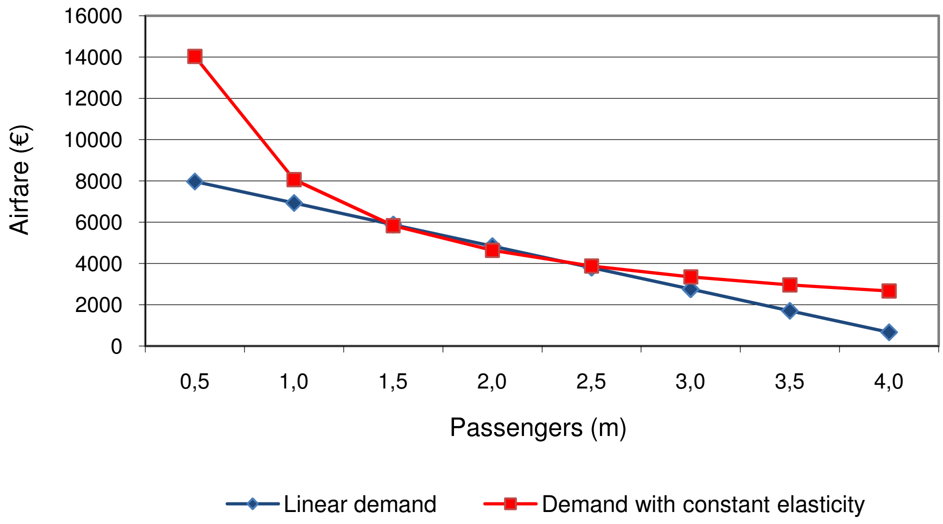


Figure 3 – Linear and non-linear air travel demand (Business, long-haul to/from Germany)

A linear demand function has an elasticity along the linear curve changing from 0 to infinity, whereas constant elasticity necessitates a non-linear type of function. Given that only data on average (constant) price elasticities for different air transport markets is available, it is accurate to use demand curves with constant elasticity.

Comparing the two different demand curves depicted in Figure 3 makes clear that the area below the non-linear demand curve with constant elasticity is larger. In fact, the integration of the non-linear function leads to an improper integral as the integrand is infinite at the lower limit of integration. In economic terms there is one passenger with an infinite reservation price and, hence, an infinite consumer surplus. A solution to this problem is the use of a definite integral leaving out the passengers with a willingness to pay that is higher than the maximum airfare. That defines a definite integral with the number of passengers willing to pay the maximum airfare as the lower limit to the equilibrium value of passengers as the upper limit. The lower limit of the integral is calculated by using the maximum airfare in the inverse demand function. Since this integral leaves out the consumer surplus of the passengers willing to pay more than the maximum price, their consumer surplus needs to be added by multiplying the number of these passengers by the difference between the maximum and the average (equilibrium) airfare, as shown in Figure 4.

# 5. CONSUMER SURPLUS OF AIR TRANSPORT

This paper estimates consumer surplus for users of air transportation services to and from Germany for the year 2008. The markets explicitly considered are continental and inter-continental passenger travel, both of which are further differentiated between business and leisure segments. The business segment is defined as passengers flying in business class or first class irrespective of the purpose of their trip, the leisure segment contains passengers flying in economy class (incl. premium economy). Further markets, e.g. short-haul air travel, can be analysed in the same manner after proper market definition and data collection. Also a more detailed analysis is possible such as a differentiation of long-haul air travel to and

from different regions of the world as long as estimates for prices, quantities and price elasticities in market equilibria are available.
The consumer surplus in the market under consideration is calculated with a definite integral. Geometrically it is the rectangular area between zero and the intersection of the maximum fare with the inverse demand function plus the area under the demand curve from the intersection of the maximum fare with the inverse demand function to the equilibrium quantity minus the total market revenue.

