International Transport Forum

# Assessing Consumer Welfare Impacts of Aviation Policy Measures

Discussion Paper

180 Roundtable

**Guillaume Burghouwt**

SEO Amsterdam Economics

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# The International Transport Forum

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# Introduction

Assessing the potential economic impacts of aviation policy measures is a recurrent topic. Examples of such policy measures are public investments in aviation infrastructure, the liberalisation of air transport markets, the introduction of aviation taxes or environmental restrictions on airport growth. In many countries, investments in aviation infrastructure are evaluated through Cost-Benefit Analysis (CBA) (e.g. CEPA, 2007; Decisio et al., 2014; Forsyth, 2013; Jorge and De Rus, 2004; UK Airports Commission, 2015). In addition, aviation policy measures/ reforms such as deregulation and environmental measures have been assessed using CBA/ welfare analysis (Booz, 2007; Forsyth, 2014a,b), although applications are less widespread.[*]

## Direct demand and travel cost effects

Within a CBA framework, an important part of the effects of aviation policy measures usually consists of the direct consumer welfare impacts or consumer surplus. In general, the focus in such analyses is on the first order consumer welfare impacts/ direct user impacts resulting from changes in travel costs (fares, travel times) and associated changes in demand. For example, liberalising a passenger aviation market may result in more airline competition. It creates a direct benefit to aviation users due to lower ticket prices, higher frequencies, more direct routes, shorter travel times and new demand generated. Alternatively, the introduction of an aviation tax is likely to have an upward impact on air fares. As a result, travel costs will rise, demand will be lost and consumer welfare is negatively affected.

## What about airline supply responses?

However, potential second order effects resulting from airline supply reactions are frequently not taken into account in such analyses. These effects can be substantial. Using the example of the air travel tax again, the decrease in demand may cause the occupancy rate of a particular flight to drop below the break-even load factor. This could force the airline to cut frequencies or cancel the route altogether, as airlines are unable to adjust capacity continuously to demand because seat capacity is “lumpy”. The airline’s flexibility to use smaller aircraft is generally limited and flight frequencies need to remain above certain thresholds to be able to compete successfully in a market.

The lumpiness of capacity can result in discontinuous supply effects that go beyond the individual flight and route level:

- Airlines may decide to close operating bases in response to policy measures (see Ryanair’s decision to close its Oslo Rygge base in response to the introduction of the Norwegian air travel tax).
- At hub airports, the typical characteristics of the airline hub operation can lead to a “domino effect” when the hub airline decides to rationalise its route network at the hub. Closure of one route results in less passenger feed to other routes to and from the hub. If the hub carrier

[*] Author affiliation on the cover was provided at the time of drafting.

cannot sustain these other routes, it will need to close them, which again affects the remaining routes in its network, etc.

- Other airlines may enter "abandoned" markets or expand capacity at existing routes.

In sum, discontinuous airline supply side reactions can leverage initial demand and consumer welfare impacts.

## Policy makers and regulators should be aware of potential second order airline supply effects

An important message of this paper is that policy makers should be aware that policy interventions in the aviation market could potentially trigger airline supply responses, which may increase the demand and welfare impacts beyond the direct, first order impacts from the policy measure itself.

Airlines themselves frequently use the argument of the risk of second order supply impacts in their advocacy and lobbying work against proposed policy measures. A proper assessment of the risk of such second order impacts is therefore useful for policy makers in their discussions with industry stakeholders.

Hence, the risk of second order supply impacts should at least be addressed qualitatively in a CBA, and preferably be quantified.

## Examples of policy measures that can trigger second order impacts

The areas in which policy measures could involve second order impacts are numerous. They cover for example the following areas:

- (De)regulation of aviation markets: deregulation of aviation markets has proved to be beneficial for consumer welfare due to enlarged competition, lower fares, better service and stimulation of demand. However, additional competition in (transfer) markets affects hub carrier market shares and profits and can trigger rationalisation/dehubbing of airline hubs.
- Introduction of air travel taxes: the introduction of air travel taxes results in higher airline costs. When these costs are (partially) passed through to the passenger by means of higher fares, demand substitution and degeneration will occur. Airlines may react to cost increases and demand reductions by moving aircraft elsewhere, up to the level of closing entire operating bases.
- Changes in airport charges, ATC costs, noise levies and security costs: if airlines at a specific airport are confronted with increases in charges/fees, the question is to what extent the airlines will absorb the cost increase and to what extent they are able to pass these costs through to the passenger. In both cases, route profitability may be affected, which can trigger airline supply reactions. In particular, at hub airports, strong supply effects may arise when the hub carrier starts to rationalise its network in response to increasing cost levels.

## A model framework to take into account first and second order effects

This paper presents an approach that estimates not only the first order demand and consumer welfare impacts due to a certain policy measure, but also potential second order supply effects. It discusses how policy makers may integrate the second order network effects in a CBA.

We first discuss the so-called NetCost generalised travel cost model to calculate first order demand and consumer welfare impacts resulting from aviation policy measures. This model is a generalised travel cost model at the individual origin-destination level, which allows for calculating demand and generalised travel cost changes as a result of certain policy measures. Special attention need to be given to the issue of cost pass-through: to what extent are airlines likely to pass on a higher cost level resulting from a policy intervention to their passengers? In addition, we argue that when assessing consumer welfare impacts in aviation, both direct and indirect travel options and their associated generalised travel costs need to be taken into account. Affected relevant markets need to be identified carefully.

Next, we argue that an assessment of consumer welfare impacts needs to determine if there are any significant, potential second order effects at stake that may arise because of airline supply responses. We introduce the Hub Network Rationalisation (HNR) model to estimate part of these second order impacts. The HNR-model iteratively estimates further demand and supply effects, including the entry of new airlines/ expansion of capacity by existing airlines as well as potential "cascade effects" at hub airports. When a stable situation has been reached, results are fed again into the NetCost model to estimate final consumer welfare impacts. The model is suitable for both non-hub and hub airports, but shows its real value when applied to typical hub airports such as Frankfurt, Atlanta, Dubai and Amsterdam.

Finally, we discuss how to integrate the presented framework in a CBA-context. We highlight important caveats as well as avenues for future work.

## Scope of the paper

This paper is limited to consumer welfare impacts of policy measures. Other impacts within a CBA-context (for example, producer surplus, wider economic benefits and environmental externalities) are outside the scope of this paper. In addition, the paper focuses on the air passenger market and not on the cargo market.

# Measuring direct consumer welfare impacts

## Consumer surplus

Consumer surplus or consumer welfare impact is a widely accepted way of quantifying changes in welfare from policy interventions. In short, consumer surplus is a concept of monetised welfare. It is the amount consumers are willing to pay for these policy interventions in excess of the actual price they pay for the service without these interventions.

In the context of connectivity and air travel, consumer surplus relates to the change in welfare resulting from a change in the generalised travel costs. The generalised travel costs include direct costs (such as ticket prices) and a valuation of travel time. To estimate the economic benefits of a policy measure, for example the introduction of an aviation tax, the change in consumer surplus/consumer welfare impact for existing demand can be calculated as a result of a change in generalised travel costs. The consumer surplus for lost or newly generated demand is calculated as the change in demand times the half of the welfare gain per passenger (the "rule of half").

There are various ways to estimate the consumer welfare impacts in aviation. They range from macro approaches, which calculate at a fairly high level of aggregation (Jorge and De Rus, 2004) to micro approaches at the individual origin-destination level (Lieshout and Matsumoto, 2012; Lieshout, 2012; Lieshout et al., 2016; Veldhuis, 2011).

### Box 1. Measuring consumer surplus using a generalised travel cost model

One example of a micro-level generalised travel cost model, specifically developed for the aviation market is NetCost (Burghouwt et al., 2016; Lieshout and Matsumoto, 2012; Lieshout, 2012; Lieshout et al., 2016; Veldhuis, 2011).

The NetCost model first identifies available direct and indirect travel options from a certain (set of) originating regions to all possible final destination regions. For example, consumers travelling by air from the region of Utrecht (The Netherlands) to Singapore have different options to travel to Singapore. They can travel via Amsterdam Airport directly with KLM or Singapore Airlines to Singapore. However, they also have the possibility to choose a multitude of indirect travel options, such as with Lufthansa via Frankfurt of with Emirates via Dubai. Travellers may also use foreign departure airports such as Brussels. Direct travel options follow directly from the OAG schedules database. Using available schedules, NetCost then builds the indirect travel options.

Next, the model estimates the generalised travel costs for each individual travel option. For each travel option, the model distinguishes between the generalised travel costs for business and leisure passengers, as these passenger segments have different time and price sensitivities. The generalised travel costs consist of:

- *Air travel time costs*: time costs of in-flight time and transfer time (in case of an indirect connection) using Values of Time. An intermediate transfer does not only result in additional travel time, but also in inconvenience. Hence, we apply an additional cost penalty to transfer time, which has been based on a calibration of NetCost on revealed passenger choice data.
- *Airfare*: NetCost estimates the airfare for each individual travel option based on a number of variables, including flight distance, market concentration/competition, carrier type (low-cost carrier or other) and type of connection (direct/indirect flight option). To estimate market concentration levels, it is important to carefully delineate the relevant market. In case of the market for the Utrecht/New York regions, we do not only consider the direct and indirect flights between Amsterdam Airport and New York JFK to be part of the relevant market, but also travel options to New York Newark and travel options via other airports in the Dutch catchment area, such as Rotterdam via Frankfurt to New York JFK. The air fare module has been estimated using observed fare data.

