# Focus on benefits: assessing consumer welfare impacts of aviation policy measures

## Airline responses, lumpy capacity and hub rationalization

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# INTRODUCTION

Assessing the potential economic impacts of aviation policy measures is a recurrent topic. Examples of such policy measures are the liberalization of air transport markets, 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 & De Rus 2004; UK Airports Commission 2015). Also 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** resulting from changes in travel costs (fares, travel times) and associated changes in demand. For example, liberalizing 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.

## But 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 minimum flight frequency levels are important for operating competitively 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 rationalize its route network at the hub. Closure of routes at the hub results in less passenger feed to other routes to/from the hub. If the hub carrier cannot sustain other routes anymore, there will be again less feed for another set of routes, etcetera;
- Other airlines may enter 'abandoned' markets or expand capacity at existing routes.

In sum, discontinuous airline supply 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 can potentially trigger airline supply responses, which may cause demand and welfare impacts that are larger than the direct, first order effects from the policy measure itself. Airline seat capacity is lumpy, which means that airlines find it difficult to adjust capacity continuously to demand. In other words, airlines can and do make discontinuous changes in their networks, which may result in second order demand and consumer welfare impacts. At the same time, reduction of capacity by one airline, may provide opportunities for others.

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

Hence, the risk of second order supply effects should be at least 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:

- (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 rationalization/dehubbing of airline hubs.

- Introduction of air travel taxes: the introduction of air travel tax generally results in higher total fares for passengers, demand substitution and degeneration. Airlines may react to such drop in demand 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 rationalize its network in response to increasing cost levels;

- Impact of the regulation of environmental externalities through caps on airport capacity.

## 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 as a result of a certain policy measure, but also potential second order supply effects. It discusses how policy makers can integrate such an approach in a CBA of specific policy/regulatory measures.

We first discuss the so-called NetCost methodology to calculate first order demand and consumer welfare impacts resulting from aviation policy measures. This model is a generalized travel cost model at the individual origin-destination level, which allows for calculating demand 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 generalized 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 Rationalization (HNR) model 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 effects within a CBA-context (for example, producer surplus, wider economic benefits, environmental externalities) are largely outside the scope of this paper. In addition, the paper is focused 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 monetized 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 as a result of a change in the generalized travel costs. The generalized 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 generalized 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 do calculations at a fairly high level of aggregation (Jorge & De Rus 2004) to micro approaches that estimate changes in generalized travel costs, demand redistribution over various travel options and demand (de)generation at the individual origin-destination level (Burghouwt et al. 2016; Lieshout & Matsumoto 2012; Lieshout 2012; Lieshout et al. 2016; Veldhuis 2011).

**Measuring consumer surplus using a generalized travel cost model**

One example of a micro-level generalized travel cost model, specifically developed for the aviation market is NetCost (Burghouwt et al. 2016; Lieshout & Matsumoto 2012; Lieshout 2012; Lieshout et al. 2016; Veldhuis 2011). The NetCost model 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. But they have also the possibility to choose a multitude of indirect travel options, such as with Lufthansa via Frankfurt of with Emirates via Dubai. Travelers 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 generalized travel costs for each individual travel option. For each travel option, the model distinguishes between the generalized travel costs for business and leisure passengers, as these passenger segments have different time and price sensitivities. The generalized 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 Utrecht-region/ New York-region, 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 kilometer by access distance to the departure airport. Subsequently, we divide this amount by the average number of travelers in the car. We use a car cost per kilometer of 0.30 euro. The average number of travelers per car is set at three for non-business purposes and 1.5 for business purposes.

NetCost then translates the change in generalized 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 Burghouwt et al. (2016) or Lieshout et al. (2016) for a detailed description of the NetCost model.

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

In relation to consumer welfare impacts and policy measures, it is important to note that 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 close substitutes with a transfer at their respective hubs.

Hence, in a 'hub-and-spoked world', policy interventions can affect multiple markets at the same time. For example, liberalization of air services between country A and country B, usually not only affects competition in the origin-destination 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, liberalization 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 generalized 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 for the resulting consumer welfare impact (as well as the distribution of costs between consumers and producers) is the extent to which airlines pass through higher costs 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, whereas in more competitive situations, sector-wide cost changes may also be passed through to a large extent, but not fully. In competitive situations 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.

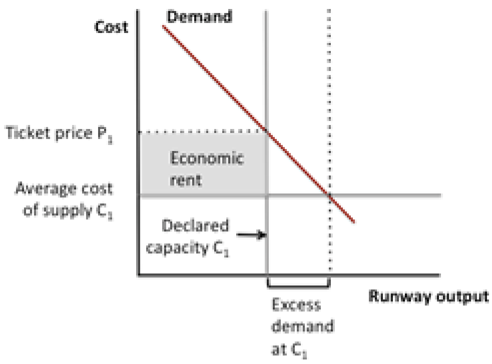
## The issue of capacity constraints

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 an environmental cap is likely to have impacts on consumer welfare.

