Civil Aviation in the EU Emissions Trading Scheme

Effects on the aviation sector, consumers and the environment

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Summary

On 1 January 2012 the aviation industry was brought within the European Emissions Trading Scheme (EU ETS) and must now purchase emission allowances for some of its CO_2 emissions.

At a price of 10 euros per emission allowance, model calculations indicate that passenger numbers travelling with EU airlines will decline by on average 0.2% if only the costs of the purchased allowances are passed on to customers. If the airlines also pass on the value of their free emission allowances, passenger numbers will decline by 0.9%. This decline is relative to the expected market growth curve without ETS. A sensitivity analysis shows that at a price of 50 euros the effects are about five times as large. This analysis takes no account of any adjustments the airlines may make to their networks. In practice, the actual costs airlines decide to pass on to customers will depend on what is most favourable for their operating results. The impact on operating result will never be greater than the costs of the purchased allowances.

For Schiphol and KLM the changes in passenger numbers will be two to three times larger than the average. This is because they handle and carry more transfer passengers, who are more sensitive to increases in ticket prices than passengers in the domestic market. Besides this response in demand, there is a risk that parties outside the EU will take generic or specific retaliatory measures, or both. An example of a generic measure is a boycott of the ETS. Specific measures may have a disproportionate impact on the Dutch aviation sector, which could lead to an accumulation of ETS costs and retaliatory measures.

As the aviation market is growing, more allowances will be needed for the flights falling under the ETS than the total available to the airlines. The airlines will therefore have to either reduce their emissions by taking mitigating measures or purchase additional emission allowances from other ETS sectors. The reduction in 2020 will be about 29% of the expected airline emissions in 2020.

Civil aviation in the ETS: Free emission allowances are insufficient
On 1 January 2012 the aviation sector was brought within the existing European Emissions Trading Scheme (EU ETS). This system sets a limit (‘cap’) on the CO_2 emissions of a large number of market actors, until recently mainly in the industrial and energy sectors. Each year the companies participating in the ETS must surrender a number of emission allowances equivalent to their CO_2 emissions to the emission authorities. The total number of available emission allowances is limited by law.

The emissions trading scheme for aviation covers the CO_2 emissions of all flights arriving and departing at airports in the European Union (plus Iceland, Lichtenstein and Norway). Airlines must possess emission allowances equal to all the CO_2 emissions from their flights (one emission allowance is equivalent to one tonne of

CO_2). To include the emissions of the aviation sector within the current ETS, the existing ETS emissions cap has been increased by about 215 million emission allowances in 2012; for the period 2013 to 2020 the increase will be about 210 million allowances in each year. These numbers correspond with 97% and 95% respectively of the annual average level of emissions for the period 2004 to 2006. This increase is less than the actual emissions from the aviation sector. The total size of the emissions cap for all sectors has therefore become relatively tighter.

For 2012 the aviation sector has been allocated about 183 million free emission allowances, and for 2013–2020 the sector will receive about 173 million allowances each year. These free allowances amount to 85% and 82% of the total number of aviation allowances which have been added to the existing emissions cap.

The allocation of free allowances to the airlines is based on the activity of each operator in 2010 in terms of revenue tonne kilometres. The remaining allowances are allocated by auction. If the free allowances allocated to the airlines are not sufficient to cover their emissions, they can take mitigating measures to reduce emissions, purchase additional allowances at auction, or buy allowances from other ETS participants, especially from those outside the aviation sector who have allowances to spare.

In 2012 the airline sector will have to buy emission allowances worth 0.6 billion euros
As the aviation sector is growing, the number of free emission allowances in 2012 is sufficient to cover on average about 75% of the emissions from flights within the ETS. In subsequent years the proportion of aviation emissions covered by the free allowances will gradually decline to about 58% in 2020 due to a reduction in the number of free allowances and, more significantly, the expected growth in the aviation sector.

At a price of 10 euros per tonne of CO_2, the airlines are expected to make up most of this shortage by purchasing additional allowances. This is because taking measures to reduce emissions in the sector is generally more expensive per avoided tonne of CO_2. If we assume the airlines purchase allowances to cover their entire shortfall, the total cost in 2012 will be about 0.6 billion euros. This sum will increase to about 1.2 billion euros in 2020 because the aviation sector is growing and the number of free allowances will have been reduced. If the price of emission allowances is higher, the costs will be proportionately greater.

The calculations in this report do not take account of any variations in price, but work with constant high and low prices. As the price of emission allowances rises, reduction measures within the sector will become more financially attractive, in turn reducing the number of emission allowances that have to be purchased. On the other hand, these measures also involve certain costs.

The number of allowances that have to be bought is not the same for all airlines. Those airlines with high fuel efficiency will have to purchase relatively fewer emission allowances than other airlines. The same is true for airlines that have grown less rapidly in recent years. The biggest European airlines will have to buy a higher than average number: the estimate for Air France-KLM is 30% of their requirement, for British Airways 34% and for Lufthansa 38%. Low-cost airlines like

Ryanair and easyJet will have to buy a lower than average number; the estimates are 24% and 21% of their requirement respectively. The method for allocating free allowances is favourable for Emirates, which in 2012 will probably not have to buy any, or just a small number, of emission allowances.

How ETS costs are passed on is a strategic choice
Airlines will only pass on the costs of purchased allowances to passengers if this is more beneficial for their operating result than absorbing the costs. If they absorb the costs, ticket prices, passenger numbers and turnover will remain unchanged. Furthermore, the free emission allowances also have a value; the opportunity costs. The airlines can choose to pass on all or some of these costs to passengers. They will do this only if it improves their operating result compared with passing on only the costs of the purchased allowances. The maximum negative effect on the operating result is therefore equal to the costs of absorbing the cost of the allowances.

Whether airlines will pass on the costs of emission allowances, and if so how much, will in practice vary between specific routes and customer groups. This is a strategic choice to be made by the individual airlines themselves. Factors that can influence this choice are:

- the degree of competition with other airlines;
- the price sensitivity of the customer groups in different market segments;
- the possibilities for passing on costs to passengers on routes falling outside the ETS (if the airline in question operates on these routes).

If airlines raise ticket prices in direct proportion to the costs of purchased allowances (one-on-one), irrespective of the route or customer group, most return tickets will be just a few euros more expensive if the price of emission allowances is 10 euros. The price of a return flight from Amsterdam to London will increase by almost 20 euro cents, a return flight from Amsterdam to New York will rise by about 3 euros and a return flight from Amsterdam to Jakarta by about 5 euros. If the value of the free emission allowances is passed on as well, these prices will rise by about 1 euro, 11 euros and 21 euros respectively.

Slight drop in passenger numbers in the total market
The increase in ticket prices is expected to lead to a fall in passenger numbers in all markets from, to and within Europe. If the airlines only pass on the costs of the purchased emission allowances, the number of passengers flying with EU airlines will fall by 0.2%. If they also pass on the value of the free emission allowances, passenger numbers will fall by 0.9%. These are the expected effects at a price of 10 euros per emission allowance.

The effect on passenger numbers may be greater in certain geographical market segments. The largest decline will be in transfer passengers from and to destinations outside the European Union (EU) via a European airport, for example from New York via Schiphol to Mumbai. These passengers have a relatively large number of transfer options to choose from outside the EU, for example via Zurich, or Dubai. For this reason the number of transfer passengers flying via an airport outside the EU will increase. This increase is reflected in a similar decline in the numbers of these transfer passengers flying via an EU airport: 1% to 5% in the relevant market segment, depending on which costs are passed on. However, these markets are small compared with the size of the total aviation market affected by the emissions trading scheme.

This calculation takes no account of any second-order effects on the number of passengers resulting from changes made to the network. The reduction in the number of passengers may make certain routes unprofitable, leading to lower frequencies or the abolishment of some routes. The chance of the network eroding as a result of this second-order effect increases as the ETS induced cost increase rises. However, it is not possible to estimate the likelihood of this occurring in advance. This requires accurate information about the margins on each route and the contribution each route makes to the whole network, and only the airlines have that information. The analyses in this report do not therefore include an estimate of the likelihood of this happening.

Overall effects on KLM are greater
If KLM passes on the full costs of its purchased emission allowances to all customer groups, the total number of KLM passengers in 2012 is expected to fall by 0.6%, with this decline increasing to 0.9% in 2020 due to the higher costs of emission allowances per passenger. This is related to the reduction in the number of free allowances the airline will receive and the expected growth in the aviation sector. If KLM chooses to pass on the value of their free emission allowances as well, passenger numbers will decline by 2.2%. To illustrate: KLM had 25.1 million passengers in 2011; the above mentioned percentages would mean a reduction in passenger numbers of 150,000 to 550,000.

KLM will only pass on the value of its free allowances if the effect on its operating result is more beneficial than passing on the costs of its purchased allowances, and will only pass on the costs of purchased allowances if this gives a more favourable outcome than absorbing the purchase costs. These costs therefore represent the upper limit of the economic effects. For the period from 2012 to 2020, the costs to KLM of purchasing emission allowances are estimated to be about 30 million euros per year.

Lufthansa and British Airways will also experience greater reductions in passenger numbers in 2012 than the average reduction across all airlines. Depending on the scenario, their passenger numbers will fall by 0.3–1.3% and 0.7–2.9% respectively. Their home airports are also more vulnerable to the effects of the emissions trading scheme than the average EU airport. The effects on Air France will be about the same as the average.

Airlines with a favourably located home airport in relation to the EU, such as Emirates, Swiss Airlines and Turkish Airlines, will profit from the emissions trading scheme. In the scenarios discussed above, the numbers of passengers carried by these airlines will rise as follows: Emirates, by 0.7% to 2.7%; Swiss Airlines, by 0.5% to 1.9%; Turkish Airlines, by 0.1% to 0.6%. The upper limits of these percentages are roughly equivalent to a rise of 220,000, 190,000 and 65,000 passengers respectively.

The emissions trading scheme will generally have a greater effect on network airlines than on low-cost airlines. This is because low-cost airlines do not normally operate on transfer markets and because as ticket prices rise passengers will be more inclined to choose to fly with a low-cost airline, such as easyJet, than a full service airline like KLM.

Effects on and around Schiphol airport: Lower turnover and employment
In 2012 the number of passengers passing through Schiphol will fall by 0.4% to 1.6%. Compared with the passenger numbers in 2011, this represents a fall of 0.2 to 0.8 million passengers in 2012.

The drop in passenger numbers will result mainly in a loss of income from passenger fees, car parking charges and passenger spending at the airport. This loss of income for the Schiphol Group is estimated to be in the order of 4 to 14 million euros in 2012, rising in future as the number of passengers rises.

The fall in passenger numbers may also lead to a temporary drop in employment levels at and around Schiphol airport compared with the previous growth curve. A rough estimate of this drop in employment levels is about 200 to 800 jobs, depending on which costs airlines pass on to their customers. The degree to which the drop in passenger numbers will actually result in unemployment depends on the proportion of unskilled labour and the displacement effects in other sectors under current labour market conditions. This will be influenced by the further growth of the aviation market.

Airlines will not avoid European airports
Although the demand for flights both in and via the EU will decline, it is expected that airlines will make only limited adjustments to their routes or destinations. A distinction must be made between low-cost airlines and network airlines based in the EU and between network airlines based within and outside the EU.

Owing to their business model, it is easier for low-cost airlines to adjust flight frequencies and scrap destinations. Because they generally operate only within Europe, they are not affected by the restrictions imposed by aviation policies (a free market operates within the EU).

Network airlines based within the EU are tied to their home base because of their business model and aviation policy restrictions, and for practical reasons cannot operate outside the EU. Landing rights are needed for destinations outside the EU, for which aviation policies play a decisive role. These airlines could choose to introduce ‘operational’ stopovers (where no passengers board or deplane) on their intercontinental flights at airports just outside the EU. No landing rights are needed for these stopovers and so aviation policy restrictions do not apply. However, such operational stopovers entail considerable disadvantages, such as a loss of service quality for passengers and extra take-off and landing fees and fuel costs. For these reasons, this option will only become interesting for EU network airlines if the price of emission allowances reach very high levels. This option was not investigated further within the scope of this study.