- *Access time costs*: access time costs are the access times multiplied by a Value of Time. Access times from each NUTS3-region are determined using car travel times in Google Maps.
- *Access user costs*: access user costs are the monetary costs for using the access mode. The current model is limited to car mode. Access user costs have been determined by multiplying costs per kilometre by access distance to the departure airport. Subsequently, we divide this amount by the average number of travellers in the car. We use a car cost per kilometre of 0.30 euro. The average number of travellers per car is set at three for non-business purposes and 1.5 for business purposes.

The estimation of the generalised travel costs in combination with flight frequency results in a utility valuation for each flight alternative. Based on the changes in these utility valuations, demand substitution and degeneration are estimated. Finally, NetCost translates the change in generalised travel costs in relation to the change in passenger numbers into a consumer welfare impact in each scenario, in comparison to a reference situation. We refer to the Annex for a more detailed description of the NetCost model.

### Direct and indirect travel options, competition and consumer welfare

A major part of the worldwide air traffic is carried by network airlines. These airlines operate hub-and-spoke networks. They serve markets with direct flights, but also with indirect flights (with a transfer at their hubs). For example, Lufthansa and Singapore Airlines compete directly, head to head on the Frankfurt-Singapore market, but also with carriers such as Emirates, KLM and Qatar Airways, which provide travel alternatives with a transfer at their respective hubs.

In a “hub-and-spoked world”, policy interventions can affect multiple markets at the same time. For example, liberalisation of air services between country A and country B, usually not only affects competition in the origin-destination (OD) market between country A and country B, but also markets between country A/B and third countries that carriers from one or both countries serve with (in)direct services via their respective hubs. For example, liberalisation of the restricted Austria-UAE air service agreement would not only affect the opportunities for Austrian Airlines/Emirates to compete in the market between Austria and the UAE, but also markets that both carriers serve indirectly via Vienna and Dubai respectively. It could allow Emirates to increase its service in the Vienna-via Dubai-Bangkok market, for example. In this market, Austrian Airlines also offers a direct flight from Vienna.

When assessing consumer welfare impacts in aviation, both direct and indirect travel options and their associated generalised travel costs need to be taken into account. Affected relevant markets need to be identified carefully.

## The issue of pass through

If airlines are confronted with a cost increase due to a certain policy measure, an important question is the extent to which airlines can pass these higher costs through to the passengers via higher air fares.

In air transport studies, it is often assumed that airlines fully pass through higher costs to the consumer on the longer term (Koopmans and Lieshout, 2016). In reality, airlines will apply different pass-through strategies, but there is little empirical evidence in relation to pass-through strategies by airlines. Koopmans and Lieshout (2016) conclude that the pass-through level strongly depends on the cost change and market conditions. In monopolistic markets, a large part of the price change may be passed through. In more competitive markets, sector-wide cost changes may also be passed through to a large extent, but not fully. In competitive markets where cost changes only affect one competitor, pass through levels are likely to be much smaller. The authors state that although a 100% pass-through is likely under perfect competition, most aviation markets are not perfectly competitive.

As there is quite some uncertainty in terms of the level of pass through of airline cost increases, it is useful to use different pass through assumptions in evaluations of policy measures involving cost changes for airlines, at least as a sensitivity analysis.

## The issue of capacity constraints

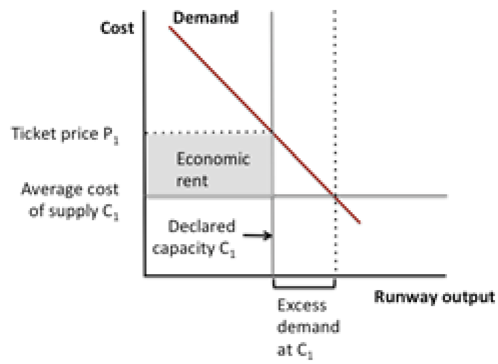
Policy measures and regulation can affect airport capacity. One can think of environmental caps that restrict the airport's annual capacity. When the demand for airport capacity exceeds the supply of airport capacity, the introduction or abolition of such a cap is likely to have positive impacts on consumer welfare.

In a situation where demand for airport capacity exceeds the supply of airport capacity, prices can be used to balance the level of demand with the capacity available. If the airport prices efficiently through its airport charges, scarcity will be reflected in higher (peak period) charges, hence in higher costs to the airlines and, in turn and depending on the market situation, in higher fares charged to passengers for travel at peak periods.

Nevertheless, regulation often prevents congested airports from clearing the market through airport charges. The sensible airline will maintain its fares at market clearing levels where airport charges are capped at a level below the market clearing rate. This will result in higher air fares. In other words, airlines will charge what the market can bear and may make excess profits on the use of scarce slots (Starkie 1998). It does not make sense for the airlines to pass on sub-optimally low airport charges in the form of lower fares for passengers (Starkie, 1998). Therefore, airlines have no incentive to compete the low airport costs away (Forsyth, 2004; Gillen and Starkie, 2016).

Hence, restrictions on airport capacity may result in negative welfare impacts for consumers due to the scarcity rents generated in case demand starts to exceed declared capacity, in addition to the impact of non-accommodated demand on consumer welfare. The other way around, lifting constraints can generate consumer benefits, as fares are expected to decrease and more demand can be accommodated.

Figure 1. Excess demand may generate economic rents




Source: ITF and SEO (2015).

## Consumer welfare impacts of allocating additional traffic rights to a third country carrier

As a simple example, we analyse the consumer welfare impacts of a policy intervention in a long-haul country-pair aviation market between a European country and a third country. The bilateral air service agreement allows the governments of both countries to designate one airline from each country to operate services on the country-pair. The bilateral agreement does not allow them to fly more than seven times per week, but they are free to set fares and choose the capacity of their aircraft.

Assume that two carriers (one from each country) compete with a daily flight on the country-pair. They operate each a transfer hub at one end. Hence, apart from the origin-destination traffic between both countries, both carriers carry a significant amount of transfer traffic beyond their own hubs. As such, they also compete on a number of markets indirectly served via their hubs. The third country carrier has requested traffic rights to operate an additional daily frequency on the route. In preparation of the air service negotiations, the government of the European country has gained insight into the potential welfare impacts of an additional daily frequency by the third country carrier.

Using the NetCost generalised travel cost model, Table 1 shows that the European country may see a consumer benefit of EUR 10 million for its own residents for a number of reasons. First, additional frequencies to the third country increase flexibility for travellers. Second, more indirectly served destinations via the third country hub become available for residents of the European country, who will benefit from shorter travel times to these destinations, as well as more flexibility. Third, fares decrease slightly due to changing competition levels in the various markets affected. Fourth, total demand in the market will be stimulated because of overall lower generalised travel costs in the market. At the same time, load factors and yields of the European country's carrier are reduced.

Table 1. Direct consumer welfare impacts of the allocation of additional traffic rights to a third country carrier (first year)

| | Reference situation | Scenario 1 | Change |
|---|---|---|---|
| **Third country carrier** | | | |
| Flights / year | 365 | 730 | 365 |
| Passengers / year | 150 000 | 243 250 | 93 250 |
| *Of which are:* | | | |
| Direct origin-destination pax | 30 000 | 43 250 | 13 250 |
| Beyond the hub pax | 120 000 | 200 000 | 80 000 |
| **European carrier** | | | |
| Flights / year | 365 | 365 | 0 |
| Passengers / year | 589 800 | 556 800 | -33 000 |
| *Of which are:* | | | |
| Direct origin-destination pax to the third country + pax to competing destinations beyond the third country carrier hub | 572 000 | 547 000 | -25 000 |
| Pax travelling indirect to third country | 17 800 | 9 800 | -8 000 |
| **Consumer welfare impacts (x mln)** | | | |
| Consumer welfare impact all passengers travelling from/to the European country | | | EUR 20.0 |
| *Of which are:* | | | |
| On local origin-destination market | | | EUR 2.3 |
| On markets beyond the third country carrier hub | | | EUR 17.7 |
| Consumer welfare impact residents European country | | | EUR 10.0 |
| *Of which are:* | | | |
| On local origin-destination market | | | EUR 1.2 |
| On markets beyond the third country carrier hub | | | EUR 8.8 |
| Impact on revenues European country carrier | | | EUR -36.0 |

Source: SEO NetCost model; OAG
Note: Total passengers per year for the European carrier relate to all passenger traffic in the markets that are affected by the entry of the third country carrier. These include the directly travelling origin-destination passengers to the third country, the passengers travelling to destinations also served indirectly by the third country carrier and passengers travelling indirectly with the European carrier (and partners) to the third country.

# Airline supply reactions

Generalised travel cost modelling can be used to estimate consumer welfare impacts of certain policy measures, as shown in the example above. However, a policy measure may also affect the revenues/ profitability of an airline supplier in the market. This could potentially trigger supply side reactions, which affect service levels, fares and demand in the market.