In a situation where demand for airport capacity exceeds the supply of airport capacity, prices would 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.

But for various reasons congested airports may not be able to clear the market through airport charges (Starkie 2008). 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. If they were to do so, service quality would deteriorate. Specifically, a growing number of customers would be unable to obtain a booking at posted prices (Starkie 1998). So airlines have no incentive to compete the low airport costs away (Forsyth 2004; Gillen & 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. The other way around, lifting constraints can generate consumer benefits, as fares can be expected to decrease.

Figure 1.1. **Excess demand may generate economic rents**




*Source:* ITF & SEO (2015)

## Example: 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 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 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 generalized travel cost model, table 1.1 shows that the European country may see a consumer benefit of EUR 9 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. At the same time, load factors and yields of the European country's carrier are likely to be reduced.

Table 1.1. **Direct consumer welfare impacts of the allocation of additional traffic rights to a Third Country carrier (first year)**

| | Reference situation | Change | Scenario |
|---|---|---|---|
| **Third country carrier** | | | |
| Flights/ year | 365 | 365 | 730 |
| Passengers / year | 146 553 | 58 060 | 204 613 |
| *Of which are:* | | | |
| Direct origin-destination pax | 45 041 | 8572 | 53 613 |
| Beyond the hub pax | 101 512 | 49 488 | 151 000 |
| | | | |
| **European carrier** | | | |
| Passengers/ year | 595 351 | -26 969 | 568 382 |
| *Of which are:* | | | |
| Direct origin-destination pax to the Third Country + pax to competing destinations beyond the Third Country carrier hub | 574 960 | -19 592 | 555 368 |
| Pax travelling indirect to Third Country | 20 391 | -7 377 | 13 014 |
| | | | |
| **Consumer welfare impacts** | | | |
| Consumer welfare impact all passengers travelling from/to the European country | | EUR 19.7 million | |
| Consumer welfare impact residents European country | | EUR 9.9 million | |
| Impact on revenues European country carrier | | -22% | |

*Source:* SEO NetCost model; OAG

## AIRLINE SUPPLY REACTIONS

Generalized 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 trigger further supply side reactions, which affect service levels, fares and demand in the market. Such supply side reactions are generally not taken into account. In the context of consumer welfare impacts, there are a number of airline supply reactions that are important to consider.

### Airline seat capacity is lumpy

Airline seat capacity is lumpy. This means that airlines –when confronted with a demand loss, higher costs or both- may not be able to continuously adjust seat capacity to changing market conditions (Starkie 2013). In principle, airlines can reduce capacity in two ways: by reducing frequencies (including route closure) and by using smaller aircraft. As Starkie (2013) points 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’ (Starkie 2013, p.10).

Supply side adjustments largely come from cutting frequencies, closing routes and sometimes closing entire bases. Reducing frequency levels or closing routes will again affect demand. In other words, discontinuous airline supply reactions can leverage initial demand and consumer welfare impacts.

## Rationalization and closure of airline operating bases

Welfare impacts of policy interventions can also be discontinuous because of base rationalization and base closure. Airlines generally operate out of operating bases, of which some are used as transfer hubs, whereas most are used for stabling aircraft overnight, and as crew and maintenance bases.

Low-cost carriers have shown to be particularly footloose in terms of base rationalization 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 to close its Oslo Rygge operating base in response to the Norwegian government’s policy initiative to introduce an air travel tax in Norway. 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, because of insufficient market opportunities without the Ryanair base.

The Rygge example shows that policy initiatives can have consequences that are discontinuous and reach much further than the initially expected consumer welfare impacts.

## Hub rationalization

A specific type of base rationalization 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 to 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 rationalization effect.

At a hub airports such as Frankfurt, Munich, Amsterdam, Singapore, 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 a number of routes in the network with a large number of transfer passengers will negatively affect the traffic feed to other routes in its network, possibly to the point that those routes cannot be operated viably anymore and need to be closed as well. These route closures will again affect other routes in the network. This hub rationalization 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 step in in response to airline decisions to rationalize route networks/ exit certain markets and of scarce slots becoming available at congested (hub) airports. Entry of a new home based hub carrier after dehubbing is not a very likely scenario though[1]. 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.

But 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 rationalization/ dehubbing/ base closure on demand/consumer welfare may be ‘softened’ due to entry of/ expansion by other suppliers.