At first sight, network airlines based outside the EU do appear to have the choice of avoiding EU destinations. However, they have chosen these destinations because of the numbers of passengers they allow them to serve. The airlines concerned would only choose other destinations outside the EU simply to avoid the costs of the emissions trading scheme if they could find destinations outside the EU that generate just as many yield. In addition, landing rights and slots must be available for these destinations. Only airlines that call at a European airport en route between two non-EU airports for paying passengers or cargo might be inclined to switch to non-stop flights (without a stopover). However, these airlines are few in number, especially at Schiphol. Moreover, the flights without stopovers must still carry sufficient paying passengers or cargo.

Lower CO_2 emissions, but primarily in non-aviation sectors
With the growth in the aviation sector of 3.5% per year and fuel efficiency improvements of 1% per year assumed in this report, airline emissions from flights falling under the ETS in 2020 will be about 296 megatonnes of CO_2. However, the increase in the overall ETS cap resulting from the inclusion of the aviation sector is 214 megatonnes in 2012 and will be 210 megatonnes in the years 2013 to 2020. The inclusion of the aviation sector in the ETS therefore means that a total emissions reduction of almost 86 megatonnes has to be achieved by 2020. Given the expected growth in the market, this is equivalent to an emissions reduction of about 29%. This reduction may be achieved within the aviation sector or in other ETS sectors, because the ETS mechanism leads to reduction measures being taken where they are cheapest.

An effect of the ETS is that more passengers than before will choose flights falling wholly or partly outside the ETS, leading to an increase in CO_2 emissions outside the ETS area. At a price of 10 euros per emission allowance, this increase will be 0.5 to 1.1 megatonnes of CO_2 in 2020, depending on whether only the costs of purchased allowances are passed on to the passengers, or whether the value of the free emission allowances is also passed on.

Retaliatory measures may have a disproportionate effect on the Netherlands
The European Emissions Trading Scheme has met with much resistance among airline companies and governments outside the EU. As a consequence, various legal, economic and policy measures are being prepared, and some have been implemented. Among these are threats to renegotiate aviation rights, increase tariffs for flyover rights, boycott participation in the emissions trading scheme and hold off orders from European aircraft manufacturers. There is no way to objectively determine at what point these threats may be put into effect. Looking back to previous conflicts, it is not inconceivable that retaliatory measures will be taken and that these will disproportionately affect the Dutch aviation sector. Accumulation of these retaliatory measures could have greater effects on the competitive position of European airlines than the emissions trading scheme itself.

The effects of one of the possible retaliatory measures were investigated by calculating a boycott scenario in which all non-EU airlines refuse to participate in the ETS and therefore do not pass on any costs to their passengers. The outcome was that the negative consequences for European airlines become greater because more passengers will fly with non-European airlines. For KLM the reduction in passenger numbers is 1.5 times larger than without the boycott. In the above scenarios for calculating certain types of costs, and with a price per emission allowance of 10 euros, this leads to a reduction of 0.9% to 3.7%. On the other hand, non-European airlines, such as Emirates, actually gain additional benefits. When both the value of the free emission allowances and the purchased allowances are passed on to the customer, the number of Emirates passengers rises by 2.9% instead of 2.7% in the scenario in which they do participate in the ETS.

Range of outcomes
In the report a model and various scenarios are used to investigate the range and order of magnitude of possible effects of the ETS. The summary discusses only those effects for the scenario in which the price of emission allowances is set at 10 euros. If the price of emission allowances rises in future, the effects will change roughly in proportion to the change in price. The scenarios in the report are not accompanied by any statement about their probability, but additional calculations were made with an arbitrary price of 50 euros to analyse the sensitivity of the effects to large price increases. At a price of 50 euros, the effects on passenger numbers are almost five times larger than for a price of 10 euros.

The effects described in this report should be interpreted as changes in relation to the expected market growth curve without ETS. In the report an average annual growth of 3.5% is assumed. The calculations take no account of any second-order effects on demand resulting from adjustments made to airline networks. The likelihood of such effects is small when the price of emission allowances is low, but increases as the price of emission allowances rises.

1 Introduction

1.1 Brief review of the EU ETS for aviation

On 1 January 2012 the aviation sector was brought within the existing European Emissions Trading Scheme (EU ETS). The CO_2 emissions of all flights arriving and leaving airports in the European Economic Area (the 27 EU member states plus Iceland, Lichtenstein and Norway) fall within the scheme.[1]

The EU ETS sets a cap on the number of emission allowances – each of which affords the right to emit a tonne of CO_2 – initially allocated to the aviation sector. The airlines can also acquire additional credits. The cap is therefore not an actual limit on emissions, but is equal to the amount of emission allowances that were added to the ETS when it was extended to include aviation. In 2012 the aviation cap amounted to 97% of historical aviation emissions, determined as the average of the annual emissions in 2004, 2005 and 2006.

In 2012 85% of the cap, the emission allowances initially allocated to the aviation sector, will be provided free to the airline companies. Each company will receive free allowances in proportion to the number of tonne-kilometres they flew in the reference year 2010. This rewards fuel-efficient flying. The remaining 15% of these emission allowances will be auctioned at an auction open only to the aviation sector. From 2013 the number of emission allowances available to the aviation sector each year will be lowered to 95% of historical emissions. Of these, 82% will be allocated as free emissions, 15% will again be auctioned and 3% of the allowances will be held in reserve for new airlines and rapidly growing airlines. Airlines that emit more CO_2 than the amount covered by their free allowances and any allowances they have purchased at the auction may buy additional allowances on the market for ETS emission allowances.

1.2 Reason for the study

Non-EU countries and various airlines and aviation organisations have always resisted a system unilaterally introduced and imposed by the EU to control greenhouse gas emissions by aircraft. Most of these opponents favour a global system for emissions reduction to be devised and implemented by the International Civil Aviation Authority (ICAO).[2] The European Commission also advocates such a global approach, but after several years felt that too little progress had been made and therefore decided to establish its own regional system. This resulted in a directive on the inclusion of the aviation sector within the existing EU ETS, which was unanimously adopted by the Council and the European Parliament in 2008.[3]

In 2011 the resistance to the system unilaterally introduced and imposed by the EU grew visibly. American airline companies initiated legal proceedings to test the legality of the EU directive. In addition, various countries threatened to take retaliatory measures, such as restricting aviation rights, increasing overflight fees and putting orders for the Airbus on hold. Several airlines have again expressed

[1] In the remainder of this report we use EU to refer to all these countries.
[2] This does not necessarily have to be an emissions trading system.
[3] More information on the Aviation EU ETS can be found in Appendix A.

their concerns about the costs of the system, with European airlines in particular pointing to possible disruption to the level playing field.

In view of this situation, the Directorate-General for Mobility and Transport of the Netherlands Ministry of Infrastructure and the Environment felt the need for an up-to-date overview of the effects of the EU ETS on the aviation sector and on the environment.

In the past much research has been carried out into the effects of various options for an ETS for aviation, and in particular their effects on the Dutch aviation sector. Since then, however, new and more detailed information has become available about the size of the emissions cap, the number of allowances the airlines need and the price of emission allowances. These highlight the relevance of an up-to-date study of the effects of the EU ETS on the Dutch aviation sector.

1.3 Research questions

The main question this study set out to answer was:

What will be the effects of the EU ETS for the Dutch aviation sector, the consumer and the environment?

This main question was broken down into a number of subsidiary questions relating to the following topics:

How will the airlines pass on the costs of the scheme:
- To what extent will the airlines pass on the costs of the emission allowances?
- To what extent will airlines be able to redistribute the costs of the ETS via a system of cross-subsidisation, for example by passing on some of the costs to markets that do not fall within the ETS?
- What will be the size of the effect on airline profits if they pass on 100% of the costs versus a situation in which they absorb 100% of the costs?

The fall-off in demand (no longer flying) and avoidance behaviour by passengers (choosing other routes):
- What will be the general effect on consumers of higher ticket prices?
- What will be the extent of the fall-off in demand and avoidance behaviour?
- What will be the net effects on CO_2 emissions of a fall-off in demand and avoidance behaviour?

The competitive position of the various parties involved:
- What will be the relative effects of a fall-off in demand and avoidance behaviour on the competitive position of Dutch, EU and non-EU carriers?
- What will be the effects of a fall-off in demand and avoidance behaviour on the competitive position of network airlines compared with low-cost airlines?
- What changes in the networks operated by the airlines could result from this?

Effects specific to Amsterdam Schiphol Airport:
- What will be the effects on hub competition in general?
- What will be the effect on the number of flight movements at Schiphol?
- What are the risks of retaliatory measures affecting the network from Schiphol?

- What impact will the ETS have on employment at and around Schiphol?

1.4 Structure of the report

Chapter 2 describes the background to the study, the underlying assumptions made and the methods used. It begins by setting out the main choices and assumptions made in order to answer the research questions. The remaining sections of Chapter 2 explain the reasoning behind these choices. In addition, relevant background information is given for readers less familiar with the workings of the aviation market and the EU ETS for aviation.

Chapter 3 examines the outcomes of the calculations of effects. These include the effects on ticket prices, the fall-off in demand and avoidance behaviour in various markets, and the effects of these on the airlines and airports, and on CO_2 emissions.

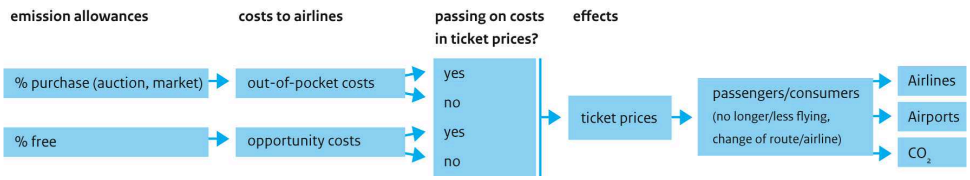
Finally, Chapter 4 considers two other possible consequences of the EU ETS for the aviation sector. These are how the receipts from the sale of auctioned aviation emission allowances are spent and the possible retaliatory measures arising from the opposition to the scheme from other countries.

2 Background, assumptions and methods

2.1 Review of methods, main assumptions and scenarios

The study method is illustrated diagrammatically in Figure 2.1. This section presents the most important assumptions and scenarios for the analysis of the effects of the Aviation EU ETS. These choices and the terms used in the analysis are explained in the following sections.

Figure 2.1
Diagram of the study method



- We explored the period covering the first two years of the EU ETS for aviation: 2012 and 2013. The size of the emissions cap and the proportion of emission allowances allocated free are different in these two years. In addition we looked at the situation in 2020 to determine what the effects (particularly the costs) will be in the longer term and over the whole period from 2012 to 2020.
- We assumed that the number of tonne-kilometres[4] from and to Europe will grow by 3.5% per year. We also assumed an annual improvement in aviation efficiency of 1%. This in turn means that the number of required emission allowances will rise by 2.5% per year. Because no more detailed prognoses were available per airline, these assumptions were applied uniformly across all airlines.
- Our calculations were based on two scenarios for the price of emission allowances: one in which the price is 10 euros per tonne of CO_2 (about the same as the current market price) and one in which the price is 50 euros per tonne of CO_2. The second scenario is intended to reveal the sensitivity of the outcomes to large price increases.
- In 2012 the free emission allowances allocated to the sector as a whole will amount to on average 75% of all the emission allowances it needs. This proportion will fall to 69% in 2013 and 58% in 2020.[5] The airlines will have to purchase the additional allowances they need at an auction and on the market for emission allowances.
- The cost of the emission allowances the airlines will have to buy are out-of-pocket expenses. The airlines do not have to pay for their free emission allowances; however, the allowances do have a value if they are sold on to other airlines. These free allowances therefore have opportunity costs.
- There are two scenarios for passing on the costs. In both scenarios 100% of the out-of-pocket costs are passed on to the passengers. In one of the scenarios 100% of the opportunity costs are also passed on. In the other scenario none of these costs are passed on (0%).

[4] Here this refers to the number of 'revenue tonne-kilometres'. These are the kilometres flown for sold capacity measured in tonnes of passengers and cargo.
[5] Aggregated over the whole period from 2012 to 2020 the airlines will receive 65% of all the emission allowance they need free and will have to purchase the remaining 35%.

- A particular question with regard to the passing on of ETS costs is whether non-EU airlines will pass on ETS costs to passengers on routes that do not fall under the ETS. This would allow them to improve their competitiveness on ETS routes compared with airlines that do not have this opportunity. There is no scientific consensus on the rationality of such 'additional cross-subsidisation'. To reveal the effects of any such additional cross-subsidisation, some scenarios include an algorithm for the assumption that airlines on non-ETS routes with limited competition have opportunities to recoup some of the ETS costs.
- Various airlines and other relevant parties have threatened not to participate in the ETS. For this reason scenarios have been included in which airlines from all non-EU countries boycott the ETS. These scenarios show the maximum effect of such retaliatory actions.
- Table 2.1 summarises the scenarios used in the study.