Let us consider again the simple example of the long-haul country-pair aviation market, where a third country carrier expands its service with seven frequencies per week (Table 1). The European carrier faces a substantial reduction of traffic and revenues, which could force the European carrier to reduce service levels or even cancel its service all together. In the case of such a second order supply response, consumers travelling in the market between the European country and the third country will be confronted with 1) lower frequency levels on the local origin-destination market and 2) increase in fares as the third country carrier is now the only supplier of direct services. Both effects increase generalised travel costs and lower the initially estimated direct consumer welfare gain.

Table 2 shows both the initially estimated consumer welfare impact in comparison to the reference situation (scenario 1), as well as the consumer welfare impacts after the second order supply reaction by the European carrier (scenario 2). Including the potential second order impacts reduces the initially estimated impacts. As the European carrier carried substantial transfer traffic on the route over its own hub and relatively limited local origin-destination traffic, the reduction of initially estimated direct consumer benefits is about 5%. This percentage can be higher on routes with more local demand or where the European carrier carries substantial traffic beyond a partner's hub as well. In addition, higher order impacts may arise if the cancelled route affects the viability of other routes in the European carrier's network because of a decrease of transfer traffic feed.

**Table 2. Direct consumer welfare impacts of the allocation of additional traffic rights to a third country carrier (first year): first and second order impacts**

| | Reference situation | Scenario 1 | Change | Scenario 2 | Change |
|---|---|---|---|---|---|
| **Third country carrier** | | | | | |
| Flights/ year | 365 | 730 | 365 | 730 | 365 |
| Passengers / year | 150.000 | 243.250 | 93.250 | 256.350 | 106.350 |
| *Of which are:* | | | | | |
| Direct origin-destination pax | 30.000 | 43.250 | 13.250 | 56.350 | 26.350 |
| Beyond the hub pax | 120.000 | 200.000 | 80.000 | 200.000 | 80.000 |
| **European carrier** | | | | | |
| Flights/year | 365 | 365 | 0 | 0 | -365 |
| Passengers/ year | 589.800 | 556.800 | -33.000 | 541.600 | -48.200 |
| *Of which are:* | | | | | |
| Direct origin-destination pax to the third country + pax to competing destinations beyond the third country carrier hub | 572.000 | 547.000 | -25.000 | 531.800 | -40.200 |
| Pax travelling indirect to third country | 17.800 | 9.800 | -8.000 | 9.800 | -8.000 |
| **Consumer welfare impacts (x mln)** | | | | | |
| Consumer welfare impact all passengers travelling from/to the European country | | | EUR 20.0 | | EUR 19.0 |
| *Of which are:* | | | | | |
| On local origin-destination market | | | EUR 2.3 | | EUR 1.3 |
| On markets beyond the third country carrier hub | | | EUR 17.7 | | EUR 17.7 |
| Consumer welfare impact residents European country | | | EUR 10.0 | | EUR 9.5 |
| *Of which are:* | | | | | |
| On local origin-destination market | | | EUR 1.2 | | EUR 0.7 |
| On markets beyond the third country carrier hub | | | EUR 8.8 | | EUR 8.8 |
| Impact on revenues European country carrier | | | EUR -36.0 | | EUR -49.0 |

Source: SEO NetCost model; OAG

Note: Total passengers per year for the European carrier relate to all passenger traffic in the markets that are affected by the entry of the third country carrier. These include the directly travelling origin-destination passengers to the third country, the passengers travelling to destinations also served indirectly by the third country carrier and passengers travelling indirectly with the European carrier (and partners) to the third country.

Discontinuous supply side reactions are generally not taken into account in a CBA, in which a more or less linear relationship between forecasted demand and the underlying network supply is assumed in the long term. In the context of consumer welfare impacts, there are a number of lumpy airline supply reactions that are important to consider as they have longer-term impacts on supply and demand at the individual airport level.

## Airline seat capacity is lumpy

In principle, airlines can reduce capacity in two ways: by reducing frequencies (including route closure) and by using smaller aircraft. As Starkie and Yarrow (2013) point out, possibilities for using smaller aircraft are generally limited due to the available fleet mix and commitments on other routes. Airlines "do not have a continuous, smooth supply function, but one that is lumpy and discontinuous". This means that airlines –when confronted with a reduction in demand cannot continuously adjust seat capacity (Starkie and Yarrow, 2013, p.10).

## Base and route closure

Supply side adjustments largely come from cutting frequencies, closing routes and sometimes closing entire bases. Low-cost carriers have shown to be particularly footloose in terms of base rationalisation and closure in response to changing policy and market conditions. Malighetti et al. (2016) found that over the period 1997-2014, at 109 out of 813 low-cost operating bases, low-cost carriers decreased their presence by at least 50%. For example, early 2016 Ryanair announced it would close its Oslo Rygge operating base in response to the Norwegian government's policy initiative to introduce an air travel tax in Norway[1]. The air travel tax is expected to result in higher total fares, affect passenger demand as well as airline revenues. Ryanair's move resulted in the airport operator's decision to fully close down the airport by 1 November 2016, because of insufficient market opportunities without the Ryanair base[2]. The Rygge example shows that policy initiatives can have consequences that are discontinuous at the individual airport level and reach further than the initially expected consumer welfare impacts.

## Dehubbing

A specific type of base rationalisation concerns hub airports. At a hub airport, a "home based" hub carrier combines various origin-destination passenger flows from, to and via (with a transfer at) the hub on the same flight. It does so with the objective of to create route density and achieve economies of density, scope and aircraft size. At hub airports, there is a possibility that initial demand effects and supply effects are further leveraged if they induce a so-called hub rationalisation effect.

At hub airports such as Frankfurt, Amsterdam, Atlanta or Dubai, the hub carrier combines various passengers travelling in a multitude of origin-destination markets on the same flight and transfers them at the central hub airport. When the hub carrier is forced to decrease capacity as a result of cost increases/demand loss, the hub carrier network may end up in a negative spiral. Cutting capacity on a route negatively affects other routes to which it provides feed. This may induce further capacity reductions on the affected routes, etcetera.

Hence, a hub rationalisation/dehubbing effect may result in less directly served destinations at the hub airport, higher travel costs for local consumers to reach affected destinations and negative consumer welfare impacts.

## New airline entry

Other airlines may intervene as a response to airline decisions to rationalise capacity in certain markets. However, entry of a new home-based hub carrier after dehubbing is not a very likely scenario. Redondi et al. (2012) have shown empirically that airports that lose their hub status do not regain their hub position in the short-medium term. This can be explained by the large (sunk) investments required and aeropolitical constraints, as well as the quick entry of low-cost carriers that occupy attractive slot pairs and create a lock-in situation. Dehubbed airports have lower traffic levels in comparison to airports that have not lost their hub function.

However, on individual markets, barriers to entry are much lower and new airline entry may take place on routes with enough demand. The same holds true for capacity expansion by competing airlines already serving an affected route. This means that second order impacts due to hub rationalisation/dehubbing/base closure on demand/consumer welfare may be softened or fully recovered because of entry of/ expansion by other suppliers.

# The hub rationalisation model

## Description of the model

We have developed a Hub Network Rationalisation (HNR) model to estimate the impact of potential lumpy airline supply decisions at a specific hub airport on consumer welfare. To our best knowledge, no other academic work has been carried out to model such effects. The model can be applied to both hub and non-hub airports, but shows its real value at typical hub airports. In this paper, we discuss the model for a typical hub airport.

The HNR-model simulates iteratively the supply reactions of the hub carrier at routes from/to the hub airport when confronted with lower passenger demand or higher costs in a single market or multiple markets it serves from, to or via the hub (i.e. local and transfer markets). In addition, the model simulates the entry of new airlines as well as capacity expansion from other airlines on routes at which that the hub carrier may cut capacity. Finally, the model calculates connectivity and welfare changes using the NetCost model, discussed earlier in this paper (see Annex).

The model consists of four main elements:

1. Input from so-called "network rationalisation scenarios". These are scenarios in which the hub carrier is faced with reduced demand in (part) of its network due to of a policy measure (e.g. an aviation tax, loss of market share due to liberalisation). As a result, it is forced to a lumpy supply decision because it cannot operate certain routes profitably anymore. In short, the hub carrier

rationalises its network. The demand reduction is exogenously given or can be estimated using the NetCost model;

2. The HNR-model iteratively simulates the hub carrier's capacity and fare decisions in response to this network rationalisation scenario. As the hub carrier carries both local origin-destination traffic and transfer traffic on the same flight, demand reduction at a specific route resulting in supply reactions on that route, will have consequences for the passenger demand level at other routes in the network. Also on these routes, the hub carrier needs to adjust supply/ fares to deal with decreased demand. This process continues until a stable situation is reached in which all remaining routes are operated with a viable load factor;
3. If the network rationalisation scenario results in capacity reductions by the hub carrier, the model assesses the feasibility of new airline entry to the abandoned route or capacity expansion by other carriers already operating on the route;
4. When a stable situation is reached, the generalised travel cost model NetCost calculates the net impacts on the airport's total traffic, in terms of passenger numbers, number of routes and number of flights. Furthermore, the NetCost model estimates changes in generalised travel costs in the network rationalisation scenario compared to the "reference situation" and calculates consumer welfare changes.