# THE HUB RATIONALIZATION MODEL

## Description of the model

We have developed a so-called ‘Hub Network Rationalization’ (HNR) model to estimate the impact of the lumpy airline supply decisions 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. Here, 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/ 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 to/from the hub that the hub carrier may decide to abandon. Finally, the model calculates connectivity and welfare changes using the NetCost model, discussed earlier in this paper.

The model consists of four main elements:

1. Input to the model are so-called network rationalization scenarios. These are scenarios in which the hub carrier is faced with reduced demand in (part) of its network as a result of a policy measure (e.g. an aviation tax, loss of market share due to liberalization). As a result, it is forced to a lumpy supply decision because it cannot operate certain routes profitably anymore. In short, the hub carrier rationalizes 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 rationalization 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. In case of substantial demand reductions, a ‘tipping point’ in the

[1] Redondi et al. (2012) in their worldwide study on dehubbing found that at dehubbed airports, virtually no ‘rehubbing’ has taken place.

hub network may be reached, resulting in a partial collapse of the hub carrier's network;
3. If the network rationalization scenario results in route closures 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 model calculates the net impacts on the airport's total traffic and connectivity, in terms of passenger numbers, number of routes, number of flights, direct and indirect connectivity. Furthermore, the model estimates changes in generalized travel costs in the network rationalization 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 rationalization scenario. For this purpose, we first construct the hub carrier's network[2] 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[3].

The hub carrier can react in different ways to a demand reduction at a certain route that brings the route's overall load factor below the critical load factor as set in the model.

### *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 to which fares can be reduced (if at all). In monopolized markets, there will be more room for 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 monopolized markets and by one % in heavily contested markets. These markets are defined as markets with an Herfindahl-Hirschman Index (HHI) of 0.5 or less. The maximum fare decrease increases linearly from one % to five % in markets with an HHI between 0.5 and one.

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 realize the required increase in load factors by means of fare adjustments, the hub carrier can decide to adjust the capacity on the route to achieve a better balance between offered capacity and available demand, either by using smaller aircraft or by decreasing the flight frequency (see also Starkie 2013).

[2] As well as that of the hub carrier's partner airlines.

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

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 on the short term.

Instead, we assume that the hub carrier will decrease the flight frequency at the route until load factors are restored or the minimum competitive frequency level is reached. This response may lead to a better balance between seat supply and passenger demand.

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. In addition, 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 if a hub carrier wants to compete in the business market successfully, minimum frequencies need to be maintained in the short- and long-haul network. On short-haul routes (up to 3 000 kilometer), the minimum competitive frequency has been set at a default value of ten flights per week. On long-haul routes (3 000 kilometer or more), the minimum competitive frequency has been set at three flights per week[4].

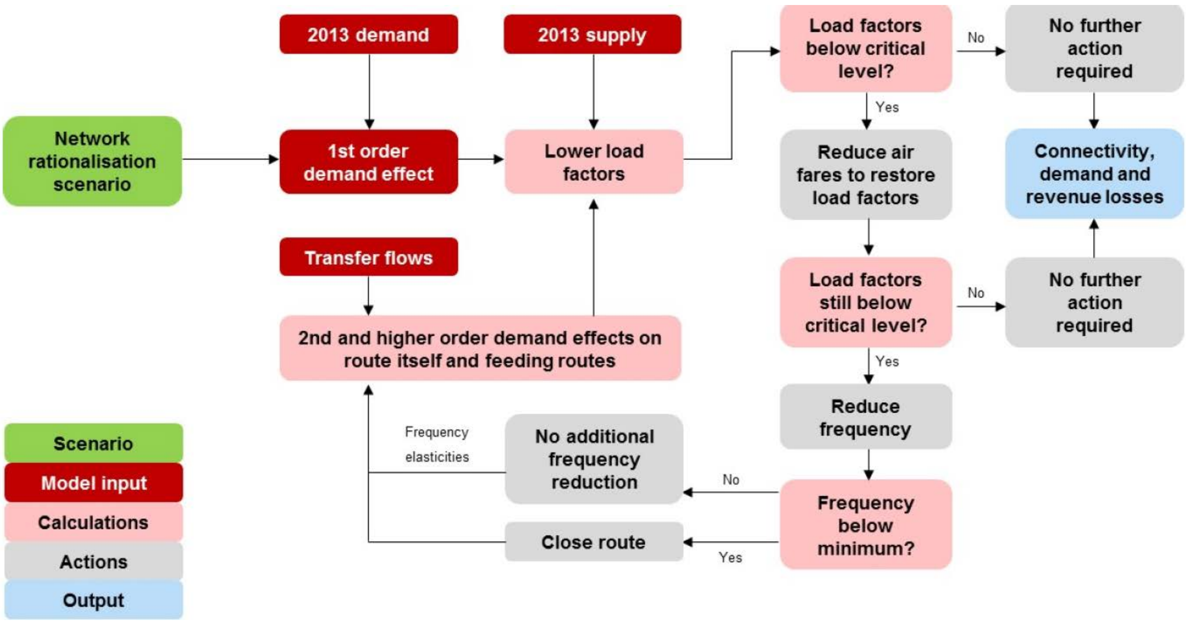
We assume that the hub carrier will cancel a route when load factors are still below the critical load factor after both fare and capacity adjustments**.**