Table 2.1
The scenarios included in this study.

Costs included	Market price (€/t)	Additional features
Total costs	10	None
Total costs	10	Additional cross-subsidy
Total costs	10	Boycott by non-EU airlines
Total costs	50	None
Total costs	50	Additional cross-subsidy
Total costs	50	Boycott by non-EU airlines
Out-of-pocket costs	10	None
Out-of-pocket costs	10	Additional cross-subsidy
Out-of-pocket costs	10	Boycott by non-EU airlines
Out-of-pocket costs	50	None
Out-of-pocket costs	50	Additional cross-subsidy
Out-of-pocket costs	50	Boycott by non-EU airlines

2.2 The civil aviation market

Before we can analyse the effects of the ETS on the aviation sector in various markets it is first necessary to define what an aviation market is. To illustrate, the term we use for this in relation to competition issues is 'relevant market', which has both a geographical and a product component (Baarsma & Theeuws, 2002).

In geographical terms an aviation market, according to the strictest definition, is determined by a pair of airports or cities (CE & MVA, 2007; Vivid Economics, 2007). These are coupled with a product component: for highly time-sensitive business travellers, Schiphol–London City is a different market from Schiphol–London Heathrow.

Many travellers have a greater choice of airlines and airport pairs. In these cases, the relevant market must be interpreted more broadly. For example, recreational travellers from the Netherlands to London can choose from several London airports, which compete with each other: Heathrow, Gatwick, Stansted, Luton and possibly City. Depending on where they live in the Netherlands and their product preferences, these travellers can choose from various airlines that depart from airports such as Schiphol, Rotterdam or Eindhoven.

The geographical boundary can be widened if, for example, passengers are flying for a holiday in the sun. In such situations the relevant market may be at the level of countries, such as the Netherlands to Spain or the Netherlands to any sunny destination. The latter situation is particularly relevant if the flight is part of a package holiday booking which also includes hotel accommodation and other arrangements.

The aviation market as a whole therefore consists of the sum total of various relevant markets that differ both in geographical scale and product features. This makes an analysis of the effects of the ETS on the aviation market a complex business. The effects will be large in some relevant markets and negligible in others.

The analyses in this report are based on calculations of the effects on airport-pair markets. The results of these calculations are presented in aggregated form to make the differences in effects visible at various geographical scales.

2.3 Passing on costs

In theory, airlines can deal with the costs of the ETS in various ways (Morrell, 2009): they can be fully ‘absorbed’ into the operating costs (reducing profitability), they can be fully passed on to the passengers via ticket prices, or only some of the costs may be passed on. The pallet of possible options is therefore large, as are the possible consequences for the airlines and their customers. These depend on which types of costs are involved. If the opportunity costs (the value of the free emission allowances; see text box) are passed on, the operating result may not be negatively affected, but actually improved.

Opportunity costs and windfall profits

Airlines are allocated a large proportion of the emission allowances they need free, according to a benchmark (see section 3.3). These emission allowances are scarce, because the total number of emission allowances is limited, and so they have a certain value. This value can be determined by examining the best alternative use of the emission allowances. If, for example, emission allowances are traded on the market for 10 euros each, an airline can consider whether it is worth selling a freely obtained allowance on the market and earning 10 euros on the sale, or using the allowance for its aviation activities. In the latter case, the airline will also want to earn 10 euros from the allowance; otherwise it would have been better to sell it on the market.

The value of the alternative use is also called the ‘opportunity cost’. Airlines can include these costs in their accounts as production costs. If airlines pass on the opportunity costs of their free emission allowances to their passengers, they receive revenue on them without incurring any costs. In effect they make a ‘profit’.[6] These

[6] This refers to the contribution made to the gross operating result. If the passengers of an airline are not very price-sensitive, this contribution may be positive because the extra contribution per passenger outweighs the losses due to the reduction in passenger numbers. As price sensitivity increase, the balance may become negative. Nonetheless, it may still be economically rational to pass on the opportunity costs. This will be the case if the effect on the operating result is less negative than if only the out-of-pocket costs are passed on.

are called windfall profits, because they are obtained without the airline having to do anything to earn them. Whether windfall profits will actually be obtained in practice depends on the degree to which the opportunity costs are passed on to the passengers. This section contains various arguments for why such windfall profits will be obtained in full or only partially.

Given the possible major consequences, the literature on the EU ETS and civil aviation contains much discussion about the question of which types of costs will be passed on and to what degree. There is a consensus that airline companies will pass on at least some of the costs via ticket prices. Opinions are divided on the degree to which this will occur, ranging from about 30% to 100%, with the majority of studies tending towards the upper limit (Bloomberg, 2011). These percentages reflect the average proportion of the costs that are passed on across the whole aviation market. For certain market segments more extreme percentages are sometimes expected, from 0%[7] to as high as even 200%.[8,9] It should be noted here that these are model studies. As yet there is no empirical evidence on the passing on of ETS costs in the aviation industry.

A strong indication that costs will be passed on can be found in the reaction of airlines to the rise in kerosene prices, for which empirical evidence is available. Experience shows that airlines pass on 90% to 105% of the increases in the costs of kerosene by raising ticket prices, although after some delay (PWC, 2005). This comparison with kerosene is particularly interesting because kerosene consumption is directly proportional to CO_2 emissions. The costs to airlines of emission allowances are therefore comparable to fuel costs on a one-to-one basis. However, the comparison between kerosene and emission allowances does not fully hold true, because a rise in kerosene prices in principle affects every airline, whereas the EU ETS does not. For example, an airline that flies directly from New York to Mumbai incurs no ETS costs, whereas an airline that flies the same route via an EU airport does.

The question of how much of the costs will be passed on involves two factors (Bloomberg, 2011):

1. Is there competition with non-EU airlines, which incur fewer or no ETS costs because their flights are outside or partly outside the EU?
2. How much will demand fall off as ticket prices rise; in other words, how price-sensitive is demand?

If the answer to the first question is ‘yes’, this may be a reason for a non-EU carrier to pass on only part, or even none, of the costs in a specific market segment in order not to lose any market share to non-EU competitors. If, in answer to the second question, the price sensitivity is high, this may also be a reason not to pass on cost increases, or pass on only part of them, in order to restrict the fall in demand.

[7] See Ernst & Young and York Aviation (2007) for heavily congested airports.
[8] See Vivid Economics (2007) for non-price-sensitive business customers on intra-European flights.
[9] Comparisons between studies are made difficult because not all the studies specify whether or not opportunity costs are included in the calculations. A number of studies simply refer to ‘costs’. For the studies that do not specify whether or not the opportunity costs are included, we followed Morrell (2009) and assumed that they only took account of out-of-pocket costs.

The literature on passing on ETS costs in aviation shows that the airlines have a broad range of options open to them. All studies are based on economic theory, in which various different models and arguments are used. The lack of empirical evidence makes it difficult to weigh up the various standpoints and determine which proportion of the costs is most likely to be passed on. The same goes for the question of additional cross-subsidisation: the limited literature available on this topic reveals a lack of scholarly consensus. Appendix B contains a more detailed examination of the various arguments on the passing on of costs and additional cross-subsidisation.

In this report, therefore, we base our analyses on scenarios designed to reveal the maximum effects. At one extreme, this is the situation in which 100% of the out-of-pocket costs and 100% of the opportunity costs are passed on to passengers. The other extreme is when both types of costs are fully absorbed into the operating result. In this case, the effects on the demand for flights do not have to be calculated because the ticket prices will remain the same. Besides these two extremes, we also examined an intermediate scenario in which 100% of the out-of-pocket costs are passed on to passengers, but the opportunity costs are not passed on. This third scenario was chosen because it marks the cut-off point between costs that reflect actual expenditure on acquiring emission allowances and costs that are more virtual in nature. The proportion of costs that are out-of-pocket costs increases over time from 25% in 2012 to 42% in 2020 (see section 2.6).

To reveal the effects of any additional cross-subsidisation, the relevant scenarios contain an algorithm for the passing on of ETS costs to non-ETS routes. This is for routes with little competition[10] and it is assumed that half the total costs of emission allowances per seat-kilometre can be charged to these routes.[11] The flight timetables were used to determine, for both EU carriers and non-EU airlines, the number of seat-kilometres falling under the ETS and the number on non-ETS routes with limited competition. The ratio between the two determines the degree to which an airline will pass on ETS costs to non-ETS routes. If, for example, a carrier incurs a total of 1 million euros in ETS costs, of which it can recoup 300,000 euros on markets outside the EU where it faces little competition, it will only have to pass on 70% of its ETS costs on routes where these costs are incurred.

2.4 Demand response in the aviation market

If in a certain market ETS costs are passed on to passengers, the passengers can react in three possible ways: some of them will fly on the same routes they would have chosen without the price increase, some of them will choose alternative flights for which the prices remain the same or increase to a lesser extent, while others will choose not to fly at all.[12,13] The attractiveness of each option will depend on the size of the price increases and on the number of attractive alternatives for a certain flight. If there are many attractive alternatives, relatively few passengers will decide not to fly. If there are few alternatives and the price rise is considerable, a relatively large number of passengers will decide not to fly. The total fall-off in demand in a

[10] Defined as a Herfindahl-Hirschman index equal to or greater than 0.75.
[11] At a price of 10 euros per emission allowance, this amounts to 0.00045 euros per seat-kilometre.
[12] This may be cancelling the journey altogether, or choosing another mode of transport for the journey.
[13] These do not necessarily have to be deliberate choices.

certain market is therefore determined by the sum of 'no longer flying' and 'avoidance behaviour' (choosing an alternative flight).

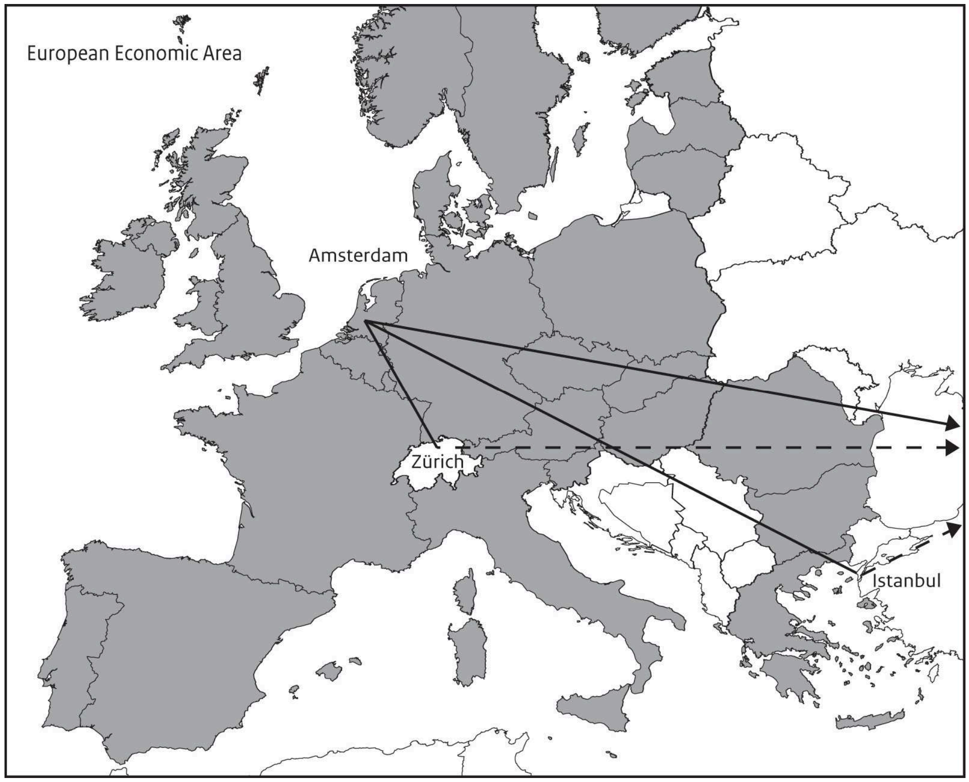
Which alternative flights are attractive to passengers will depend on the origin and destination airports. If these are within the EU, there will be no alternative flights without ETS costs. According to CE & MVA Consultancy (2007), these situations account for 65% of the market affected by the ETS. For this group of passengers the only possible alternative is not to fly. Avoidance behaviour would not give them any cost advantage and will therefore not happen.