## Hub carrier responses

The HNR-model simulates which route(s) in the hub carrier's network are not profitable anymore in the network rationalisation scenario. For this purpose, we first construct the hub carrier's network[3] and passenger flows (both local origin-destination and connecting traffic) to/from and via the hub, using OAG airline schedules data and adjusted passenger booking data. As reliable revenue, cost and profit data at the individual route level are hardly available, we assume that a route becomes unprofitable when passenger demand is below the critical load factor. Hence, we feed the model with load factors, which are derived from passenger booking data and OAG airline schedules data. Critical load factors have been set at 65% and 75% for short and long-haul routes respectively, but can be adjusted if applicable[4].

The hub carrier may restore load factors by either reducing fares or capacity.

### Fare adjustments

Generally, the hub carrier will first try to restore load factors by adjusting airfares downward. Fare reductions will stimulate passenger demand and market share. However, there is a limit to the extent that fares can be reduced (if at all). In monopolised markets, there will be more room for carrier-specific fare reductions than in heavily contested markets. As we do not have insight into the (network) profitability of individual routes, we assume that the hub carrier can reduce its fares by five % in monopolised markets and by one % in heavily contested markets. These markets are defined as markets with a Herfindahl-Hirschman Index (HHI) of 0.5 or less. The maximum fare decrease increases linearly from 1% to 5% in markets with an HHI of 0.5-1.

The impact of small fare reductions in transfer markets can be substantial, as the cross-price elasticities are often high in the transfer market (SEO 2011). In contrast, in markets with low price elasticity, the impact of fare decreases will be limited.

## Capacity adjustments

If the hub carrier fails to sufficiently restore load factors by means of fare adjustments, additional capacity reductions are required. The hub carrier can reduce capacity on the route, either by using smaller aircraft or by decreasing the flight frequency (Starkie and Yarrow, 2013).

The possibilities to adjust aircraft size are limited, because the hub carrier is constrained by the available aircraft in the fleet and commitments on other routes, at least on the short term. Hence, we do not consider the use of smaller aircraft as a general applicable, feasible response in the short term.

Instead, we assume that the hub carrier will decrease the flight frequency at the route until load factors are restored. However, a lower frequency level also results in a lower attractiveness of the hub carrier in the OD and transfer markets involved, which in turn can lead to a decrease in market share and lower passenger volumes. This is taken into account by applying frequency elasticities of demand.

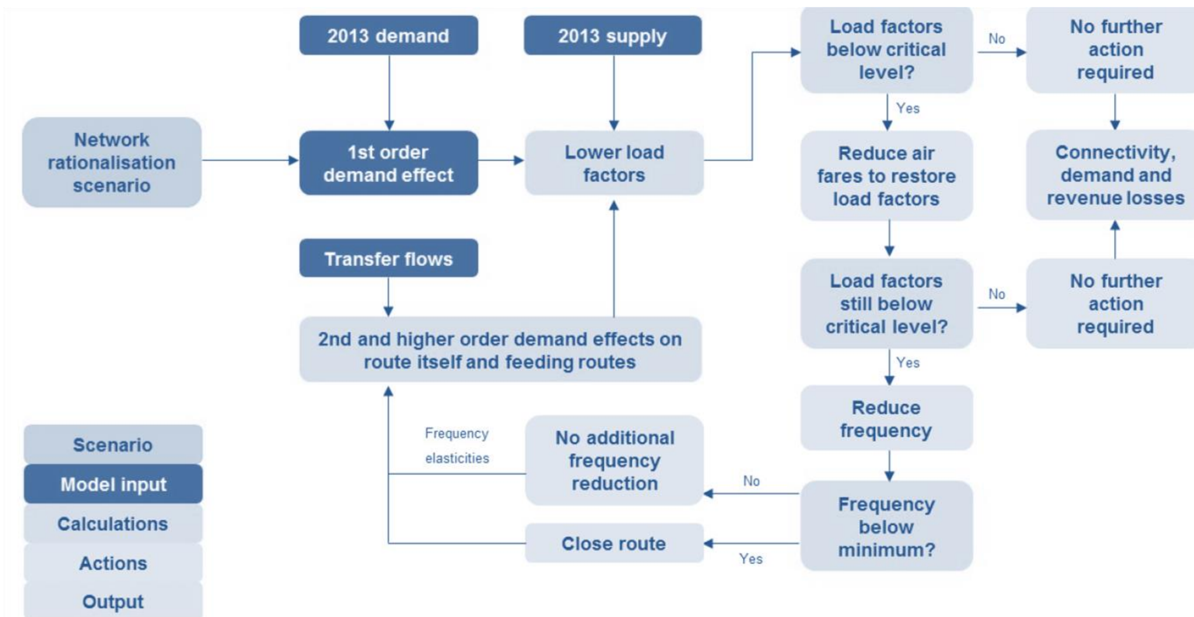
However, there is a limit to which frequencies can be reduced. Too low frequencies are not likely to be acceptable for business passengers in particular. Business passengers attach considerable value to flexibility. Hence, we assume that minimum frequencies need to be maintained in the short and long-haul network if a hub carrier wants to compete in the business market successfully. On short-haul routes (up to 3 000 km), the minimum competitive frequency has been set at a default value of ten flights per week. On long-haul routes (3 000 km or more), the minimum competitive frequency has been set at three flights per week[5]. It is assumed that a route is cancelled altogether when the frequency level drops below the minimum competitive frequency.

## Second order network effects

When a carrier adjusts fares and capacity on a certain route, not only passenger demand on this specific route is affected, but also on other routes to which it feeds (Figure 3). Because of capacity reductions at one route, the hub carrier may therefore need to restore load factors on other routes as well. The HRM-model iteratively tries to restore the load factors throughout a hub carrier's network by fare and capacity adjustments. It does so, until equilibrium has been reached and all remaining routes are above the critical load factor.

Figure 2. Modelling scheme of first and second order network effects




Source: Burghouwt et al. (2016).

## Simplified illustration of the Hub Network Rationalisation-model

To illustrate the workings of the HNR-model, let us assume that a hub carrier at a European hub airport (H) offers three destinations:

- London Heathrow (LHR): 14x/week with 100 seats per flight;
- Toronto (YYZ): 7x/week with 250 seats per flight;
- Delhi (DEL): 4x/week with 250 seats per flight;

The hub carrier at hub H is faced with increasing competition on the H-DEL route due to a government initiative to liberalise the market. The table below provides the passenger demand, capacity and load factor figures per market. For example, on the H-LHR route, 520 local and 600 transfer passengers travel weekly on the route, generating a load factor of 80%.

Table 3. Passenger demand, capacity and load factors in a simplified hub network (for illustration purposes only)

| | London Heathrow (LHR) | Toronto (YYZ) | Delhi (DEL) |
|---|---|---|---|
| Passengers weekly | | | |
| Local passengers | 520 | 575 | 100 |
| Transfer passengers | 600 | 500 | 600 |
| *LHR-H-XXX* | - | *500* | *100* |
| *YYZ-H-XXX* | *500* | - | *500* |
| *DEL-H-XXX* | *100* | *500* | - |
| **Total number of passengers** | 1 120 | 1 575 | 700 |
| **Capacity** | 1 400 | 1 750 | 1 000 |
| **Load factor** | 80% | 90% | **70%** |

Source: Burghouwt et al. (2016).

Because of increasing competition, the load factor on H-DEL decreases to 70%, well below the critical load factor of 75% for long-haul routes. Fare and frequency reductions are insufficient to restore load factors. The hub carrier therefore cancels the Delhi-route. As a result, the London and Toronto routes no longer receive feed from Delhi, which reduces passenger demand on these routes. The load factors on H-LHR and H-YYZ decrease to 73% and 61% respectively. Because the load factor on the London route remains above the critical load factor for short-haul routes, no further action is required by the hub carrier. However, the load factor at the Toronto route decreases below the critical level for long-haul routes. Additional fare and possibly capacity reductions are required to restore load factors. In case capacity reductions are needed, this will also lead to reduced feed to the London flights.