### *Second order network effects*

When a carrier adjusts fare, capacity or cancels a route altogether, not only the passenger demand at this specific route is affected, but also other routes to which the specific routes feeds passengers to/from (figure 1.3). As a result of demand reductions at one route, the hub carrier may need to restore load factors on other routes as well. The HRM-model iteratively tries to restore the load factors at the initially affected route by fare and capacity adjustments as well as on other subsequently affected routes. It does so, until equilibrium has been reached and all remaining routes are above the critical load factor.

Figure 1.2. **Modelling scheme of first and second order network effects**

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




*Source:* Burghouwt et al. (2016)

## Simplified illustration of the HNR-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 liberalize the market. Passenger demand decreases. 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 1.2. **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)

As a result of increasing competition, the load factor on H-DEL decreases to 70%. Assuming that this is not a profitable load factor and we assume that the hub carrier has no other option than to cancel the Delhi-route (because fare and capacity adjustments do not deliver the required increase in passenger numbers), also the transfer demand between LHR and DEL and between YYZ-DEL will disappear. The load factors on H-LHR and H-YYZ will decrease to 73% and 61% respectively. Again, the hub carrier will need to restore passenger demand at these routes as well.

Table 1.3. **Cancellation of the H-DEL route will have impacts on the other two routes as well**

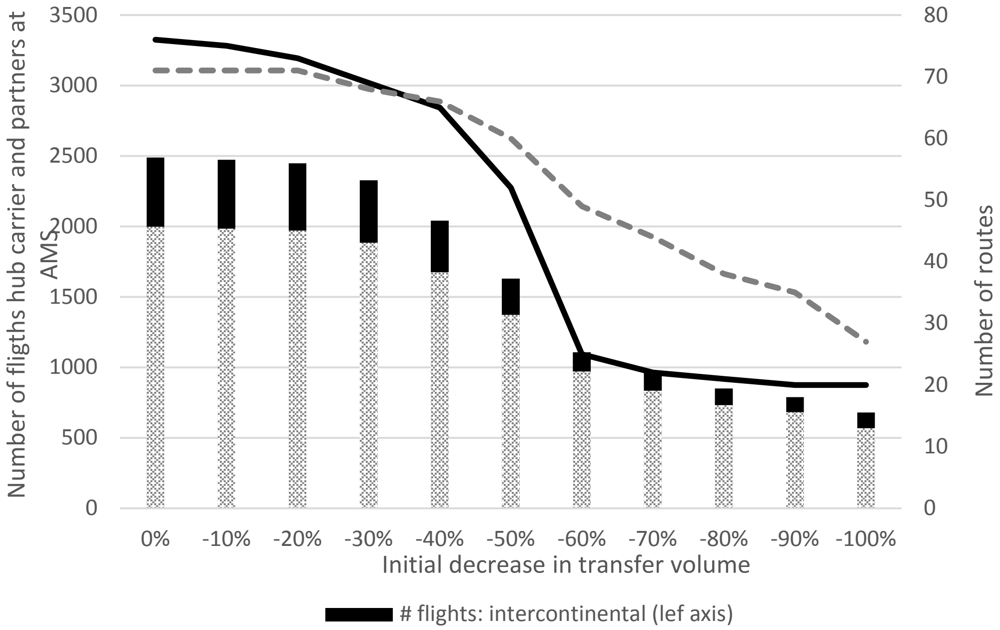
| | London Heathrow (LHR) | Toronto (YYZ) | Delhi (DEL) |
|---|---|---|---|
| Passengers weekly | | | |
| Local passengers | 520 | 575 | ~~100~~ |
| Transfer passengers | 600 | 500 | ~~600~~ |
| *LHR-H-XXX* | - | *500* | ~~*100*~~ |
| *YYZ-H-XXX* | *500* | - | ~~*500*~~ |
| *DEL-H-XXX* | ~~*100*~~ | ~~*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

Because of the feeder relations between the different routes in the hub carrier's network, the HNR-model simulations show a 'tipping point' in case of a hub network that is highly dependent on transfer traffic and is confronted with a substantial demand reduction. When the 'tipping point' has been reached, the hub network deteriorates quickly with additional loss of transfer traffic until a more or less stable situation is reached. The network in the latter situation is mainly supported by the local origin-destination demand from and to the hub.