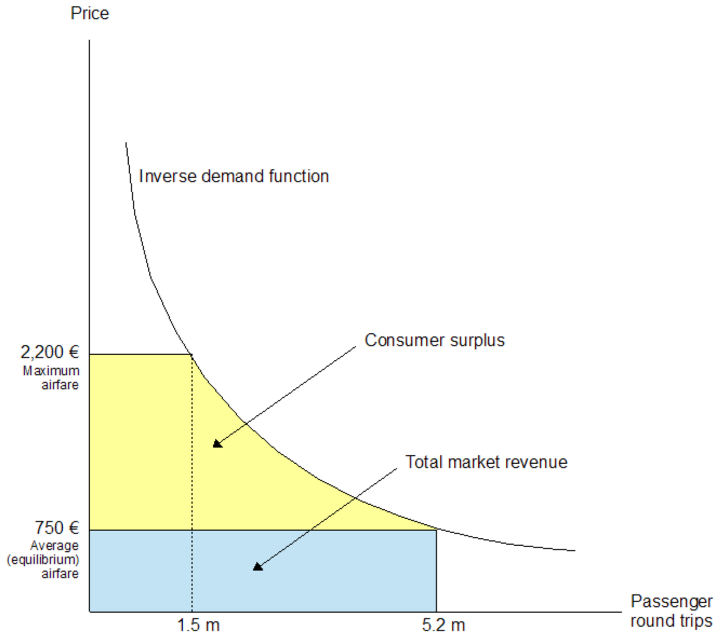


Figure 4 – Geometrical representation of consumer surplus in the continental business travel segment

For continental (intra-European) business air travel to and from Germany the calculation is as follows. Using a non-linear inverse demand function

$$p = a \cdot x^b \tag{1.1}$$

with

$p = 750$ €, $x = 5{,}200{,}000$ passengers and the median value of $\varepsilon = -1.15$ (values taken from Table I) leading to

$$b = \frac{1}{\varepsilon} = \frac{1}{-1.15} = -0.87 \tag{1.2}$$

and

$$a = p \cdot x^{-b} = 750 \cdot 5{,}200{,}000^{0.87} = 518{,}876{,}702. \tag{1.3}$$

The resulting inverse demand function is

$$p = 518{,}876{,}702 \cdot x^{-0.87} \tag{2}$$

which is then used to determine the lower limit of the integral by using the maximum fare of € 2,200 as $p$ in the inverse demand function:

$$2{,}200 = 518{,}976{,}702 \cdot x^{-0.87}$$

$$=> x = \left(\frac{2{,}200}{518{,}876{,}702}\right)^{\frac{1}{-0.87}} = 1{,}508{,}474.$$

The integral then is

$$\int_{1{,}508{,}474}^{5{,}200{,}000} 518{,}876{,}702 \cdot x^{-0.87}\,dx$$

$$= \left[\frac{1}{0.13} \cdot 518{,}876{,}702 \cdot x^{0.13}\right]_{1{,}508{,}474}^{5{,}200{,}000}$$

$$= 4{,}457{,}078{,}633. \tag{3}$$

Adding the total amount that the 1.5 million passengers were willing to pay at € 2,200 each

$$1{,}508{,}474 \cdot 2{,}200\ € = 3.318.641.917\ € \tag{4}$$

and subtracting the total market revenue

$$5{,}200{,}000 \cdot 750\ € = 3{,}900{,}000{,}000\ € \tag{5}$$

results in the total consumer surplus

(3) + (4) – (5) = 3,875,720,551 €. (6)

Using a median elasticity value for the inverse demand function, the total consumer surplus for the continental business travel segment amounts to € 3.9 billion.
The inverse demand functions and consumer surpluses listed in Table II were derived in the same way for the twelve own-price elasticity values taken from Table I.