Table 4. Cancellation of the H-DEL route will have impacts on the other two routes as well

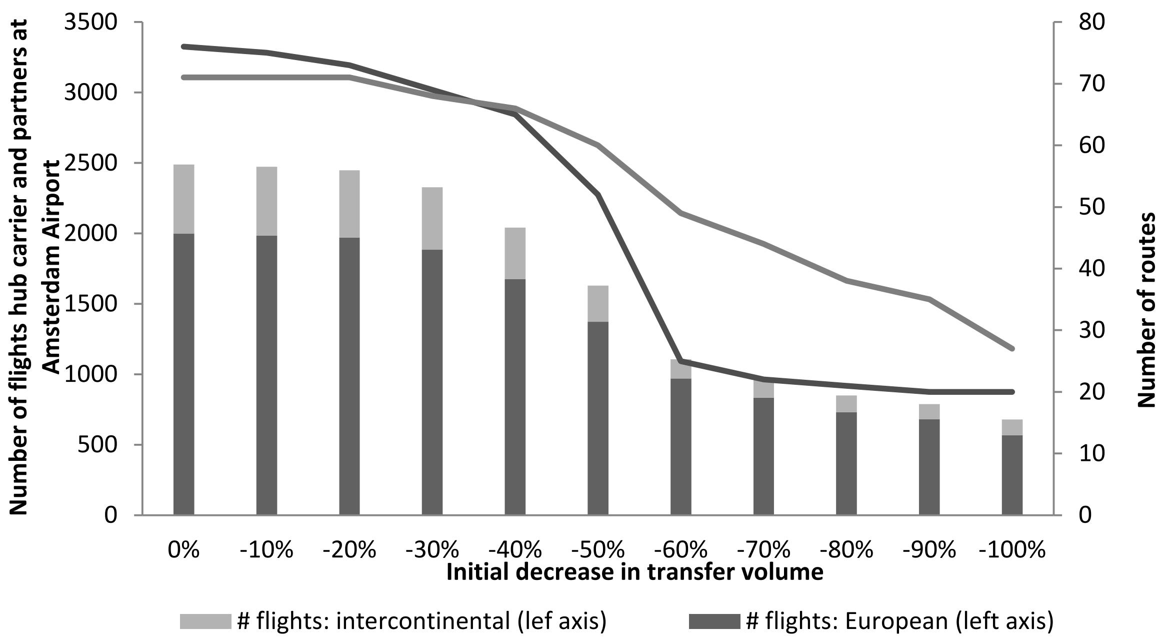
| | London Heathrow (LHR) | Toronto (YYZ) | Delhi (DEL) |
|---|---|---|---|
| Passengers weekly | | | |
| Local passengers | 520 | 575 | 100 |
| Transfer passengers | 600 | 500 | 600 |
| *LHR-H-XXX* | - | *500* | *100* |
| *YYZ-H-XXX* | *500* | - | *500* |
| *DEL-H-XXX* | *100* | *500* | - |
| **Total number of passengers** | 1 020 | 1 075 | 700 |
| **Capacity** | 1 400 | 1 750 | 1 000 |
| **Load factor** | 73% | 61% | **70%** |

Source: Burghouwt et al. (2016).

## ‘Tipping points’ in the hub carrier’s network

Figure 3 shows the potential risk of a “cascade” or “domino” effect in the hub carrier’s network when we exogenously reduce transfer demand of the hub carrier at Amsterdam Airport in a stepwise manner using the HNR-model. The hub carrier’s network is fairly robust in terms of the number of flights and number of routes up to a reduction in transfer demand of 30%. Around a 40% transfer demand reduction, a tipping point is reached, and the number of viable flights and destinations decreases quickly. When 80% of the transfer traffic is removed from the carrier’s network, the impact of a further reduction in transfer demand is much less dramatic: the situation reflects a network that is mainly supported by local origin-destination demand.

Figure 3. Tipping points in the hub carrier network rationalisation process: the example of Amsterdam




Source: HNR-model; MIDT adjusted passenger booking data for Amsterdam Schiphol; OAG data; SEO (2015)

## Other airline entry and capacity expansion

Route cancellations by the hub carrier may offer opportunities for other airlines. They can decide to enter abandoned routes or increase capacity on routes, which they already operate. Dehubbing cases around Europe (e.g. Milan Malpensa, Barcelona, Budapest) show that substantial low-cost carrier entry is likely to take place on short-haul routes (Bilotkach 2014; Lieshout et al. 2015; Redondi et al. 2012). On long-haul routes, entry and capacity expansion is more challenging, due to potential bilateral restrictions and greater need for beyond/ behind transfer passenger feed to operate a route profitably[6].

The HNR-model simulates new airline entry and capacity expansion on routes abandoned by the hub carrier and partners. The model determines if airlines are likely to take over capacity on routes abandoned by the hub carrier, based on the available local demand and potential behind and beyond transfer passenger demand. An algorithm identifies candidate airline(s) and selects the airline that can potentially deliver the highest frequency level.

Finally, this results in a new airport network in terms of routes, airlines and frequencies. This network is then compared to the reference situation to derive consumer welfare impacts, using the NetCost generalised travel cost model.

# Example of consumer welfare impacts of hub rationalisation at Amsterdam Schiphol

This section is draws on Burghouwt et al. (2016) and Lieshout et al. (2015).

## Network scenarios

We have applied the HNR-model framework to Amsterdam Airport Schiphol to determine to what extent *hypothetical* network rationalisation due to a policy intervention can potentially affect the airport's connectivity and consumer welfare[7]. For this purpose, two hypothetical network rationalisation scenarios have been defined, which are the input to the HNR-model[8].

## Non-hub scenario

In the first scenario, the hub carrier decides to close its entire hub operation at Amsterdam Airport. Amsterdam Airport becomes a non-hub airport. The remaining route network is based on the local origin-destination market. New airline entry and capacity expansion of existing airlines takes places on markets with enough demand. The operations of Air France and SkyTeam partners remain at the airport, to the extent to which these operations are still feasible without the extensive KLM-feed to the Air France and SkyTeam partner flights.

### Partial dehubbing

In the second scenario, the hub carrier rationalises its network in response to increasingly challenging market conditions. A smaller-scale hub operation is maintained. Based on Redondi et al. (2012) and the dehubbing cases of Brussels and Zurich, we assume that the initial (but not final) frequency loss in the hub carrier's network is 50%. We assume that frequency losses mainly take place at the least profitable routes. These are in our case those routes with the lowest load factors.

For each scenario, we estimate the second order network impacts using the HNR-model. In addition, we determine to what extent other carriers (incumbents and new entrants) can increase their capacity at Amsterdam Airport in response to the network rationalisation by the hub carrier, based on the available local origin-destination demand. Subsequently, we calculate total changes in consumer welfare compared to a reference scenario. The reference scenario is the network at Amsterdam Airport Schiphol in 2013, the latest year for which sufficient traffic data were available to carry out the analysis. Hence, we implicitly assume that the network rationalisation scenarios would have taken place in 2013. In addition, this means that we estimate the immediate (single year) impacts of these scenarios in comparison to the reference scenario.

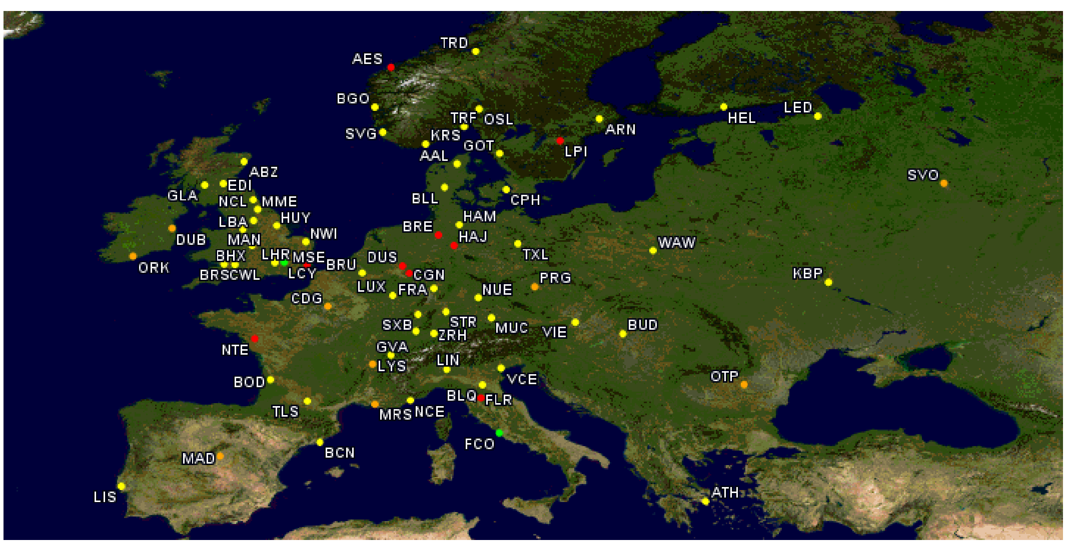
## Network impacts

### Non-hub scenario

In the non-hub scenario, the number of SkyTeam-destinations at Amsterdam Airport will decrease by 82% (Table 5). However, as other airlines will enter abandoned routes and increase capacity on existing routes (+61% in number of destinations), only a few European destinations in the 2013-network at Amsterdam will not be served anymore with direct flights (6% reduction in destinations). These are mainly low demand routes with low load factors, which provide little potential for other carriers to take over from the hub carrier. However, most of the European destinations remain available after dehubbing.

This result is in line with previous European dehubbing cases, such as Brussels, Barcelona and Milan Malpensa. Competing carriers on the hub carrier's routes continue operating after dehubbing or they may increase capacity. On other routes, new airline entry takes place. However, as Figure 4 shows, the weekly flight frequency decreases on many routes, as it was the hub operation that delivered sufficient transfer demand for multiple daily services to complement origin-destination traffic. Whereas the number of European destinations at Amsterdam Airport only decreases by 6%, the number of weekly flights decreases by 39%.