If the origin and/or destination are outside the EU, there will be alternatives with lower or no ETS costs. According to the analysis by CE & MVA (2007), these situations account for 35% of the market affected by the ETS, of which 33% consists of passengers flying between an EU and a non-EU destination (group A) and 2% consists of passengers flying between two non-EU destinations who can fly on a route via an EU hub airport (group B). In group A, 20% of the passengers fly direct, 40% fly on indirect routes via an EU hub and 40% on indirect routes via a non-EU hub. The passengers in group B can only fly on indirect routes; 50% do so via an EU hub airport and 50% via a non-EU hub.

The ETS makes an indirect flight via a hub airport outside the EU more attractive to the subgroups that have not done this in the past.[14] Hub airports that can profit from this include Zurich, Istanbul, Dubai and hubs on the east coast of the United States. For travellers with an origin or destination within the EU, hubs closer to Europe are more attractive than hubs located further away because this minimises the proportion of the flight that falls under the ETS, as illustrated in Figure 2.2. This is not relevant for travellers with an origin and destination outside the EU. Some of these travellers will continue to fly via European hubs, but as the number of interesting alternatives without ETS costs is largest for this group, they will display the most avoidance behaviour.

[14] For an origin or destination at the edge of the EU it is also conceivable that airlines will choose a departure or arrival airport just outside the EU. However, for most flights from and to the EU these border effects will be negligible; for flights from and to the Netherlands this effect is not relevant at all.

Figure 2.2
Map illustrating the part of a flight from Schiphol to a destination in Asia that falls under the ETS. The solid lines show the part of the flight that falls under the ETS. The dashed lines show that the second legs of the indirect flights via Zurich and Istanbul do not fall under the ETS.



How attractive certain indirect alternative routes will be depends on the size of the ETS costs and any additional journey and transfer times incurred by taking these alternative flights. As an example we take a flight from Amsterdam to Jakarta.[15] For this flight there is a direct route with KLM. A return flight costs about 700 euros and the duration of the flight is on average 16 hours. An alternative indirect route via Dubai with Emirates costs about 550 euros and the flight duration is on average 19 hours. In the situation without ETS costs, time-sensitive travellers will choose a direct flight alternative and price-sensitive travellers will choose an indirect flight alternative. If the ETS costs are fully passed on in the price of a return ticket to Jakarta, the ETS share of the ticket price will be almost 21 euros (see also section 3.1). The ETS cost of an indirect alternative in the same situation will be more than 9 euros (applies only to the first leg to Dubai). For the time-sensitive travellers, the 12 euros net ETS cost will not be a sufficient reason to opt for the indirect route with 3 hours extra journey and transfer time. On the other hand, in every market there is a point of equilibrium at which there are travellers for whom the balance between time and cost just tips towards the more expensive, but shorter journey. For some of these travellers, the relative price increase due to the ETS will now tip the balance in favour of the cheaper, indirect route.

[15] The example is based on a real flight departing on a randomly chosen date, Wednesday 8 February 2012, and returning on Sunday 12 February 2012. Information was obtained from the price comparison site vliegtickets.nl on 24 January 2012.

For other routes and other markets, the outcome may be different. The ETS costs could have a large effect, particularly where the differences in price and journey times of the alternatives are small. This is to be expected especially on the international transfer market, where travellers in many cases can fly just as easily via a European hub as via a non-European hub.

SEO Economisch Onderzoek have analysed the choice behaviour of passengers in various markets using the NetScan$^+$ model. Appendix C contains a detailed description of the model, including the formulas used.

2.5 Supply response in the aviation market

On routes that fall under the ETS, higher ticket prices may lead to a fall-off in demand such that the passenger load factor falls below the break-even point. In such cases the airlines concerned will generally reduce the frequency of flights on these routes or, if possible, deploy a smaller aircraft. If certain services are badly affected, some destinations may even be scrapped. However, EU airlines will respond differently than airlines based outside the EU, while low-cost carriers (LCCs) will respond more flexibly than full-service carriers or network airlines.

European LCCs and charter airlines operating point-to-point networks will more readily reduce the frequency of their services than full-service carriers: LCCs and charter networks are more seasonal in nature, which makes the continuity of routes less important.[16] When deciding on reducing the frequency of services or scrapping services, European network airlines will also take account of the feeder value of routes in their hub-and-spoke systems. In any case, intercontinental routes must have a minimum frequency of once every day if they are to compete for the custom of business travellers. The scarcity of available slots is a more pressing consideration for network airlines, because relinquishing slots often means a considerable loss of value, given the opportunity costs they represent.

Other factors also contribute to the greater reluctance of full service carriers to decide to reduce frequencies of services or scrap destinations. Cutting back too severely could eventually endanger the continuity of their networks, which would become less attractive to transfer passengers, leading to more passengers deciding not to fly or switching to another airline.

Airlines based outside the EU can, in theory, also adjust their routes and change destinations or stopovers within the EU to airports outside the EU. However, it should be emphasised that network airlines outside the EU serve certain European destinations from locations outside the EU primarily because of the demand potential for these routes. Choosing destinations outside the EU simply to avoid the ETS costs is only possible if the airlines concerned could find other destinations with a corresponding demand potential outside the EU. It is to be expected that few such changes will be made because the alternative destinations with sufficient market potential will be hard to find – certainly on the long-distance routes. As a rule, only the bigger airports on other continents offer sufficient potential for a daily service.

A more predictable response is that expected from non-EU airlines that operate routes with fifth-freedom rights between airports outside the EU with a stopover at

[16] For example, Ryanair took 80 aircraft out of service during the 2011/12 winter season.

a European airport, such as Delta on the route New York–Amsterdam–Calcutta. If the size of the market potential for Amsterdam–Calcutta and vice versa is not a decisive factor, Delta could consider, given the extra ETS costs, flying directly between New York and Calcutta without a stopover in Amsterdam. However, such fifth-freedom operations have limited significance and for Schiphol can be counted on the fingers of one hand.

Angler & Köhler (2010) point not only to the previously mentioned constraints imposed by network effects and slots, but also to the required aviation rights. In many cases, air traffic between countries within and outside Europe, with the exception of North America, is subject to aviation policy restrictions. This may make it necessary to enter into new negotiations on aviation rights for new routes.

Besides rerouting flights to avoid ETS costs, it is conceivable that both EU and non-EU airlines will try to avoid a significant proportion of the ETS costs on long-distance routes by making an ‘operational’ stopover (where no passengers board or deplane) just outside the EU. This would mean that only the leg the route from the EU airport to the airport just outside the EU (and vice versa) would be subject to ETS rules. For example, for a flight between Amsterdam and Christchurch (New Zealand), a stopover could be made at Zurich. Without the stopover, the emissions for the whole route would be counted for the ETS; with the stopover, only the emissions for the first leg of the journey from Amsterdam to Zurich would count. However, the reduction in ETS costs thus achieved would have to outweigh the costs of an additional landing and take-off cycle,[17] the additional landing and take-off fees at Zurich and the loss of earnings resulting from the reduction in the quality of the travel product owing to the longer journey time because of the stopover and the longer, more indirect route. No calculations were made on the price of emission allowances at which this could be economically worthwhile. It is expected that the price of an emission allowance would have to be very high before the avoided ETS costs outweigh the disadvantages of a stopover. For this reason the calculations took no account of supply responses by airlines.

2.6 Required number of emission allowances

An important input parameter for the analysis of the effects of the EU ETS is the number of emission allowances the aviation sector needs in a certain target year and what proportion of this is allocated free to the sector.

In 2012 the aviation sector will receive 182.6 million free emission allowances (tonnes CO_2). The volume of emissions in 2012 is projected by the European Commission to be 243 megatonnes of CO_2 (EC, 2011a). This means that in 2012 the airlines will be allocated free emission allowances that will cover about 75% of their collective emissions.

In the period from 2013 to 2020 the aviation industry will receive 172.5 million free emission allowances (tonnes CO_2) each year (EC, 2011a). To calculate the number of allowances the airlines will need during this period we assumed a general growth in the number of tonne-kilometres and a general efficiency factor for the emission of CO_2.

[17] Such as landing and take-off cycle uses a disproportionate amount of fuel in relation to the distance flown.

Estimates of these vary quite widely. Boeing, Airbus and ICAO expect the market to grow by about 4% per year (Boeing, 2011; Airbus, 2011; ICAO, 2011). According to the ICAO (2010) and the International Energy Agency (IEA, 2010) an autonomous improvement in energy efficiency of 1% per year is possible. This means that CO_2 emissions will rise by an average of 3% per year.

Estimates by the European Commission (2011a) and the model used in the study by Bloomberg (2011) referred to above indicate a growth in emissions of about 2% per year. If we assume the same improvement in efficiency of 1% per year, this gives a market growth of about 3% per year.

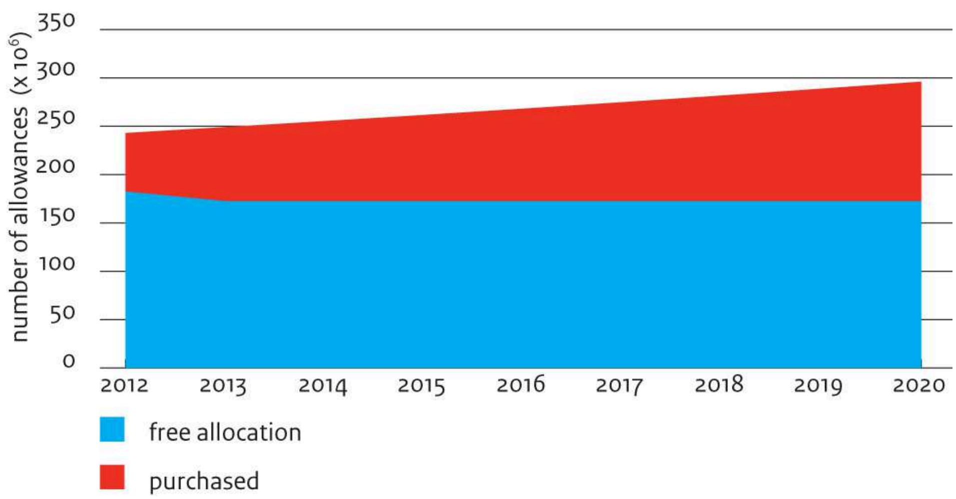


Figure 2.3
The number of emission allowances needed by the aviation industry for flights from, to and within Europe from 2012 to 2020.
Source: EC, 2011a; adapted by KiM.

For the present study we chose a growth scenario in between those given by the aforementioned studies: a market growth of 3.5% per year and an efficiency improvement of 1% per year. This means that emissions increase by 2.5% per year. Figure 2.3 shows the consequences of this for the period to 2020 and for the difference between actual emissions and the free allocation of emission allowances.[18]

In 2012 the airlines will have to purchase on average 25% of the emission allowances they need at the auction and on the market for emission allowances. By 2020 this proportion will have risen to 42%. Over the whole period from 2012 to 2020 on average about 35% of all the allowances needed will have to have been purchased. In the calculations with NetScan$^+$ it is assumed that the proportion of allowances that have to be purchased is the same for all airlines. The reason for this is that specific data on the proportion of allowances to be bought are not available for many of the airlines.

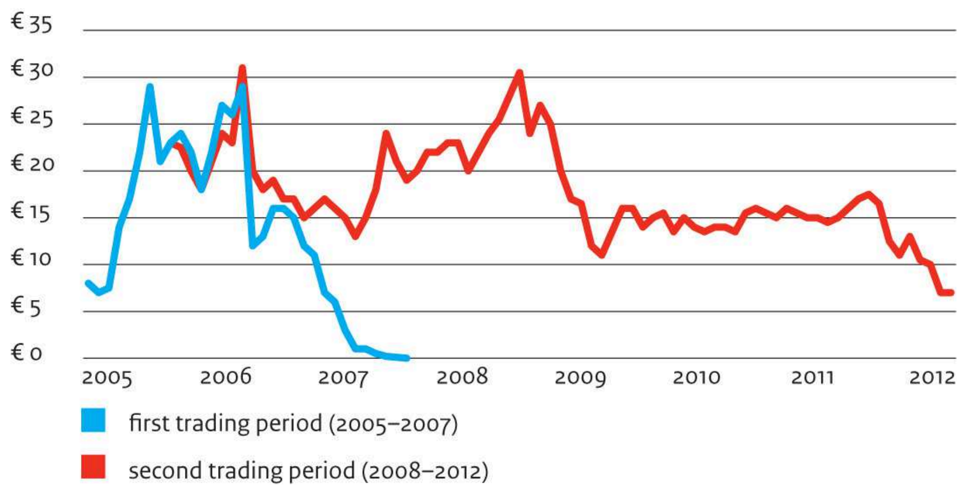
[18] This allocation of free emission allowances from 2013 does not include the 3% special reserve. This will only become available halfway during the 2013–2020 period (based on a tonne-kilometre benchmark in 2014). Newcomers and fast growing airlines will profit most from this. This reserve will therefore not lead to any reduction in the costs to many of the present carriers.

