ESTIMATING REVENUES AND CONSUMER SURPLUS FOR THE GERMAN AIR TRANSPORT MARKETS

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Abstract

In addition to direct, indirect, and induced impacts of air transport there are wider economic benefits, also referred to as catalytic impacts. The most immediately visible economic benefits are direct employment and revenues for companies in the aviation industry. Input-output analysis has been used by a multitude of studies to estimate indirect and induced impacts. In contrast, quantifying the wider economic benefits beyond these multiplier impacts is considered a difficult task. This paper investigates the wider economic benefits of air transport.

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 for air transport demand to estimate consumer surplus. The approach also requires the specification of average prices (airfares, freight rates) as well as sales volumes (passenger round-trips, freight tonnage one-way) in the air transport markets under consideration. The paper provides estimated inverse demand functions for air transport markets to and from Germany and figures for revenues and consumer surplus for the German air transport markets.

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 are wider economic benefits, also referred to as catalytic impact. Immediately visible economic benefits are direct employment and income for companies in the aviation industry. 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 and cargo 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 a often-cited example of such studies. Further noted reports 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 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. (2003). 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 and cargo 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.

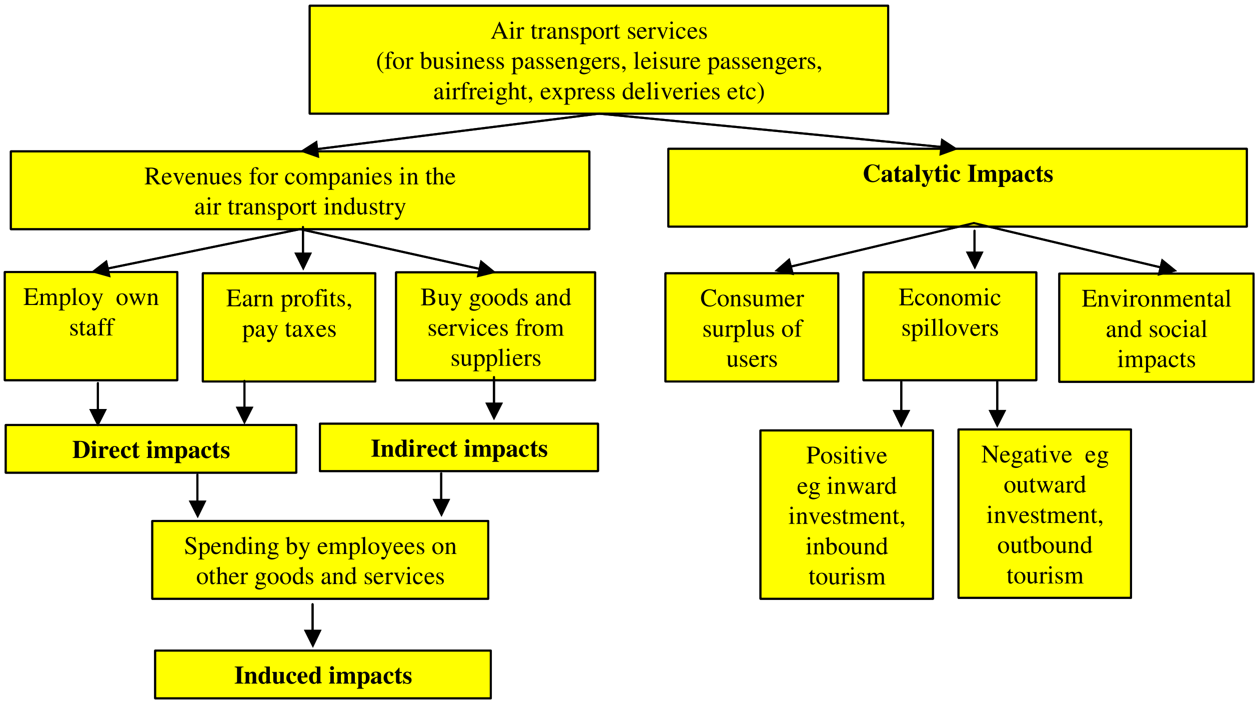

Figure 1: Benefits (and costs) of air transport

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 1 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.