Table II – Inverse demand functions and consumer surpluses for Germany 2008

| Market segment | Own-price elasticity | Inverse demand function | Consumer surplus |
|---|---|---|---|
| Business inter-continental | -0.475 | $p = 4{,}000 \cdot 2{,}400{,}000^{2.11} \cdot x^{-2.11}$ | € 17.0 billion |
| | -0.265 | $p = 4{,}000 \cdot 2{,}400{,}000^{3.77} \cdot x^{-3.77}$ | € 19.7 billion |
| | -0.198 | $p = 4{,}000 \cdot 2{,}400{,}000^{5.05} \cdot x^{-5.05}$ | € 20.7 billion |
| Leisure inter-continental | -1.70 | $p = 750 \cdot 9{,}700{,}000^{0.59} \cdot x^{-0.59}$ | € 8.4 billion |
| | -1.04 | $p = 750 \cdot 9{,}700{,}000^{0.96} \cdot x^{-0.96}$ | € 16.4 billion |
| | -0.56 | $p = 750 \cdot 9{,}700{,}000^{1.79} \cdot x^{-1.79}$ | € 30.3 billion |
| Business continental | -1.428 | $p = 750 \cdot 5{,}200{,}000^{0.70} \cdot x^{-0.70}$ | € 3.4 billion |
| | -1.15 | $p = 750 \cdot 5{,}200{,}000^{0.87} \cdot x^{-0.87}$ | € 3.9 billion |
| | -0.836 | $p = 750 \cdot 5{,}200{,}000^{1.20} \cdot x^{-1.20}$ | € 4.6 billion |
| Leisure continental | -1.228 | $p = 200 \cdot 46{,}600{,}000^{0.81} \cdot x^{-0.81}$ | € 16.7 billion |
| | -1.104 | $p = 200 \cdot 46{,}600{,}000^{0.91} \cdot x^{-0.91}$ | € 19.1 billion |
| | -0.787 | $p = 200 \cdot 46{,}600{,}000^{1.27} \cdot x^{-1.27}$ | € 27.7 billion |

The total consumer surplus for all market segments considered in this paper varies widely depending on the own-price elasticities used for the inverse demand functions. Adding the minimum, median and maximum values respectively for consumer surpluses, we come to the result that there is at least a consumer surplus of € 45.5 Euros derived from air travel and a maximum consumer surplus of € 83.3 billion. The median values add up to € 59.1 billion. In any case, the estimated consumer surplus goes beyond the € 30.1 billion total market revenue of all market segments considered.

# 6. CONCLUSIONS

The wider economic benefits of aviation – also called catalytic impacts – add to the direct, indirect and induced impacts. Measuring these wider economic benefits is difficult. The present paper proposes the use of average price elasticities of air transport demand to estimate consumer surplus. By using data on prices, quantities and own-price elasticities the revenues generated in several aviation markets to and from Germany for the year 2008 are calculated. For example, the total revenue from inter-continental business travel by air to and from Germany is € 3.9 billion. In addition to this direct impact there is a catalytic impact of another € 3.9 billion due to travellers' consumer surplus. Accordingly, revenues for inter-continental leisure trips to and from Germany amount to € 9.3 billion and these trips create a consumer surplus of € 19.1 billion. Assuming a median price elasticity for all market segments considered in this paper, the consumer surplus generated by passenger air travel to and from Germany (€ 59.1 billion) constitutes almost twice the amount of the total market revenue (€ 30.1 billion).

Other results are non-linear inverse demand functions for different segments of passenger air transportation to and from Germany. These functions represent demand on an aggregated level rather than route or carrier specific demand. In addition, no distinction has been made with regard to price sensitivity of incoming and outgoing passengers. The application of a non-linear inverse demand function is theoretically more robust and leads to more realistic estimates of the catalytic impacts of air transport than the demand functions with linear curvature used in previous studies. Further research on the appropriate curvature of the demand function is needed, e.g. a proper implementation of price discrimination. Other variables besides price might also be included in the demand model.

The price elasticities used in this paper are measured at the equilibrium point of a given air transport market and will vary with this equilibrium. The suggested approach also requires the specification of average price and sales volume in the air transport market under consideration. Hence, researchers need data which – at least in Germany – is only available from industry sources. This might be a problem when applying the suggested approach to other markets than Germany.

The proposed method to estimate the wider economic benefits of air transport relies on the availability and reliability of price elasticities of air transport demand. Existing empirical research on own-price elasticity of air transport demand leads to a rather wide range of outcomes. In particular for air cargo the empirical evidence is limited and rather outdated. Hence, further empirical work to validate and refine price elasticity estimates of air transport demand is necessary.

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