2.7 Cost of emission allowances

Since the EU ETS started in 2005 the price of emission allowances has fluctuated quite a lot.[19] Figure 2.4 shows that during the first few years the price fluctuated within a range of roughly 15 to 25 euros per tonne CO_2. In 2010 the average price was more than 13 euros per tonne and in 2011 it was 11.5 euros per tonne CO_2 (Point Carbon, 2012). In the second half of 2011 the price of emission allowances fell as a result of the economic crisis. Production declined in the energy and manufacturing sectors, leading to a surplus of emission allowances, and by January 2012 the price had fallen to about 7 euros per tonne of CO_2.

The trend in the price of emission allowances over the coming years will depend on many factors, including the level of economic growth, the trend in the price of oil, the development of renewable energy, global agreements on reducing greenhouse gas emissions and the weather (Graus et al., 2009).

Figure 2.4
The price of emission allowances (EUAs) since 2005.
Source: Bloomberg, 2012; Carbon Finance, 2010 and Graus, 2009; adapted by KiM.



Point Carbon (2011) expected that in the third trading period (from 2013 to 2020) the price of emission allowances will be about 12 euros per tonne CO_2. Graus et al. (2009) expected the price of emission allowances during this period to be about 20 euros per tonne CO_2. The European Commission based its Impact Assessment (EC, 2006) on a price range of 6 to 30 euros per tonne CO_2.

Effects of the Aviation EU ETS within the EU ETS
The aviation sector was included in the EU ETS in the final year of the second trading period, which runs from 2008 to 2012. The third trading period begins in 2013 and runs until the end of 2020. A common emissions cap has been set for all the ETS sectors.

The number of emission allowances added to the EU ETS in 2012 when aviation was brought within the scheme was 215 million (one emission allowance is equal to one tonne of CO_2); the number allocated to aviation in the years 2013 to 2020 will be

[19] There are various types of emission allowances and credits: (Aviation) EU Allowances; (A)EUA's, Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs) (see Appendix A). The prices of these differ, as do the conditions for their use. In the analysis a single price is assumed for all types of credits.

about 210 million each year. The airlines receive some of the allowances free, while others are available for purchase by auction. The total number of these emission allowances is referred to as the ‘emissions cap’ for aviation. This cap is not an absolute limit on aviation emissions: any additional emissions have to be covered by buying additional allowances.

Sectors that have been participating in the ETS for longer include the industrial and electricity sectors. The emissions cap for these sectors had already been set at 2,039 megatonnes for 2013, falling to 1,777 megatonnes in 2020 (EC, 2012). This is equivalent to -21% greenhouse gases compared with 2005 (EC, 2008). The emissions cap for the aviation sector has been added to the emissions cap for the other ETS sectors, thus raising the total ETS emissions cap (by less than 10%).

The number of emission allowances added to the ETS owing to the inclusion of the aviation sector in the scheme (of which some are allocated free to the airlines and some are available for purchase by auction) is lower than the total number needed by the airlines, making the total emissions cap tighter. In the period 2012–2020 the aviation sector will face an average shortage of about 58 megatonnes of CO_2 compared with the autonomous growth curve without the ETS.

In principle, the airlines can make up this shortfall in allowances in two ways:

- by buying allowances from other ETS sectors;
- by reducing emissions within the aviation sector, for example via more energy-efficient aircraft or lower carbon fuels.

The general expectation in the literature is that the aviation sector will mainly choose to buy additional allowances from other sectors, because at the current price of emission allowances this is expected to be less costly than making reductions within the sector (e.g. Wit et al., 2005; EC, 2006[20]). The price of kerosene and the sharp fluctuations in this price already form a powerful incentive for the aviation sector to make reductions. At the current price of emission allowances, the additional incentive afforded by the ETS is relatively small (see also section 3.5). If the aviation sector buys enough allowances to make good the shortfall, this will create an additional demand for emission allowances within the total ETS – including the other ETS sectors – of about 3%. Because this additional demand is relatively small, little or no increase in the price of emission allowances is expected as a result.

The analyses in the present study are based on two scenarios for the price of emission allowances: one with a price of 10 euros per tonne CO_2 and one with a price of 50 euros per tonne CO_2. The first scenario shows what the effects would be if the price remains about the same as the current market price. The second scenario is intended to reveal the sensitivity of the outcomes to large price increases.

[20] In the fictitious case that the aviation sector would not be allowed to buy additional emission allowances from outside the sector, according to the European Commission the price of emission allowances for the aviation sector would be more than 100 euros per tonne CO_2 (EC, 2006). This illustrates that emission reduction *within the aviation sector* (to the size of the relevant emissions cap for aviation) is relatively expensive compared with reductions in other ETS sectors.

From section 2.6 it can be concluded that in 2012 the airlines will have to purchase about 60 million emission allowances by auction and from other sectors on the market for emission allowances. At a price of 10 euros per tonne CO_2, the airlines' out-of-pocket costs will amount to about 0.6 billion euros in total. In 2020 the airlines are expected to have to buy more than 120 million emission allowances. If the price of emission allowances remains the same, their total out-of-pocket costs will then be around 1.2 billion euros.

2.8 Calculation of ETS costs per route

The ETS costs for specific routes are based on a calculation of the CO_2 emissions per passenger. A special module of the NetScan$^+$ model calculates the emissions for the average passenger for each journey option, taking account of the distance flown, the various flight phases (landing/take-off, climb, cruise and descent), any stopovers, the type of aircraft, the average aircraft size and the passenger load factor. The absolute and relative increases in the price of each journey alternative are calculated by applying the scenario assumptions about the price of emission allowances and the degree to which these are passed on to the passengers.

These price rises are then used to allocate the passenger numbers among the different routes. This in turn leads to different emission volumes for each journey alternative, based on the average emissions per passenger in the situation without the ETS. If the ETS leads to an increase in the number of passengers taking a certain journey alternative, the emissions from this alternative will therefore also increase. Accordingly, the emissions from journey alternatives for which the number of passengers decreases will also decrease.

This method of calculating emissions is a simplification of the much more complex reality made necessary by the limitations of the model. In practice, the emission levels depend mainly on the number of flight movements and the distances flown by each type of aircraft. The actual emissions will only change if these change. The relation between the number of passengers taking a certain journey alternative and the number of aircraft kilometres flown by a certain type of aircraft is in practice not a one-to-one ratio.

3 Effects of the Aviation EU ETS

3.1 Effects on ticket prices

If the airlines pass on the costs of emission allowances to their customers, ticket prices will rise. It is impossible to determine the effects of ETS costs on ticket prices in general. One of the reasons for this is that the ETS costs per passenger kilometre vary according to the passenger load factor and the flight distance.[21] A more important reason is that airlines can decide to pass on the costs in various degrees to different customer segments on different routes. For example, it is conceivable that ETS costs will be passed on at a higher than proportional rate to business class passengers and at a lower than proportional rate to economy class passengers, and also differently on different routes, or at different rates depending on how far in advance the tickets are purchased. Moreover, there is the question of the degree to which ETS costs are passed on to the cargo segment (Morrell, 2011).

It is possible, though, to obtain an indication of the order of magnitude of the ETS costs for various destinations. Table 3.1 shows the ETS costs for return flights to several popular destinations from Schiphol in 2012. For sake of simplicity, the total costs of the EU ETS have been divided by the total number of tonne-kilometres flown. The calculation is explained in detail in Appendix D.

Table 3.1
ETS costs per passenger per return ticket in three scenarios in 2012.

	Distance (return)	Price €10/tonne Out-of-pocket	Price €10/tonne Total costs	Price €50/tonne Total costs
Amsterdam – London	740 km	€0.2	€0.8	€4
Amsterdam – Barcelona	2,480 km	€0.6	€2.4	€12
Amsterdam – New York	11,730 km	€2.7	€10.8	€54
Amsterdam – Jakarta	22,730 km	€5.2	€20.8	€104

Given the growth in the aviation market and the efficiency improvements made by airlines (see section 2.7), and all other things being equal, the ETS costs per passenger kilometre in 2020 will be about 44% higher. In the scenario in which only the out-of-pocket costs are passed on to the passengers and the market price of emission allowances is 10 euros per tonne of CO_2, this means an additional 0.29 euros on the ticket price for a return flight from Amsterdam to London and an additional 7.50 euros on a return flight from Amsterdam to Jakarta.

Figure 3.1 shows that more than three-quarters of the origin–destination traffic at Schiphol are return flights of distances up to 6,000 kilometres.[22] At a price of 10 euros per emission allowance and if both the out-of-pocket costs and the opportunity costs are passed on, the ETS costs for these flights will be no more than 5.40 euros on a return ticket.

[21] Emissions per passenger kilometre decline as the average passenger load factor increases or as the length of a flight increases.
[22] The Schiphol questionnaire (Schipholenquête) includes the destinations of departing travellers. These were used to determine the flight distance to Schiphol. For the analysis it was assumed that the passengers take the same flight back. The origins of the transfer passengers are also known and this information could be used to determine the distance of that part of the flight to Schiphol.

Figure 3.1
Number of passengers at Schiphol by distance class for a return flight.
Source: Schipholenquête, 2007; adapted by KiM.

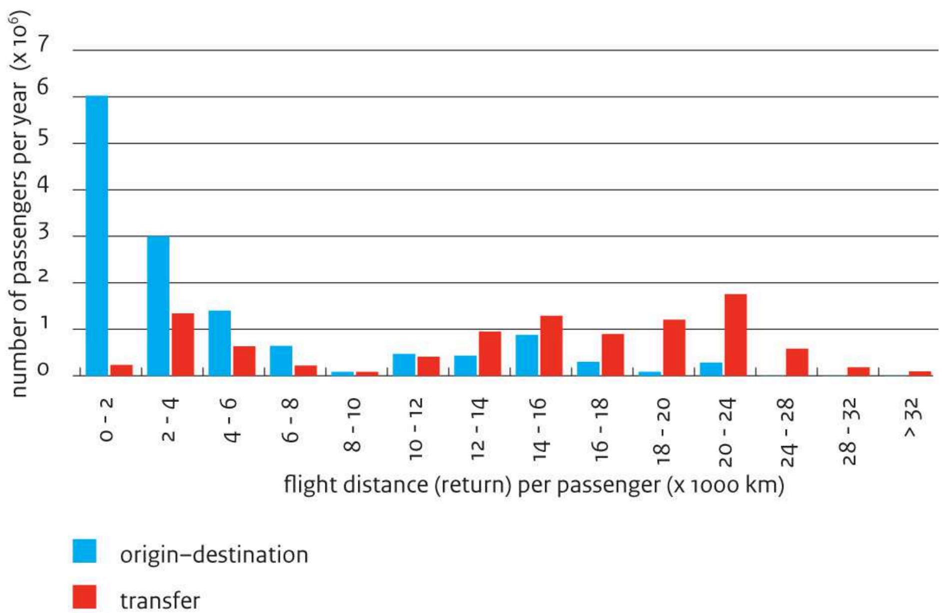


Figure 3.1 also shows that transfer passengers at Schiphol generally travel longer distances than origin–destination passengers. For a complete picture, both the length of the arriving and the connecting flight were taken into account, because both legs of the journey fall under the ETS and the accompanying additional costs can be passed on to the transfer passengers. The largest group of transfer passengers are in the distance class 20,000–24,000 kilometres (return). For them the maximum ETS costs, under the same assumptions as described above, are 21.60 euros per return ticket. The proportion of transfer passengers at Schiphol is about 42% of the total; the remaining 58% are origin–destination passengers (see Appendix E for more information).