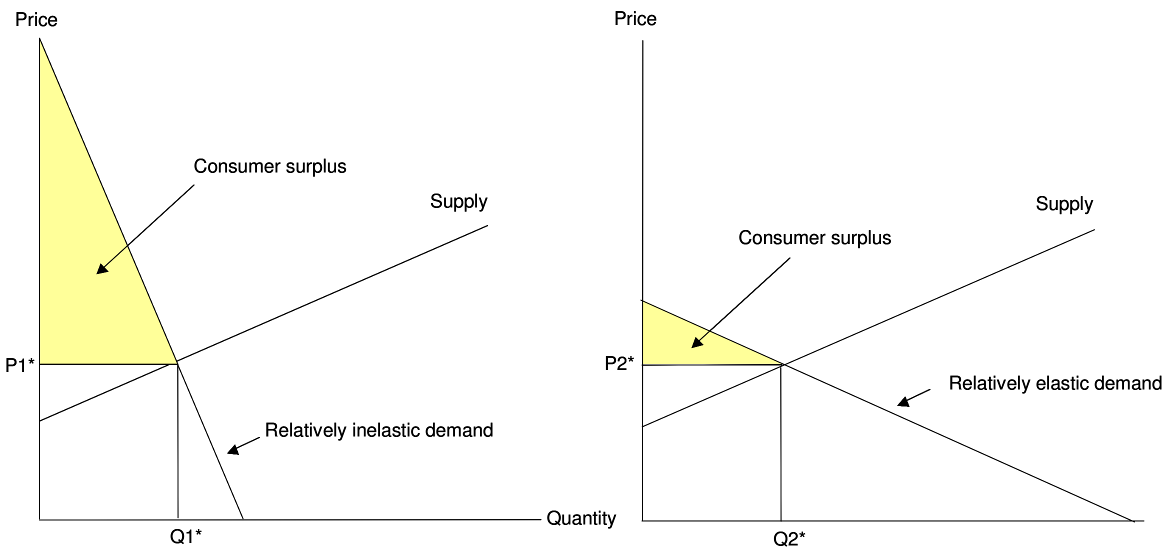

Figure 2: Consumer surplus in two illustrative air transport markets

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 1 are taken from a study by Ernst & Young (2007) that provides median values for price elasticities for specific markets but no ranges like in other studies (e.g. Gillen et al. 2003).

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. With regard to quantities the number of passenger round-trips (RT) is taken from DLR (2009). These round-trips possibly contain several legs. The data on freight tonnage one-way (OW) to and from Germany is provided by German Airports Association (ADV, 2009).

With regard to the size of specified market segments (e.g. business and leisure passengers, standard and express cargo) no published source is available. Hence, primary data collection is required. With regard to the share of business and leisure passengers on long-haul flights to and from Germany several interviews with German airlines were completed. The same source provided market-specific average airfares. The share of express freight and general cargo was determined with data provided by German airports. Interviews with German cargo airlines resulted in estimates for average freight rates. Table 1 contains the resulting parameter values for quantity, price in Euro (€) and own-price elasticity with regard to market for long-haul trips to and from Germany as well as for the air cargo market.

Table 1: Inverse demand functions for air transport markets to and from Germany 2008

	Quantity	**Price (€)**	**Own-price elasticity**	**Inverse demand function**
12.1 m Long-haul trips		Ø airfare (RT)		
Business 20%	2.4 m	4,000 €	-0.8	$p = 9{,}000 - 0.0020833 \cdot x$
Leisure 80%	9.7 m	750 €	-1.0	$p = 1{,}500 - 0.0000773 \cdot x$
3.7 m t airfreight		Ø freight rate (OW)		
Standard 67.3%	2.49 m t	1,800 € / t	-1.6	$p = 2{,}925 - 0.0004518 \cdot x$
Express 32.7%	1.21 m t	2,900 € / t	-0.8	$p = 6{,}525 - 0.0029959 \cdot x$

All inverse demand functions shown in Table 1 possess a linear curvature. 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. However, 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. The consequences of different curvatures of demand functions is exemplified in Figure 3 for short-haul 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.