Figure 1.3. **Tipping points in the hub carrier network rationalization process: the example of Amsterdam**




*Source:* HNR-model; MIDT adjusted passenger booking data for Amsterdam Schiphol; OAG data

Figure 1.3 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.

### 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[5].

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.

Based on a certain network rationalization scenario, the HNR-model estimates the impact on the hub carrier's network and simulates new airline entry/ expansion. The final result is 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 generalized travel cost model.

## EXAMPLE OF CONSUMER WELFARE IMPACTS OF HUB RATIONALIZATION AT AMSTERDAM SCHIPHOL[6]

### Network scenarios

We have applied the HNR-model framework to Amsterdam Airport Schiphol to answer the question to what extent *hypothetical* network rationalization due to a policy intervention can potentially affect the

5 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.

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

airport's connectivity and affect consumer welfare[7]. For this purpose, two hypothetical network rationalization scenarios have been defined, which are the input to the HNR-model[8].

### *Non-hub 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. 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. With the HNR-model, we determine the feasibility of the Air France and SkyTeam-partner operations at Schiphol. When the hub carrier closes its hub operation, part of the local traffic will be handled by other incumbent and new entrant carriers, both low-cost airlines and network carriers. Using the model described in the previous section, we determine to what extent other carriers can increase their capacity at Amsterdam after closure of the hub operation.

### *Partial dehubbing*

The hub carrier and SkyTeam-partners rationalize their network at Amsterdam Airport 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 and total frequency loss at the airport level are 50% and 20% respectively. 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. In addition, we determine using the HNR-model to what extent other carriers (incumbents and new entrants) can increase their capacity at Amsterdam Airport in response to the network rationalization by the hub carrier, based on the available local origin-destination demand.

For each scenario, we estimate the second order network impacts using the HNR-model. In addition, we calculate total changes in consumer welfare using NetCost.

We compare the impacts 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 rationalization 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/ base case.

## Network impacts

#### *Non-hub scenario*

In case of a non-hub scenario at Amsterdam Airport, the SkyTeam number of destinations of SkyTeam (hub carrier and partners) will decrease by 82% (Table 1.4). 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 (- six % in number of 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.

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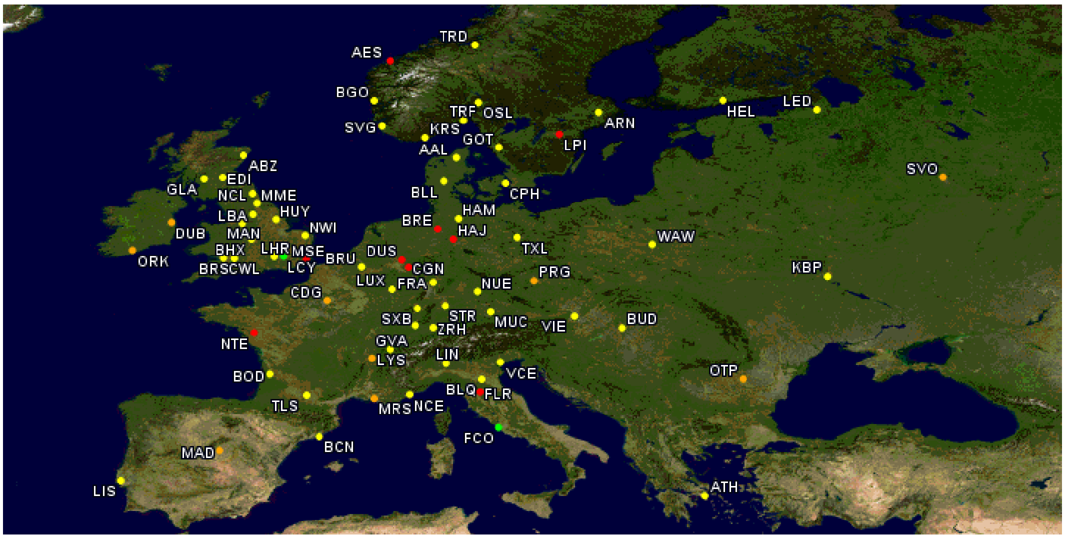
[7] The other way around, the analysis demonstrates the current connectivity and economic contribution of the hub operation at the airport.

[8] The network rationalization scenarios have in this case 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.

This result is in line with the experience at European dehubbing cases that took place in the past, 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 1.4 and Figure 1.5 show, 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 six %, the number of weekly flights decreases by 39%.