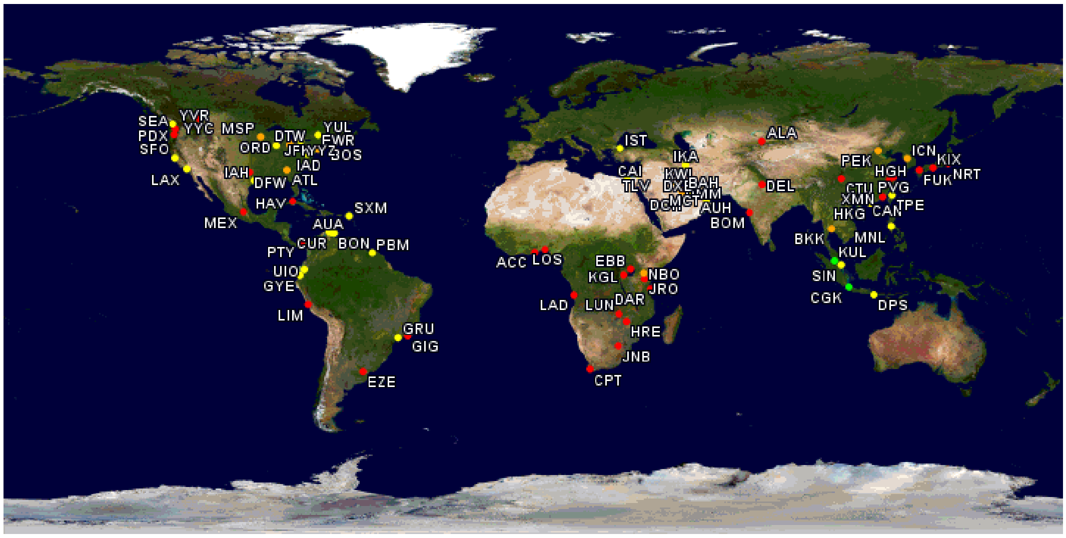
Figure 4. European hub carrier network at Amsterdam in the non-hub scenario




Note: Green: frequency SkyTeam maintained; orange: frequency SkyTeam decreases; yellow: former hub carrier/SkyTeam destination now only served by other carriers; red: direct service from AMS cancelled
Source: HNR-model

For Amsterdam's intercontinental network, implications are much more severe (Figure 5): a substantial number of intercontinental destinations will not be served directly anymore, in particular destinations in Africa and Asia. These routes heavily relied on the transfer demand carried over Amsterdam Airport, which constituted on average a 70% of total passenger volume at the intercontinental hub carrier routes. A number of destinations are only expected to be served by competing airlines following dehubbing, such as United to the United States and Emirates to Dubai. In total, we estimate that Amsterdam will lose 26% of its intercontinental direct destinations and 38% of intercontinental frequencies in the non-hub scenario.

Figure 5. Intercontinental hub carrier network at Amsterdam in the non-hub scenario




Note: Green: frequency SkyTeam maintained; orange: frequency SkyTeam decreases; yellow: former hub carrier/SkyTeam destination now only served by other carriers; red: direct service from AMS cancelled
Source: HNR-model

Table 5. Number of directly served destinations and frequencies in the non-hub scenario at Amsterdam Airport

| Routes | Type of route | Number of weekly flights | | | | | | Number of destinations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Absolute number | | | % change | | | Absolute number | | | % change | | |
| | | Hub carrier and partners | Other carriers | Total | Hub carrier and partners | Other carriers | Total | Hub carrier and partners | Other carriers | Total | Hub carrier and partners | Other carriers | Total |
| Routes served by hub carrier and partners | Europe | 315 | 1 051 | 1 366 | -84% | 90% | -46% | 11 | 55 | 62 | -85% | 67% | -13% |
| | Intercontinental | 100 | 222 | 323 | -80% | 75% | -48% | 15 | 32 | 44 | -80% | 52% | -42% |
| | Subtotal | 415 | 1 273 | 1 688 | -83% | 87% | -47% | 26 | 87 | 106 | -82% | 61% | -28% |
| Other routes | Europe | | 485 | 485 | | 0% | 0% | | 69 | 69 | | 0% | 0% |
| | Intercontinental | | 162 | 162 | | 0% | 0% | | 46 | 46 | | 0% | 0% |
| | Subtotal | | 647 | 647 | | 0% | 0% | | 115 | 115 | | 0% | 0% |
| Total routes AMS | Europe | 315 | 1 536 | 1 851 | -84% | 48% | -39% | 11 | 124 | 131 | -85% | 22% | -6% |
| | Intercontinental | 100 | 384 | 484 | -80% | 33% | -38% | 15 | 78 | 90 | -80% | 16% | -26% |
| | Total | 415 | 1 920 | 2 336 | -83% | 45% | -39% | 26 | 202 | 221 | -82% | 20% | -16% |

Note: The number of destinations offered by the hub carrier and partners and by other carriers does not add up to the total number of destinations offered at the airport. This is because there is overlap in destinations served by the hub carrier and partners and other carriers.
Source: HNR-model

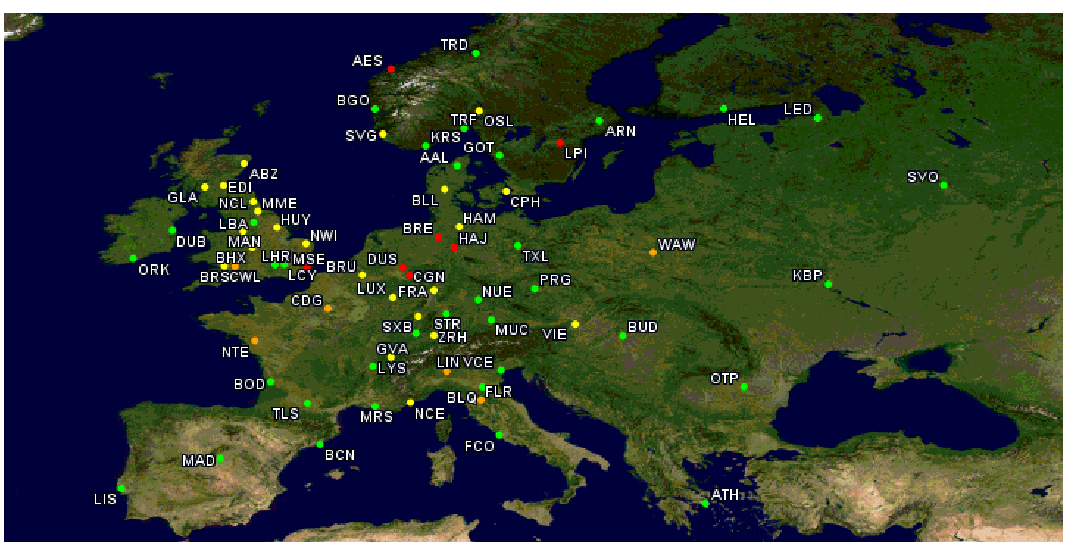
The analysis demonstrates that in particular for a large long-haul destination portfolio, a hub operation is indispensable, but less so for the European portfolio. In addition, the hub operation contributes to a much more frequent European and long-haul network than would be possible based on the local origin-destination demand alone.

## Partial dehubbing

In the partial dehubbing scenario, we estimate that the number of destinations at Amsterdam will drop by 9% and the number of frequencies by 21% in comparison to the reference scenario. In case of partial dehubbing, the hub carrier will rationalise part of its network at Amsterdam Airport, resulting in a decrease in the number of frequencies of 50%. This initial decrease will have second order impacts on the rest of the hub carriers and partners' network. In addition, it will trigger capacity growth or entry by other carriers on routes from/to Amsterdam Airport.

The model results show that the hub carrier and partners are able to maintain a major share of the European destinations, although a number of hub carrier route cancellations are expected in the United Kingdom and Scandinavia (Figure 6). The model shows that most of the destinations will be taken over by competing (low-cost) carriers. In total, the number of European destinations served by the hub carrier and partners decrease by 42%, whereas the number of European destinations served by other carriers from Amsterdam Airport increases by 27% (Table 6). The net impact on the direct European network at Amsterdam is a decrease in 5% in the number of destinations. As in the non-hub scenario, the impact on the European flight frequency is more severe, with a net decrease of 23% in total number of European flights. The average European flight frequency of the hub carrier and partners decreases from an average of 36 flights per week to 29 times per week.