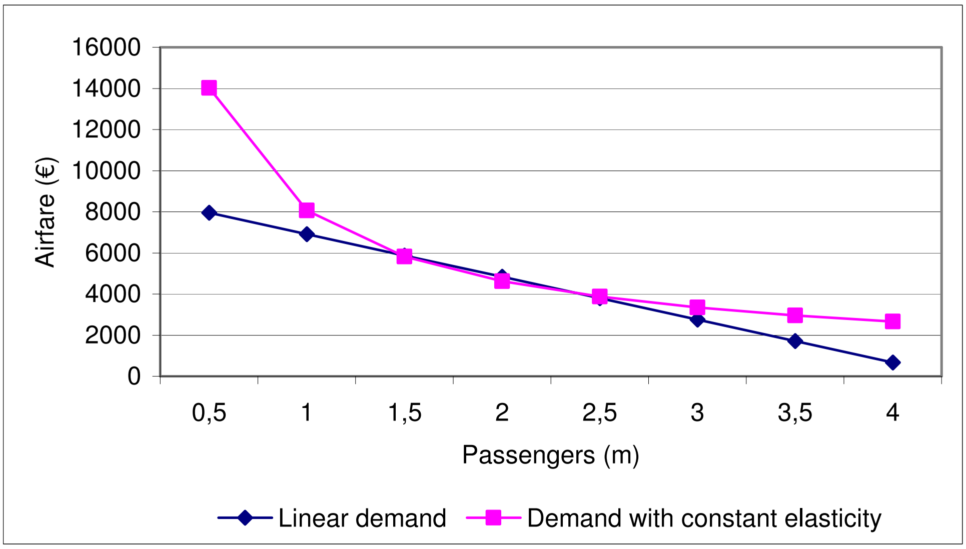

Figure 3: Linear and non-linear air travel demand (Business, long-haul to/from Germany)

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 simple solution to solve this problem is the use of an definite integral leaving out the one passenger with the highest willingness to pay. That defines a definite integral with 1 passenger as the lower limit to the equilibrium value of 5.2 m passengers as the upper limit. As long as this lower limit of integration is chosen to be a small number the non-linear demand function results in high values for aggregated consumer surplus. For this reason, the present paper assumes a linear curvature of demand function resulting in conservative estimates of aggregated consumer surplus.

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 long-haul air travel and air cargo. Long-haul is further differentiated between business and leisure segment, air cargo between express and standard. 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). Express is defined as cargo with a guaranteed or time-definite service component regardless whether it is carried by traditional cargo airlines or integrators. Further markets, i.e. 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 definite integral. Geometrically it is the area under the demand curve from zero to the equilibrium quantity minus the total market revenue. For business long-haul air travel to and from Germany the calculation is as follows:

$$\int_{0}^{2,400.000} 9{,}000 - 0.0020833 \cdot x \, dx = \left[9{,}000 \cdot x - \frac{0.0020833}{2} x^2 \right]_{0}^{2,400.000} = 15{,}600{,}096{,}000 \qquad (1)$$

The difference between € 15.6 B and € 9.6 B market revenue constitutes the consumer surplus of € 6.0 B shown in Table 2. The other values are derived in the same way.

Table 2: Consumer surplus for users of air transport to and from Germany 2008

	Revenues	**Consumer surplus**
Long-haul trips		
Business	€ 9.6 B	€ 6.0 B
Leisure	€ 7.3 B	€ 3.6 B
Airfreight		
Standard	€ 4.5 B	€ 1.4 B
Express	€ 3.5 B	€ 2.2 B

In relation to the generated revenue the aggregated consumer surplus is relatively high in markets with low own-price elasticities such as business travel and express freight. This catalytic impact adds significantly to the direct impact of these air transport markets to the national economy.

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 transporting air cargo by air to and from Germany is € 8.0 B. In addition to this direct impact there is a catalytic impact of € 3.6 B due to shippers' consumer surplus. Accordingly, revenues for long-haul trips to and from Germany amount to € 16.9 B and these trips create a consumer surplus of € 9.6 B.

Another result are simple demand functions for different segments of 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 and cargo. The application of a linear demand function leads to conservative estimates of the catalytic impacts of air transport. Further research in the appropriate curvature of the demand function is needed. 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 a 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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