Figure 1.4. **European hub carrier network at Amsterdam in the non-hub scenario**

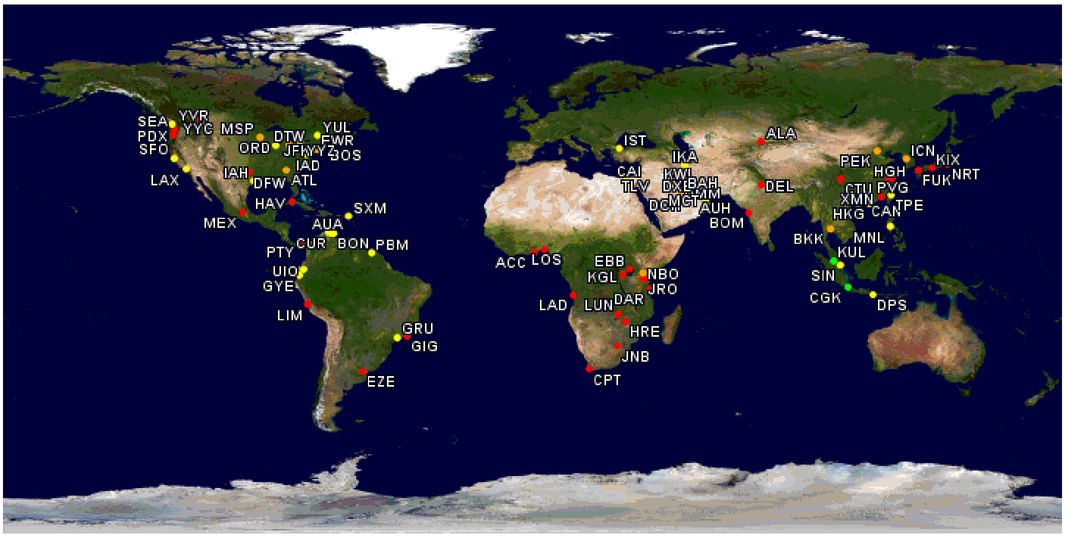



*Note:* Green: frequency SkyTeam maintained; orange: frequency SkyTeam decreases; yellow: former hub carrier/SkyTeam destination now only served by other carriers; red: direct service from AMS cancelled

*Source:* HNR-model

For the intercontinental network of Amsterdam, implications are much more severe (Figure 1.5). In case of full dehubbing, 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 constitutes on average a 70% of total passenger volume at the intercontinental hub carrier routes. A number of destinations is expected to be only served by competing airlines following dehubbing, such as United to the US 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 1.5. **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*

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.

Table 1.4. **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** | | |
| | | Hubcarrier 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 & 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% |

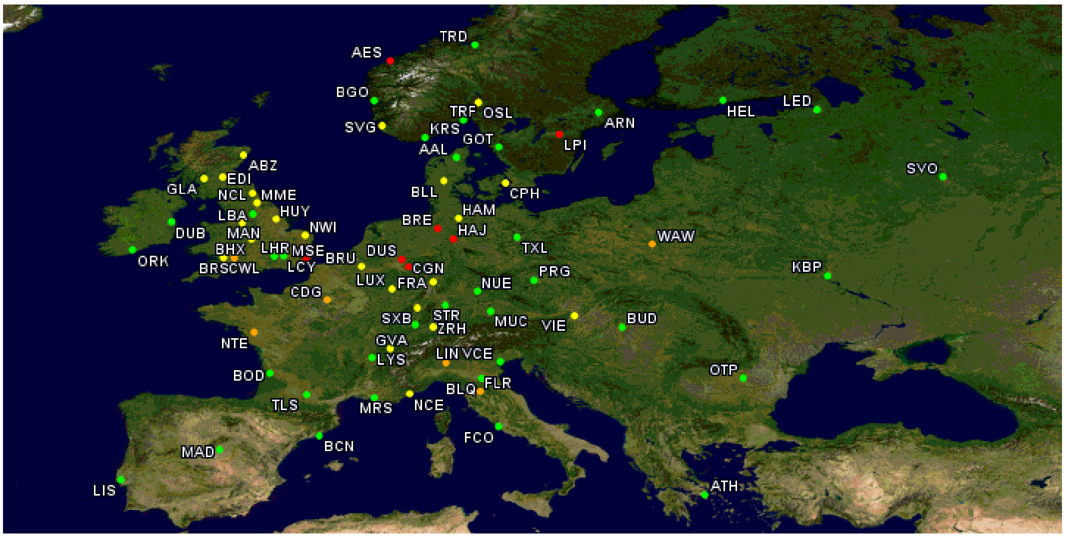
*Note:* The number of destinations offered by the hub carrier and partners and by other carriers does not add up to the total number of destinations offered at the airport. This is due to the fact that there is overlap in destinations served by the hub carrier and partners and other carriers.