The sums given in Table 3.1 for a flight from Amsterdam to New York are more or less of the same order of magnitude as a previous estimate made by the European Commission. In late 2011 the Commission expected that the cost of a ticket for a transatlantic flight would rise by no more than 2 euros if the value of the free allowances were not passed on to the passenger. If this value were to be passed on, the cost of a ticket could rise by about 12 euros (EC, 2011b).

At the time of writing, several reports have already appeared in the media about airlines raising the prices of tickets on certain routes. According to Transport World Online (2012a), Delta Air Lines, US Airways and American Airlines have increased the prices of tickets to and from Europe sold in the US by 3 dollars per one-way ticket. Air France-KLM and Alitalia, as joint venture partners of Delta Air Lines, followed suit on these routes (weblog The Beat, 2012). Ryanair has indicated that it will increase ticket prices by 0.25 euros per one-way ticket (Air Transport World Online, 2012b). It seems, therefore, that in practice airlines will choose to impose a flat rate per region and not to differentiate the costs per route according to distance or other aspects.

3.2 Effects on the aviation market

In this and the following sections we present the main results of the analyses carried out using the NetScan+ model. The results in section 3.2.1 reflect the average effect on EU airlines across all markets affected by the ETS for the years 2012, 2013 and 2020. Detailed results for various geographical market segments, airlines and airports are reported in later sections. The NetScan+ results give the order of magnitude of the effects. An important aspect is that the model calculations are based on the same proportion of free and purchased allowances for each airline (see section 2.6).

3.2.1 Effects on EU airlines in various scenarios

Table 3.2 shows the average decline in the numbers of passengers travelling with EU airlines in the total aviation market affected by the ETS. The percentages are the changes in growth in that year compared with the growth curve without the ETS. In section 2.6 this growth curve is defined as an average of 3.5% per year. This means that in 2012 the growth in passenger numbers drops off in 2012 by a certain percentage depending on the scenario. Given the operation of the ETS, this percentage reduction in passenger numbers may be different for the years following 2012.

Table 3.2
Average change in the number of passengers travelling with EU airlines in the total aviation market affected by the ETS for various target years in different scenarios. The percentages are relative to the growth curve without the ETS.

Scenarios	2012	2013	2020
€10; out-of-pocket costs	-0.2%	-0.3%	-0.3%
€10; total costs	-0.9%	-0.9%	-0.8%
€50; out-of-pocket costs	-1.1%	-1.3%	-1.6%
€50; total costs	-4.2%	-4.1%	-3.9%

The effect on the demand for flights at a market price of 10 euros per tonne of CO_2 will vary between -0.2% and -0.9%, depending on whether or not the opportunity costs are passed on.

To analyse the sensitivity of the outcomes to large price rises, additional scenarios were calculated in which the price of emission allowances was 50 euros per tonne. In general, the effects are then almost five times greater than with a price of 10 euros per tonne.[23] This applies to both the aggregated results and the more detailed calculations for different market segments (see the next subsection). In addition, the outcomes of the scenarios in which the total costs are passed on are on average four times higher in 2012 than when only the out-of-pocket costs are passed on.

In the scenarios in which only the out-of-pocket costs are passed on, the effects increase by about a factor of 1.5 between 2012 and 2020. The explanation for this is that the growth in the aviation market means that additional emission allowances have to be bought, which increases the costs per passenger. In section 2.6 it was stated that in 2012 airlines will have to purchase on average 25% of the emission allowances they need, in 2013 on average 31% and in 2020 on average 42%.

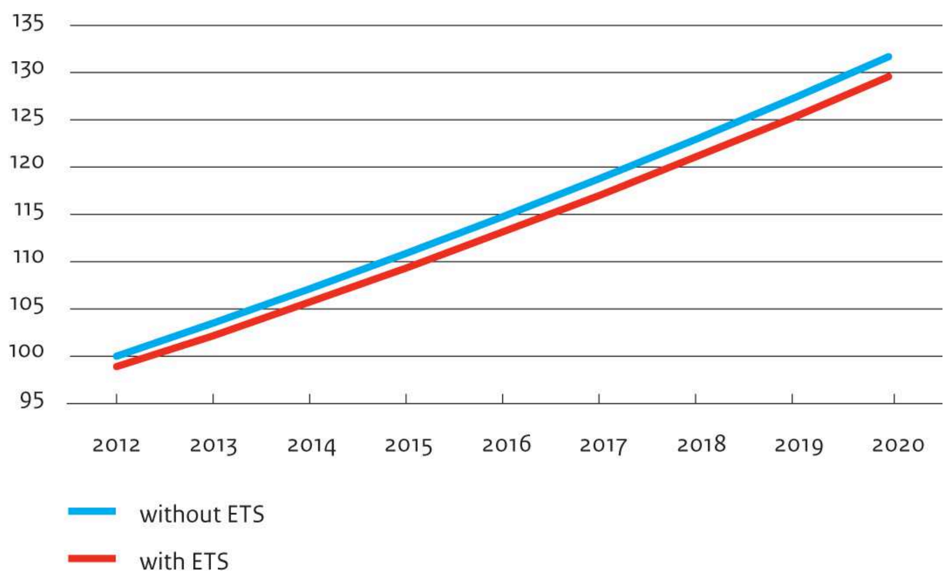
In the scenarios in which the total costs are passed on, the effects decrease between 2012 and 2020. This can be explained by the fact that the total costs of all the emission allowances required by the airlines rise less rapidly than the number of

[23] This does not always seem to be apparent in the table due to rounding off.

passengers (see the assumptions in section 2.6), which means that the costs per passenger decrease.

Figure 3.2 illustrates how this affects the growth of the European aviation market. To make the example as clear as possible, the graph shows the scenario in which the price of emission allowances is 50 euros and out-of-pocket costs are passed on. In the initial years growth lags behind by about 1.1%, but the relative difference with the growth curve without the ETS gradually increases to 1.6%. The course of this curve applies only if the airlines make no changes to their networks that can cause any second-order effects on demand. The calculation takes no account of these types of effects (see also section 3.3.5).

Figure 3.2
Growth in the number of passengers travelling with EU airlines with and without the ETS when the price of emission allowances is 50 euros and out-of-pocket costs are passed on.

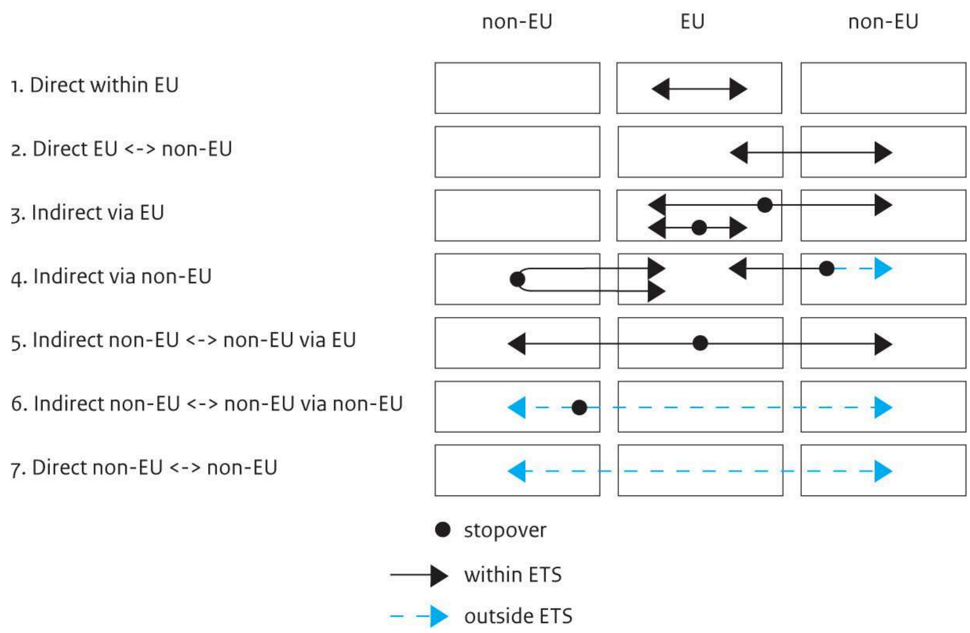


The following sections contain description of the effects only for 2012 and for the scenario in which the out-of-pocket costs are passed on and the price of emission allowances is 10 euros. The outcomes for the situations in which the price is 10 euros and the total costs are passed on are given in Appendix F.

3.2.2 *In geographical market segments*

The effects in various market segments are different from the average for the European airlines. Moreover, some non-EU airlines also fly to and from the EU and are affected by the ETS. Whether this effect is positive or negative depends on the geographical market segment concerned. Figure 3.3 shows which seven geographical market segments were used for the analysis. The total effect in a market segment consists of the balance of ‘no longer flying’ and avoidance behaviour.

Figure 3.3
The identified market segments within the total market affected by the ETS.



1. Direct within the EU: direct flights from an EU airport to an EU airport (and vice versa)
2. Direct EU <-> non-EU: direct flights from an EU airport to a non-EU airport (and vice versa)
3. Indirect via the EU: indirect flights from a non-EU airport with a stopover at an EU airport to a destination within or outside the EU (and vice versa)
4. Indirect via a non-EU airport: indirect flights from an EU airport with a stopover at a non-EU airport to a destination within or outside the EU (and vice versa)
5. Indirect non-EU <-> non-EU via EU: flights from a non-EU airport via an EU airport to a non-EU airport (and vice versa)
6. Indirect non-EU <-> non-EU via non-EU: flights from a non-EU airport via a non-EU airport to a non-EU airport (and vice versa) that compete with flights in market segment 5
7. Direct non-EU <-> non-EU: direct flights from a non-EU airport to a non-EU airport (and vice versa) in which connections compete with connections in market segment 5

Table 3.3 shows the effects in these geographical market segments for the scenario in which the out-of-pocket costs are passed on and the market price of emission allowances is 10 euros per tonne. The effects on European and non-European airlines are given separately. The effects when the total costs are passed on are given in Appendix F (Table 3.3a).

The EU ETS will lead to a reduction in the total number of passengers travelling with all EU airlines of about 0.2%.[24] The main reason for this is that some passengers

[24] This increases to 0.9% if the total costs are passed on.

will decide not to fly; in addition, a small proportion of passengers will show avoidance behaviour and choose other travel options. This can be seen in the increase in the number of passengers flying with non-EU carriers in other market segments. The net effect across all the market segments considered for the average non-EU airline is that they gain no additional passengers.[25]

Table 3.3
Effects on the number of passengers in the various geographical market segments for EU and non-EU airlines when out-of-pocket costs are passed on and the price of emission allowances is 10 euros.

Target year 2012	**Type of carrier**	**Passengers**			**Relative size of market segment**
Market segment		***Total***	***No longer fly***	***Avoidance behaviour***	
1. Direct within EU	EU	-0.1%	-0.1%	0.0%	50.6%
1. Direct within EU	non-EU	-0.2%	-0.1%	-0.0%	0.1%
2. Direct EU–non-EU	EU	-0.2%	-0.2%	0.0%	10.6%
2. Direct EU–non-EU	non-EU	-0.2%	-0.2%	0.0%	8.3%
3. Indirect via EU	EU	-0.3%	-0.2%	-0.1%	15.5%
3. Indirect via EU	non-EU	-0.5%	-0.2%	-0.2%	1.1%
4. Indirect via non-EU	EU	-0.2%	-0.2%	0.0%	0.6%
4. Indirect via non-EU	non-EU	0.1%	-0.2%	0.3%	6.2%
5. Indirect nEU-nEU via EU	EU	-1.3%	-0.3%	-1.0%	2.6%
5. Indirect nEU-nEU via EU	non-EU	-1.4%	-0.3%	-1.1%	0.7%
6. Ind. nEU-nEU via nEU	EU	-	-	-	0.0%
6. Ind. nEU-nEU via nEU	non-EU	1.3%	0.0%	1.3%	1.7%
7. Direct non-EU–non-EU	EU	-	-	-	0.0%
7. Direct non-EU–non-EU	non-EU	0.3%	0.0%	0.3%	1.9%
TOTAL	EU	-0.2%	-0.2%	-0.1%	79.9%
	Non-EU	0.0%	-0.2%	0.2%	20.1%

The biggest relative decrease and increase can be seen in market segments 5 and 6. The indirect traffic with an origin and destination outside the EU and a stopover at an EU airport declines by more than 1%, whereas the indirect traffic with a stopover at a non-EU airport increases by more than 1%.[26]

However, these market segments make up just a small share of the total market affected by the ETS, although this does not necessarily mean that their economic significance is of the same order. These markets could be more lucrative than intra-European transport, for example. Moreover, this type of traffic contributes to the network of intercontinental connections for travellers to and from European airports. However, an economic assessment of these market segments requires specific knowledge of the margins per type of passenger on routes in the different market segments.