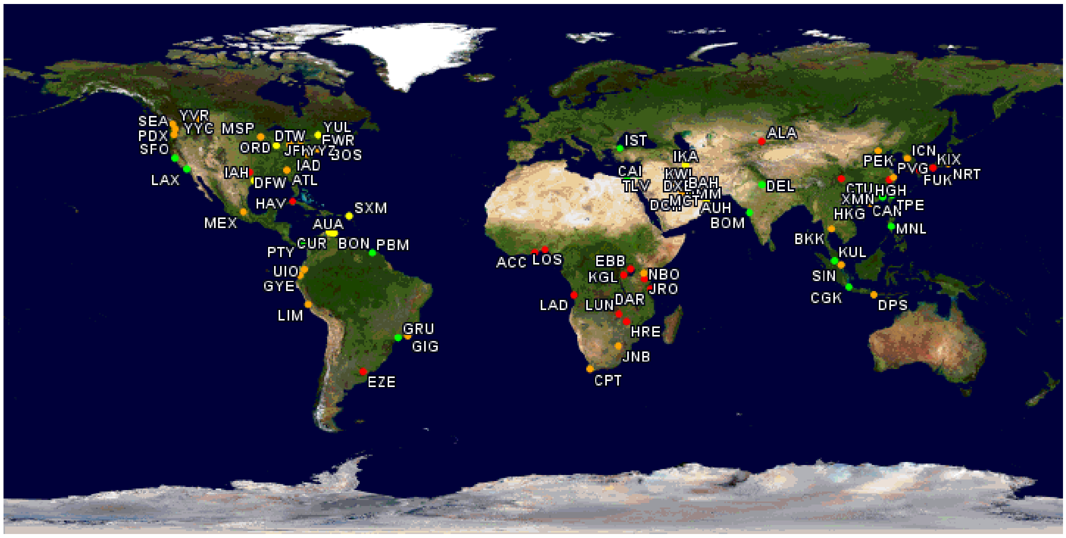
Figure 6. European hub carrier network at Amsterdam in the partial dehubbing scenario




Note: Green: frequency SkyTeam maintained; orange: frequency SkyTeam decreases; yellow: former hub carrier/SkyTeam destination now only served by other carriers; red: direct service from AMS cancelled
Source: HNR-model

Again, the connectivity impacts of a non-hub scenario are much larger for the intercontinental network than for the European network. As Table 6 shows, we estimate that the number of intercontinental destinations in the partial dehubbing scenario will decrease by 14% in comparison to the reference scenario. The number of flight frequencies drops by 15%. Amsterdam Airport will in particular lose destinations in Africa. In addition, the hub carrier will be forced to decrease frequencies on a number of routes due to the lower transfer demand in a rationalised network. Competing carriers take over or increase capacity at routes to North America, the Caribbean and the Middle East.

Figure 7. Intercontinental hub carrier network at Amsterdam in the partial dehubbing scenario




Note: Green: frequency SkyTeam maintained; orange: frequency SkyTeam decreases; yellow: former hub carrier/SkyTeam destination now only served by other carriers; red: direct service from AMS cancelled
Source: HNR-model

Table 6. Number of directly served destinations and frequencies in the partial dehubbing scenario at Amsterdam Airport

| Routes | Type of route | Number of weekly flights | | | | | | Number of destinations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Absolute number | | | % change | | | Absolute number | | | % change | | |
| | | Hub carrier and partners | Other carriers | Total | Hub carrier and partners | Other carriers | Total | Hub carrier and partners | Other carriers | Total | Hub carrier and partners | Other carriers | Total |
| Routes served by hub carrier and partners | Europe | 1 095 | 759 | 1 855 | -45% | 37% | -27% | 41 | 42 | 64 | -42% | 27% | -10% |
| | Intercontinental | 335 | 163 | 498 | -32% | 29% | -19% | 48 | 28 | 59 | -37% | 33% | -22% |
| | Subtotal | 1 430 | 922 | 2 352 | -43% | 35% | -26% | 89 | 70 | 123 | -39% | 30% | -16% |
| Other routes | Europe | | 485 | 485 | | 0% | 0% | | 69 | 69 | | 0% | 0% |
| | Intercontinental | | 162 | 162 | | 0% | 0% | | 46 | 46 | | 0% | 0% |
| | Subtotal | | 647 | 647 | | 0% | 0% | | 115 | 115 | | 0% | 0% |
| Total routes AMS | Europe | 1 095 | 1 245 | 2 340 | -45% | 20% | -23% | 41 | 111 | 133 | -42% | 9% | -5% |
| | Intercontinental | 335 | 325 | 660 | -32% | 13% | -15% | 48 | 74 | 105 | -37% | 10% | -14% |
| | Total | 1 430 | 1 570 | 3 000 | -43% | 18% | -21% | 89 | 185 | 238 | -39% | 9% | -9% |

Source: HNR-model

# Consumer welfare impacts

## Generalised travel cost changes

In both network rationalisation scenarios, connectivity levels at Amsterdam Airport are substantially affected, both in terms of the number of destinations offered, as well as the average flight frequencies.

A decrease in connectivity will result in higher generalised travel costs for consumers due to:

- The need for more indirect travel: A larger share of passengers will travel indirectly from Amsterdam as the number of direct travel options decreases. Indirect instead of direct travel involves higher time costs due to longer transfer and detour times.
- Lower frequencies: which imply a decrease in flexibility and lower available capacity.
- Increase in access costs (time and money) as passengers may have to use alternative airports in the catchment area.

The impact on fares is less straightforward: when the hub carrier and partners decrease capacity at a route or close the service, market concentration may increase, implying higher fares. When on the other hand, the hub carrier decreases capacity on markets where it had a dominant position and new (low-cost) entry takes place, fares may also decrease.

Higher net generalised travel costs will negatively affect passenger demand (distribution) at Amsterdam Airport: more passengers will use other airlines than the hub carrier, more passengers will use alternative airports in the catchment area and due to the overall increases in the cost of air travel, market degeneration will occur.

## Results

The impacts on consumer welfare are most negative in the non-hub scenario (EUR -590 million per year). The impacts in the partial dehubbing scenario are much less severe (EUR -145 million per year). Note that consumer welfare impacts relate to impacts for Dutch local residents only.

The major part of the consumer welfare change is caused by longer landside access times. Due to the lower frequencies at Amsterdam Airport, more passengers will travel to other airports in the catchment area, involving longer access times. Another part of the passengers will decide not to travel at all.

A smaller share of the welfare impact of dehubbing, but still substantial, is caused by a decrease in connectivity. More passengers will travel indirectly in one of the network rationalisation scenarios, in comparison to the reference situation. Indirect travel involves more time in the air and at the airport. Finally, the net impact on airfares is positive. Due to the decrease in capacity of the hub carrier, market concentration rises and fares increase[9].

Table 7. Consumer welfare changes in the network rationalisation scenarios (x EUR million/ year)

| | | Non-hub scenario | Partial dehubbing scenario |
|---|---|---|---|
| Effects for Dutch users of air transport services | Fare/ competition | -66 | -20 |
| | Connectivity | -154 | -46 |
| | Landside access | -370 | -78 |
| | *Total* | *-590* | *-145* |

Note: Consumer welfare changes refer to a single year and are for Dutch consumers only.
Source: Burghouwt et al. (2016).

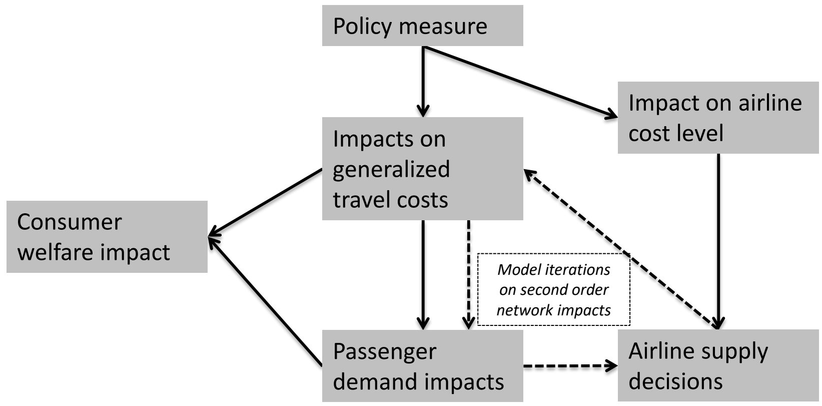
# Conclusions

First order consumer welfare impacts in aviation can be estimated using the usual transport model formulations. However, we also argue that airlines can and do make supply decisions that may have long-term discontinuous effects on generalised travel costs/ consumer welfare.

Airline seat capacity is lumpy, which may leverage demand and welfare effects. In other words, airlines cannot respond continuously to changing demand at the route level. In addition, airlines may choose to close or downsize operating bases. A specific type of operating base is the transfer hub. At hubs, network rationalisation can trigger a so-called hub rationalisation process or domino effect, as the hub carrier's flights to and from the hub are highly interrelated in terms of passenger flows. Finally, rationalisation of airline networks can trigger responses from other airlines (entry/ capacity expansion), that can alleviate initial supply effects, but may also pre-empt entry of a new hub carrier. We argue that policy makers and regulators should be aware of the risk of second order network impacts of policy interventions, address them at least qualitatively and preferably quantitatively.

This paper has presented a model framework that can be used to estimate second order network effects at hub and non-hub airports as well as the resulting consumer welfare impacts. It allows policy makers and regulators to look beyond the initial demand and welfare impacts and identify risks associated with their policy interventions, which may arise through the supply side. Figure 8 provides a general overview of how to integrate of the second order network impacts in the assessment of consumer welfare impacts.

Figure 8. Integration of airline supply responses in the assessment of consumer welfare impacts




In a regulatory/ policy context, applications of the approach are numerous and include consumer welfare impacts resulting from:

- (de)regulation of aviation markets
- greater airline competition
- changes in airport charges, ATC costs, noise levies and security costs
- changes in taxing regimes.

A number of caveats and avenues for further research apply. First, the HNR-model in its current form is suitable to analyse the impacts of network rationalisation, but not for analysing airline *network expansion*. This is a clear limitation to the current model, which can and needs to be addressed with further investments in the model.