*Source:* HNR-model

***Partial dehubbing***
In the partial dehubbing scenario, we estimate that the number of destinations at Amsterdam will drop by nine % and the number of frequencies by 21% in comparison to the reference scenario. In case of partial dehubbing, the hub carrier will rationalize 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/ 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 UK and Scandinavia (Figure 1.6). 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 1.6). The net impact on the direct European network at Amsterdam is a decrease in five % 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 1.6 **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 1.5 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 rationalized network. Competing carriers take over or increase capacity at routes to North America, the Caribbean and the Middle East.

Figure 1.7 **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 1.5. **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** | | |
| | | Hubcarrier and partners | Other carriers | Total | Hubcarrier and partners | Other carriers | Total | Hubcarrier and partners | Other carriers | Total | Hubcarrier and partners | Other carriers | Total |
| **Routes served by hub carrier & partners** | Europe | 1095 | 759 | 1855 | -45% | 37% | -27% | 41 | 42 | 64 | -42% | 27% | -10% |
| | Intercontinental | 335 | 163 | 498 | -32% | 29% | -19% | 48 | 28 | 59 | -37% | 33% | -22% |
| | Subtotal | 1430 | 922 | 2352 | -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 | 1095 | 1245 | 2340 | -45% | 20% | -23% | 41 | 111 | 133 | -42% | 9% | -5% |
| | Intercontinental | 335 | 325 | 660 | -32% | 13% | -15% | 48 | 74 | 105 | -37% | 10% | -14% |
| | Total | 1430 | 1570 | 3000 | -43% | 18% | -21% | 89 | 185 | 238 | -39% | 9% | -9% |

*Source:* HNR-model

## Consumer welfare impacts

### *Generalized travel cost changes*

In both network rationalization scenarios, we estimate that connectivity at Amsterdam Airport is substantially affected, both in terms of the number of destinations offered, as well as the average flight frequencies.

A decrease in connectivity in one of the network rationalization scenarios will result in higher 'generalized' 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 generalized travel costs will 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). The impacts in the partial dehubbing scenario are much less severe (EUR -145 million).

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 from 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 rationalization 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].

[9] This is not the case in all origin-destination markets, but the overall effect is positive.

*Table 6 Consumer welfare changes in the network rationalization scenarios (x EUR million/ year)*

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

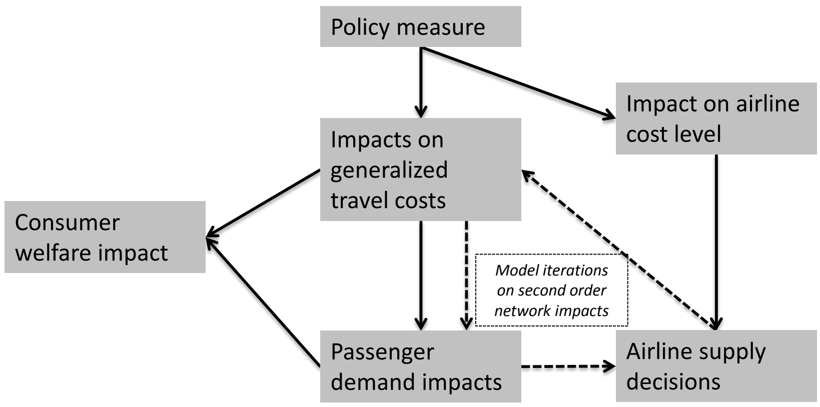
*Note:* Consumer welfare changes refer to a single year and are for Dutch consumers only.
*Source:* Burghouwt et al. (2016)

# DISCUSSION

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 have discontinuous effects on generalized 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 rationalization can trigger a so-called hub rationalization process or 'domino-effect', as the hub carrier's flights to and from the hub are highly interrelated in terms of passenger flows. Finally, rationalization 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 effects 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, that may arise through the supply side. Figure 1.8 provides a general overview of how to integrate of the second order network impacts in the assessment of consumer welfare impacts.

Figure 1.8. **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 of:

- (De)regulation of aviation markets;
- Impact of greater airline competition;
- Introduction of air travel taxes;
- Changes in airport charges, ATC costs, noise levies and security costs;
- Changes in noise levies to airlines.