Table 3.4 shows the effects in the various market segments for the same scenario, but this time with a breakdown of effects between European full-service carriers (FSC) and European low-cost carriers (LCC). The effects for the same breakdown when the total costs are passed on are given in Appendix F (Table 3.4a).

[25] If the total costs are passed on they gain 0.2% additional passengers.
[26] If the total costs are passed on the size of these effects increases to more than 5%.

Table 3.4
Effects on the number of passengers per geographical market segment for European full-service carriers (FSC) and low-cost carriers (LCC) when out-of-pocket costs are passed on and the price of emission allowances is 10 euros.

Market segment	**Type of carrier**	**Passengers**			**Relative size of market segment**
		Total	***No longer fly***	***Avoidance behaviour***	
1. Direct within EU	FSC	-0.1%	-0.1%	0.0%	32.0%
1. Direct within EU	LCC	-0.1%	-0.1%	0.0%	31.4%
2. Direct EU–non-EU	FSC	-0.3%	-0.2%	0.0%	8.4%
2. Direct EU–non-EU	LCC	-0.1%	-0.2%	0.0%	4.8%
3. Indirect via EU	FSC	-0.3%	-0.2%	-0.2%	18.9%
3. Indirect via EU	LCC	-0.1%	-0.1%	0.0%	0.5%
4. Indirect via non-EU	FSC	0.2%	-0.2%	0.0%	0.8%
4. Indirect via non-EU	LCC	-	-	-	0.0%
5. Indirect nEU–nEU via EU	FSC	-1.3%	-0.3%	-1.0%	3.3%
5. Indirect nEU–nEU via EU	LCC	-	-	-	0.0%
TOTAL	FSC	-0.3%	-0.2%	-0.1%	63.3%
	LCC	-0.1%	-0.1%	0.0%	36.6%

In general, European full-service carriers will be affected slightly more than European low-cost carriers. This is because low-cost carriers in general operate much less on transfer markets. Moreover, when prices are increased there is a small shift in passengers to low-cost carriers.

The effects in Tables 3.3 and 3.4 are those when the ETS costs arising in each market segment are passed on within the same markets. In practice, though, it is possible that airlines will cross-subsidise costs in these market segments. European airlines could pass on a higher than proportional share of the ETS costs to passengers on routes within Europe and a lower than proportional share of the costs to their intercontinental transfer passengers. The intra-European passengers have no alternatives with lower ETS costs available to them and will therefore be less sensitive to price rises than intercontinental transfer passengers. Having said that, EU airlines can only do this on intra-European routes that face little competition from other carriers. There may also be opportunities to pass on ETS costs to the cargo market segment. This possibility is not included in the analyses.

3.3 Effects on airlines

3.3.1 In geographical market segments

A significant aspect of the research question for this study is the effect of the EU ETS on the Dutch aviation sector. Although this sector consists of several airports and airlines, the analysis in this and the next section focuses on the two largest players in the market: Schiphol and KLM. In both cases, the analysis concentrates on how the effects on these players compare with the effects on competing airlines and airports.

Table 3.5 summarises the changes in the number of passengers per geographical market segment for the four big European airlines. The figures are based on the passing on of out-of-pocket costs and a market price of 10 euros per tonne CO_2. They reflect the overall effects: the balance of ‘no longer flying’ and avoidance behaviour. The effects when the total costs are passed on are given in Appendix F (Table 3.5a).

Table 3.5
The effects on the number of passengers per airline per geographical market segment when out-of-pocket costs are passed and the price of emission allowances is 10 euros.[27]

Market segment	**KLM**	**Air France**	**Lufthansa**	**British Airways**
1. Direct within the EU	-0.1%	-0.1%	-0.1%	-0.2%
2. Direct outside EU	-0.4%	-0.2%	-0.3%	-0.5%
3. Indirect via EU	-0.6%	-0.1%	-0.3%	-0.8%
4. Indirect via non-EU	-0.6%	0.0%	-0.0%	-1.2%
5. Indirect non-EU–non-EU via EU	-1.5%	-0.8%	-1.2%	-2.2%
6. Indirect non-EU–non-EU via non-EU	-	-	-	-
7. Direct non-EU–non-EU	-	-	-	-
TOTAL per airline	-0.6%	-0.2%	-0.3%	-0.7%

Table 3.5 shows that KLM is affected by the ETS more than Air France or Lufthansa, but less than British Airways. This has to do, among other things, with the number of flights operated by the airlines in the various market segments. Air France has relatively more traffic in market segments 1 and 2, which are the least sensitive to ETS costs. British Airways carries a relatively large number of passengers in market segment 5, which is the most sensitive to cost increases.

The effects on KLM are also larger than for an average European full-service carrier, for which the effects are given in Tables 3.3 and 3.4. The effects on Air France, Lufthansa and British Airways are greatest in market segment 5, ‘indirect flights between two non-EU destinations via an EU airport’. The market share of this segment varies per airline between 8% and 12%, which means the effect on the total reduction in demand is relatively limited.

There are many network airlines based outside the EU which can profit from the ETS. To illustrate this, we looked at the position of Emirates, Swiss Airlines and Turkish Airlines. These airlines may become more attractive carriers for intercontinental transfer passengers who no longer want to travel via an EU airport and for passengers to the EU who no longer want to fly directly, but indirectly. Table 3.6 (and Table 3.6a in Appendix F) shows that these airlines will indeed profit from the ETS in these market segments. Emirates in particular will see a relatively large growth in those market segments. Both Swiss Airlines and Turkish Airlines also have a small share of the passengers in market segment 5, ‘indirect flights between two non-EU destinations via an EU airport’. Like the other airlines, they will lose passengers in this market segment.

[27] N.B. The percentages cannot be added up; for each airline they represent a different size of absolute effect, because the size of the market segment is different for each airline.

Table 3.6
The effects on the number of passengers per airline per geographical market segment when out-of-pocket costs are passed on and the price of emission allowances is 10 euros.[28]

Market segment	**Emirates**	**Swiss Airlines**	**Turkish Airlines**
1. Direct within the EU	-	-	-
2. Direct outside EU	-0.3%	-0.1%	-0.2%
3. Indirect via EU	-	-	-
4. Indirect via non-EU	0.7%	1.3%	0.4%
5. Indirect non-EU–non-EU via EU	-	-1.4%	-0.8%
6. Indirect non-EU–non-EU via non-EU*	2.55%	2.2%	1.0%
7. Direct non-EU–non-EU*	0.8%	0.8%	0.2%
TOTAL per airline	0.7%*	0.5%*	0.1%*

*) Only that part of the market served by the airline concerned and which is affected by the ETS. The increase does not therefore apply to the total number of passengers carried by the airline concerned.

As an illustration of the orders of magnitude of the effects, in Tables 3.7 and 3.7a (see Appendix F) these percentage changes have been converted to passenger numbers based on the numbers of passengers carried in 2011.

Table 3.7
Illustration of the reduction in the number of passengers by converting the percentages in Tables 3.5 and 3.6 using the actual passenger numbers in 2011.
*Source: CAPA 2012; AEA, 2011 and *Netscan; adapted by KiM.*

Airline	**Passengers in 2011 (millions)**	**Relative reduction**	**Change in passenger numbers (thousands)**
KLM	25.1	-0.6%	-150
Air France	50.7	-0.2%	-100
Lufthansa	65.5	-0.3%	-200
British Airways	37.1	-0.7%	-260
Emirates*	8.2	0.7%	60
Swiss Airlines*	10.1	0.5%	50
Turkish Airlines*	11.1	0.1%	10

*) Only that part of the market served by the airline concerned and which is affected by the ETS. The increase does not therefore apply to the total number of passengers carried by the airline concerned.

3.3.2 *Additional cross-subsidy and boycott scenarios*

It would be disadvantageous to European airlines if non-EU airlines could pass on part of their ETS costs to passengers on routes falling outside the ETS, or if they did not participate in the ETS. In these scenarios, the European airlines will lose more passengers, while non-European airlines will gain more additional passengers. Table 3.8 shows the effects on a number of airlines in the various scenarios.

[28] N.B. The percentages cannot be added up; for each airline they represent a different size of absolute effect, because the size of the market segment is different for each airline.

Table 3.8
Relative changes in the numbers of passengers per airline in three scenarios when out-of-pocket costs are passed on and the price of emission allowances is 10 euros.

	Costs fully passed on	**Additional cross-subsidy**	**Boycott**
KLM	-0.6%	-0.9%	-0.9%
Air France	-0.2%	-0.4%	-0.4%
Lufthansa	-0.3%	-0.5%	-0.5%
British Airways	-0.7%	-1.1%	-1.1%
Emirates*	0.7%	0.8%	0.7%
Swiss Airlines*	0.5%	0.6%	0.5%
Turkish Airlines*	0.1%	0.3%	0.3%

*) Only that part of the market served by the airline concerned and which is affected by the ETS. The increase does not therefore apply to the total number of passengers carried by the airline concerned.

The effects in the scenario reflecting the postulated possibilities for additional cross-subsidisation (see section 2.3) are coincidentally more or less the same as in the scenario in which non-EU airlines boycott the ETS.[29] Of the European airlines listed here, British Airways is most affected in both scenarios. Of the non-EU airlines listed here, Emirates profits the most.

3.3.3 Number of free emission allowances per airline

The model calculations are based on the same ratio of free to purchased allowances for each airline (see section 2.6). In practice, though, these proportions will be different. The allocation method results in airlines with an efficient tonne-kilometre performance receiving relatively more free allowances than less efficient airlines. This is a determining factor for the financial consequences for airlines and also for the effects on various markets when the airlines only pass on out-of-pocket costs.

In 2012 the airlines receive 0.6769 emission allowances for each thousand tonne-kilometres they flew in 2010. In the years 2013 to 2020 the benchmark is 0.6422 emission allowances for each thousand tonne-kilometres (EC, 2011a). Whether the free emission allowances will be sufficient to cover the actual CO_2 emissions of the airlines concerned will depend on the energy efficiency of each tonne-kilometre flown. This can vary considerably between airlines and depends, among other things, on:

- the energy-efficiency of the aircraft: the more efficient, the better;
- the load factor of the aircraft: the higher, the better;
- the average flight length: the longer, the better (fuel consumption per kilometre is on average lower on longer flights than shorter flights).

If flights are very energy-efficient indeed, the airline may even receive more free allowances than it actually needs.

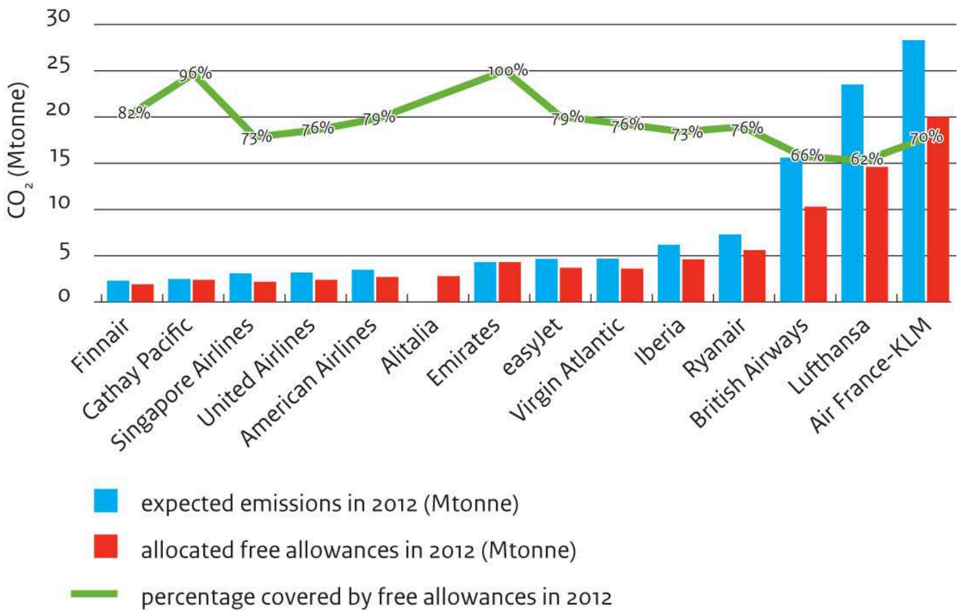
Figure 3.4 shows the differences between the number of allocated free emission allowances and the expected CO_2 emissions in 2012 for a large number of European and non-European airlines. The airlines are ranked from left to right by increasing

[29] At a price of 50 euros per emission allowance the effects are different and are more severe for the EU airlines in the boycott scenario than in the additional cross-subsidisation scenario.