Second, the HNR-model does not consider the opportunity costs for an airline of deploying aircraft at a certain route or base. For example, it is quite likely that Ryanair did not decide to close its Oslo Rygge base because it would not be profitable after the introduction of the Norwegian air travel tax. Rather, it has decided so because it can allocate its capacity *more profitably* elsewhere in the network. Answering such a question would require a full network and profitability analysis for every airline affected by a policy measure, which is clearly outside the reach of most modelling exercises. Instead, a scenario-wise risk analysis can be performed if there are early indications that an airline may close its operating base following a certain policy intervention.

Third, airlines have multiple instruments to restore load factors, when faced with decreasing demand. These include pricing and capacity decisions. Further research is needed to determine to what extent various types of airline use these instruments and in which order.

Finally, the HNR-model is most useful when policy measures are likely to result in discontinuous supply effects that have long-term effects on demand and consumer welfare. Such supply effects are most likely to occur where policy measures significantly increase costs and/or competition for a hub carrier which is to a large extent dependent upon transfer traffic.

# Notes

1 http://corporate.ryanair.com/news/news/160601-oslo-rygge-base-closure-16-route-cancellations-after-norwegian-govt-introduces-environmentally-friendly-tax/?market=en

2 http://www.en.ryg.no/mainpage/about-rygge/rsl

3 As well as that of the hub carrier's partner airlines.

4 An analysis of OAG and MIDT data shows that in the case of Amsterdam Airport Schiphol, the load factors of the hub carrier are generally above 65% and 75% for short- and long-haul routes respectively.

5 Based on a case study for Amsterdam Airport. See Burghouwt et al. (2016).

6 As stated earlier, "rehubbing" (or entry of a new hub carrier that replaces the old hub carrier after closure of a hub operation) is not likely for various reasons.

7 The other way around, the analysis demonstrates the current connectivity and economic contribution of the hub operation at the airport.

8 The network rationalisation scenarios in this case have not been related to a specific policy measure, but illustrate the working and application of the HNR-model. In other cases, the HNR-model has been used to evaluate welfare impacts of policy interventions.

9 As mentioned above this needs not be the case in each and every market. However, overall competition decreases and fares increase.

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# Annex: NetCost generalised travel cost model

The SEO NetCost model is a generalised travel cost model. It estimates the important inconveniences (time costs, out of pocket costs, schedule delay costs) that passenger experiences when travelling from A to B and expresses these inconveniences in monetary terms. These monetised inconveniences are labelled as the generalised travel costs.

## Construction of travel alternatives

The model uses OAG flight schedules to construct the feasible direct and indirect travel alternatives in the relevant origin-destination markets. The model then estimates the generalised travel costs for each travel alternative in an OD-market. The model distinguishes between the generalised travel costs for business and leisure passengers, as these passenger segments have different time and price sensitivities. In the context of a CBA, NetCost compares the generalised travel costs of a future airline network and demand forecast in a reference situation with the generalised travel costs of a future airline and demand forecast in various policy scenarios. NetCost translates the changes in generalised travel costs (and changes passenger numbers) into a consumer welfare impact in each policy scenario, in comparison to a reference situation.

The NetCost model was first presented in Heemskerk and Veldhuis (2006a, 2006b) and further developed by Veldhuis and Lieshout (2009). We provide a brief description of the model at an airport-pair market basis below. We refer to Lieshout et al. (2016) for a more detailed description of the NetCost model version used in this paper.

## Market shares

NetCost contains a disaggregated passenger itinerary share module, which measures the attractiveness of individual travel alternatives and hence their market share. The market share of a specific hub or airline in a specific market depends on the available travel alternatives and on the relative attractiveness of these alternatives vis-à-vis competing alternatives.

The attractiveness of individual travel alternatives is expressed by the frequency levels and the "generalised travel costs" of all the alternatives. Generalised travel costs are representations of all travel inconveniences the passenger perceives while travelling.

## Generalised travel costs

The generalised travel costs consist of air fares (*fare*), time costs ($GC_{time}$) and schedule delay costs and ($GC_{frequency}$).

$GC = fare + GC_{time} + GC_{frequency}$

*Air fare component of the generalised travel costs*

A fare module determines the expected average fares for each travel option, for both business and leisure trips. The fare module was econometrically estimated using MIDT fare data for the markets from/to and via Amsterdam Airport for 81 million leisure and 63 million business passenger trips.

$$Fare=\beta_0+\beta_1\cdot t_{nonstop}+\beta_2\cdot t_{nonstop}^2+\beta_3\cdot \ln(freq)+\beta_4\cdot HHI+\beta_5\cdot D_{LCC}+\beta_6\cdot D_{indirect}$$

where $t_{nonstop}$ is the (theoretical) non-stop travel time, *freq* is the offered frequency of the connection, *HHI* the Herfindahl-Hirschman market concentration index using the offered frequency of each connection, $D_{LCC}$ is a dummy if the travel option is offered by a low-cost carrier and $D_{indirect}$ is a dummy if the travel option is an indirect option with a transfer at an intermediate hub airport.

## Travel time component of the generalised travel costs

The travel time costs for direct flights are sourced from the OAG schedules database. Indirect travel alternatives involve additional travel time compared to direct alternatives. Both because of the circuitous flight and the transfer at the intermediate hub. Circuity flight time is defined as the time difference between the total indirect flight time and the (hypothetical) non-stop travel time. The transfer time is defined as the time spent at an intermediate airport. The transfer time follows from the airline schedules. Circuity time and transfer time are perceived with a higher degree of inconvenience than in-flight time, therefore penalties are applied to both circuity and transfer time. These penalties are assumed to decrease with distance. This means that a larger penalty factor remains for short-haul routes and a smaller one for long-haul routes. The difference between the penalty factors for short and long-haul routes is justified by the fact that one hour of circuity leads to relatively more inconvenience on a short-haul than on a long-haul travel option.

The same argument holds for connecting time, although the penalty factor for connecting time is overall slightly higher, as connecting time is perceived to be more inconvenient than circuity time.

$$GC_{time}=VoT*(t_{nonstop}+\phi_{circuity}\cdot\left(3-0{,}075\cdot t_{nonstop}\right)\cdot(t_{fly}-t_{nonstop})+\phi_{transfer}\cdot\left(3-0{,}075\cdot t_{nonstop}\right)\cdot t_{transfer}$$

where VoT is the Value of Time, $t_{nonstop}$ is the (theoretical) non-stop travel time, $t_{fly}$ is the total in-flight time of the travel alternative, $\phi_{transfer}$ is an additional penalty of circuity of indirect connections, $\phi_{transfer}$ is an additional penalty for the discomfort of waiting at the hub airport and $t_{transfer}$ is the transfer time.

The values of time for business passengers are higher than those of leisure passengers. The penalty factors and values of time were calibrated using MIDT data for the markets served from and via Amsterdam Airport Schiphol.

## Schedule delay cost component of the generalised travel costs

Flights usually do not depart exactly at the time desired by the passenger. The schedule delay is the difference between the departure time preferred by the passenger and the actual departure time. Schedule delay decreases when the flight frequency increases. The costs associated with schedule delay equal the schedule delay (in hours) time multiplied by the value of waiting time for the next flight. We estimate the schedule delay or generalised travel cost component of frequency as follows:

$$GC_{freq}=VoWT\cdot\left(3{,}96-0.07\cdot freq_{total}\right) \text{ if } freq_{total}<28$$

$$GC_{freq}=VoWT\cdot\left(\frac{56}{freq_{total}}\right) \text{if } freq_{total}\geq 28$$

Where $GC_{freq}$ is the schedule delay component of the generalised travel costs, VoWT is the Value of Waiting Time and $freq_{total}$ is the total offered frequency in the origin-destination market.

## Consumer value

After the generalised travel costs (GC) are calculated, a utility function is used to determine the Consumer Value (CV), having as base the frequency (*f*). A cost sensitivity parameter α is included. After calibrating the model, we find that α=0.01 for business passengers and α=0.015 for leisure passengers are the most appropriate values. The consumer value for route alternative *i* ($CV_i$) is given by:

$$CV_i=freq\cdot e^{-\alpha\cdot GC_i}$$

Market shares of route alternatives are estimated using these consumer values. The market share of a route alternative *i* is given by:

$$MS_i=\frac{CV_i}{\sum_j CV_j}$$

## Consumer welfare changes

Consumer welfare changes in the two scenarios in comparison to the reference scenario are estimated at the origin-destination market level. The difference in generalised travel costs between the two scenarios gives the welfare gain per passenger in each market. We compute the total consumer welfare change for each OD market by applying the so-called "rule of half": the welfare change per passenger is multiplied by the number of OD-passengers in the respective market in the reference scenario. The number of new passengers – which do not in the reference scenario but do not travel in the network rationalisation scenario – is multiplied by half of the welfare gain per passenger.

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# Assessing Consumer Welfare Impacts of Aviation Policy Measures

This paper presents a model framework for estimating second-order network effects and the resulting consumer welfare impacts at hub and non-hub airports. It emphasizes the benefits of looking beyond the initial demand and welfare impacts and identifying risks associated with policy interventions which may arise through the supply side.

Resources from the Roundtable on Assessing Regulatory Changes in the Transport Sector are available at:
www.itf-oecd.org/assessing-regulatory-changes-roundtable

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