A number of caveats and avenues for further research apply. First of all, the HNR-model in its current form is suitable to analyse the impacts of network rationalization, 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, the HNR model includes a number of assumptions regarding the order of use and scope of instruments to restore load factors, when an airline is faced with decreasing demand. These instruments including pricing decisions, use of smaller aircraft, frequency and route decisions. Further research is needed to determine to what extent various types of airline use these instruments and in which order.

# REFERENCES


Bilotkach, V., Mueller, J., & Németh, A. (2014). Estimating the consumer welfare effects of de-hubbing: The case of Malév Hungarian Airlines. *Transportation Research Part E: Logistics and Transportation Review*, *66*, 51-65.

Booz Allen Hamilton (2007). The economic impacts of an open aviation area between the EU and the US. Final Report. January 2007. Prepared for the Directorate General Energy and Transport of the European Commission.

Burghouwt, G., R. Lieshout and T. Boonekamp (2016). The impact of dehubbing on connectivity and consumer welfare. Paper prepared for the Air Transport Research Society Conference, Athens.

CEPA (2007). Cost benefit analysis of terminal 2 and runway 2 at Dublin Airport. Report for the Commission for Aviation Regulation. February 2007.

Decisio, To70 and SEO (2014). Actualisatie quick scan MKBA Schiphol en Lelystad Airport Middellange Termijn. Bijschaling en actualisatie kengetallen en scenario’s (in Dutch). Report commissioned by the Dutch Ministry of Transport and the Environment.

Forsyth, P. (2004). Locational rents at airports: creating them and shifting them. Journal of Air Transport Management 10, 51-60.

Forsyth, P. (2013). Airport capacity for Sydney. ITF/ OECD Discussion paper 2013.02.

Forsyth, P. (2014a). Using CBA and CGE in investment and policy evaluation: a synthesis. March 2014.

Forsyth, P. (2014). Is it in Germany's economic interest to allow Emirates to fly to Berlin? A framework for analysis. Journal of Air Transport Management, 41, 38-44.

Gillen, D. and D. Starkie (2016). EU Slot Policy at Congested Hubs, and Incentives to Add Capacity. Journal of Transport Economics and Policy (JTEP), 50(2), 151-163.

ITF & SEO (2015). Scarcity rents and airport charges. SEO reportnr. 2015-41. Report commissioned by the UK Airports Commission, conducted in cooperation with ITF.

Jorge, J. D., & de Rus, G. (2004). Cost–benefit analysis of investments in airport infrastructure: a practical approach. *Journal of Air Transport Management*, *10*(5), 311-326.

Koopmans, C., & Lieshout, R. (2016). Airline cost changes: To what extent are they passed through to the passenger? *Journal of Air Transport Management*, *53*, 1-11.

Lieshout, R., & Matsumoto, H. (2012). New international services and the competitiveness of Tokyo International Airport. *Journal of Transport Geography*, *22*, 53-64.

Lieshout, R. (2012). Measuring the size of an airport’s catchment area. *Journal of Transport Geography*, *25*, 27-34.

Lieshout, R., G. Burghouwt and T. Boonekamp (2015). Economisch belang van de hubfunctie van Schiphol (in Dutch). Study commissioned by the Dutch Ministry of Transport and the Environment, Dutch Ministry of Economic Affairs and the Dutch Ministry of Finance. SEO reportnr. 2015-22.

Lieshout, R., Malighetti, P., Redondi, R., & Burghouwt, G. (2016). The competitive landscape of air transport in Europe. *Journal of Transport Geography*, *50*, 68-82.

Malighetti, P., Paleari, S., & Redondi, R. (2016). Base abandonments by low-cost carriers. *Journal of Air Transport Management*, *55*, 234-244.

Redondi, R., Malighetti, P., & Paleari, S. (2012). De-hubbing of airports and their recovery patterns. *Journal of Air Transport Management*, *18*(1), 1-4.

SEO Economisch Onderzoek (2011). Effecten van de voorgenomen wijziging van de tariefstructuur op Schiphol. SEO-rapportnr. 2011-11. Research commissioned by the Dutch Ministry of Transport (in Dutch).

Starkie, D. (1998). Allocating airport slots: a role for the market? Journal of Air Transport Management 4, 111-116.

Starkie, D. (2004). Testing the regulatory model: the expansion of Stansted Airport. Fiscal Studies 25(4), 389-413.

Starkie, D., & Yarrow, G. (2013). Why airports can face price-elastic demands. ITF/OECD Discussion Paper 2013-23.

UK Airports Commission (2015). Airports Commission: final report. July 2015.

Veldhuis, J. (2011). The impact of airline network strategy for the service quality of airports. The case of Amsterdam Schiphol and Paris Charles de Gaulle. In: R. Macário & E. van de Voorde (eds.). Critical issues in air transport economics and business. New York: Routledge.