CO_2 emissions. The proportion of free emission allowances in relation to the expected emissions varies from 62% (Lufthansa) to 100% (Emirates).

The projected CO_2 emissions in 2012 are based on actual emissions in 2010. These were derived from various sources, especially DECC (2011), Ryanair (2006) and annual financial and social reports for 2010 by Air France-KLM, Lufthansa, Iberia and Finnair. It was assumed that the CO_2 emissions of all airlines grew by 2.5% in 2011 and 2012. Data on the number of free emission allowances allocated to airlines were taken from the allocation plans of the EU member states, which can be found on the website of the European Commission.[30]

Figure 3.4
Expected emissions and allocated free allowances in 2012 and the percentage of expected emissions covered by free emission allowances in 2012.
Source: analysis by KiM.



3.3.4 *Costs to KLM*

Airlines will only pass on the costs of purchased allowances to passengers if this is more beneficial for their operating result than absorbing the costs. If they absorb the costs, ticket prices, passenger numbers and turnover will remain unchanged. In addition, the airlines can choose to pass on all or some of the value of the free emission allowances, the opportunity costs, to their passengers. The airlines will only do this if it improves their operating result compared with passing on only the costs of the purchased allowances (see also the text box in section 2.3). The maximum negative effect on the operating result is therefore equal to the costs of absorbing the cost of the allowances.

The costs of the emission allowances KLM will have to buy in the period from 2012 to 2020 were estimated on the basis of KLM's actual emissions in 2010 and the generic growth in emissions of 2.5% per year assumed in the analyses (see section 2.6). These costs were calculated to be about 30 million euros per year. In practice, the costs of the ETS to KLM may be lower if it proves beneficial to KLM to pass on

[30] http://ec.europa.eu/clima/policies/transport/aviation/allowances/links_en.htm

all or some of these costs, and possibly also the value of their free emission allowances. In section 2.3 it was stated that this is a strategic choice that depends on several factors.

3.3.5 *Network effects*

It is difficult to predict in advance for each airline whether the effects will give them cause to make changes to their networks, and if so, to what extent. This depends in part on their network strategies and financial positions: how long will an airline want or be able to keep loss-making routes operational?[31] The chance of the network eroding as a result of this second-order effect increases as the ETS induced price rise increases. But again, the airlines themselves will decide what the consequential losses will be from making changes to their networks and weigh this up against the option of passing on less or none of the cost to passengers. Only the airlines have the information needed to make that call. The analyses in this report do not therefore include an estimate of the likelihood of network effects occurring.

3.4 Effects on airports

In the market segments with direct flights the effects on airports are not much different from the effects on the aviation market in general (see section 3.2). Only in the transfer markets in which the hub function of an airport is important do the effects differ more significantly between airports. This is most apparent for the indirect flights via EU hubs (market segment 3) and hub traffic via an EU hub (market segment 5). The alternatives to these are indirect flights via non-EU hubs (market segment 4) and hub traffic via a non-EU hub (market segment 6).

Table 3.9 shows the changes in passenger numbers in the whole domestic market plus transfer market for the four biggest European hub airports and three alternatives outside the EU. The analysis is based on the assumption that the airlines pass on their out-of-pocket costs and the market price for emission allowances is 10 euros. The results reflect the overall effects: the balance of ‘no longer flying’ and avoidance behaviour. The effects when the total costs are passed on are given in Appendix F (Table 3.9a).

Table 3.9
Relative changes in passenger numbers per airport when out-of-pocket costs are passed on to passengers and the price of emission allowances is 10 euros.[32]

Market segment	Schiphol	Paris CdG	Frank-furt	London Heathrow	Dubai*	Zurich*	Istan-bul*
Domestic market	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%
Transfer passengers	-0.7%	-0.3%	-0.6%	-1.2%	1.0%	1.6%	0.5%
TOTAL	-0.4%	-0.2%	-0.4%	-0.5%	0.4%	0.2%	0.1%

*) Only that part of the market served by the airline concerned and which is affected by the ETS. The increase does not therefore apply to the total number of passengers carried by the airline concerned.

[31] At the time of writing one airline had announced that it will cancel certain routes partly in response to the ETS. From 31 March 2012 Air Asia X will no longer fly between Kuala Lumpur and London Gatwick and Paris Orly, stating the EU ETS and rising aviation taxes as the reasons (ATW Online, 2012b).
[32] N.B. The percentages cannot be added up; for each airline they represent a different size of absolute effect, because the size of the market segment is different for each airline.

Table 3.9 shows that the ETS will have a greater effect on the transfer market at Schiphol than at Paris Charles de Gaulle. The effect on the transfer market at Frankfurt is more or less similar to that at Schiphol. Of the four EU airports considered, the transfer market at London Heathrow will be most negatively affected by the ETS.

In the previous section the positions of Emirates, Swiss Airlines and Turkish Airlines were examined to illustrate the expected effects. The effects on the hub function of these same airports are therefore also included in Table 3.9. The results show that these hubs will profit from the ETS because in certain market segments it will become more attractive to travel via a non-EU hub. In those market segments, Zurich can expect to see the highest growth.

Flight movements at Schiphol and loss of turnover for the Schiphol Group
Table 3.9 shows that in 2012 the number of passengers at Schiphol will fall by 0.4% when all the out-of-pocket costs of emission allowances are passed on and the price of allowances is 10 euros per tonne of CO_2. If the airlines also pass on the value of their free emission allowances to their customers, this will lead to a 1.6% reduction in passenger numbers (see Table 3.9a in Appendix F). In 2011 Schiphol handled almost 50 million passenger movements. The number in 2012 is not expected to be much different: a reduction of the order of 200,000 (out-of-pocket costs passed on) and 800,000 (out-of-pocket costs plus opportunity costs passed on) passengers.

In 2011 Schiphol handled about 118 passengers per flight movement. Based on the passenger numbers given above, this could lead to a reduction of about 1,700 or 6,800 flight movements respectively in 2012. This effect is illustrative and should be seen as an upper limit. The calculation is based on the assumption that the number of flight movements falls in proportion to the number of passengers according to a fixed ratio between passenger numbers and flight movements. In practice it is possible, certainly in the short term, that airlines will accept a lower occupancy rate during a certain period in the expectation that demand will pick up again in future and occupancy rates will return to normal, and also to avoid any second-order effects[33] (see also section 2.5).

If only the fall in passenger numbers is considered, this will result mainly in a loss of income for the Schiphol Group from passenger fees, car parking charges and passenger spending at the airport. This loss of income for the Schiphol Group is estimated to be in the order of 3.6 to 14.4 million euros. Other parties at Schiphol, such as ground handling, catering and hospitality operators, will also feel the consequences of a fall in passenger numbers in their turnover. However, these effects have not been quantified.

Regional employment effects at and around Schiphol
Including aviation within the EU ETS will result in a reduction in the accommodated number of passengers at Schiphol proportionate to the price of a tonne of CO_2. The decline in passenger traffic in relation to the original growth curve will also have consequences for the businesses at and around Schiphol. Whether this will lead to an increase in unemployment in the short term is uncertain.

[33] Passengers pulling out because the flights on offer are less attractive.

When determining the regional employment related to an airport a distinction is made in the literature between direct and indirect employment. Direct employment is inseparably and immediately linked with airport activities and involves activities carried out at the airport or in the immediate surroundings. Indirect employment is not directly linked to airport activities and does not therefore necessarily take place in the direct surroundings of the airport. The connection between the volume of air traffic at an airport and direct employment is reflected in the number of jobs per 1,000 passengers, or 1,000 work load units (WLUs). One WLU is equal to 1 passenger or 0.1 tonnes of cargo. As a rule of thumb, larger airports provide about 1,000 jobs per 1 million WLUs. However, Graham (2008) emphasises that the differences between airports are considerable. A specific value for Schiphol is not known.

This rule of thumb can be used to give an indication of the effect of the drop in passenger numbers resulting from the EU ETS on direct employment in the Schiphol region. According to Tables 3.9 and 3.9a the number of passengers at Schiphol in 2012 will be reduced by 0.4% in relation to the original growth curve when the airlines only pass on their out-of-pocket costs and by 1.6% when they pass on the full costs of the ETS, assuming the cost of a tonne of CO_2 is 10 euros. In absolute numbers, this is a reduction of 200,000 and 800,000 passengers respectively compared with the original growth curve, assuming that in total about 50 million passengers will be accommodated at Schiphol in 2012.

Application of the rule of thumb to this reduction in passenger numbers leads to a reduction in the number of direct jobs with respect to the trend in employment of 200 and 800 respectively. The extent to which this will actually result in an increase in unemployment in the short term depends on various factors that have not been quantified. The fall in the number of jobs is only a deviation from the trend in the growth in direct employment. This trend is primarily determined by the trend in the growth of the aviation market and the fluctuations in demand for flights associated with the general economic climate.

To determine whether the fall in passenger numbers resulting from the EU ETS will lead to an actual reduction in job numbers, other factors also have to be taken into the equation. It is perfectly possible that the net result will then be that employment simply rises less rapidly. Moreover, other factors are also relevant when translating the number of jobs into unemployment figures, such as the proportion of unskilled workers and the displacement effects of more highly skilled workers in other sectors (CPB, 2000).

No calculations were made of the effects on indirect employment because of practical and fundamental problems. First, the data for the various airports are often based on different calculation methods, which makes comparison very difficult. In addition, there are also more fundamental objections to these calculations of indirect employment effects: when applied to each sector in the national economy the sum of direct and indirect employment in all the different sectors amounts to well over the total national employment figures. For these reasons, in this report only the direct employment effects of the projected reduction in passenger traffic have been quantified.

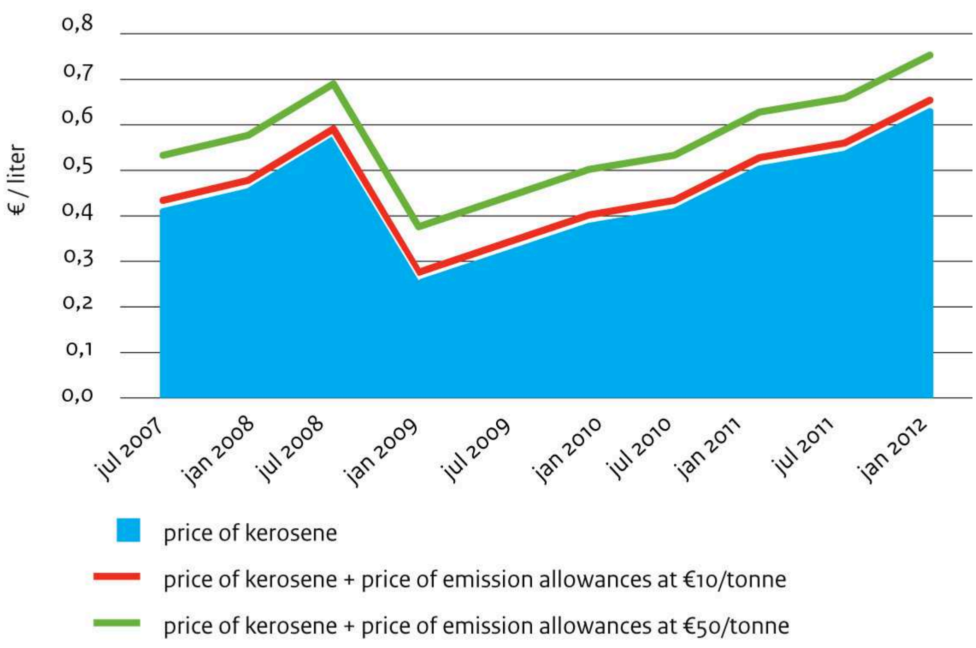
3.5 Effects on the environment

The inclusion of aviation within the EU ETS is expected to lead to emission reductions within the ETS as a whole. This is because the number of emission allowances added to the ETS as a whole as a result of the inclusion of the aviation sector is smaller than the actual emissions from the aviation sector.

The number of additional emission allowances is about 215 megatonnes in 2012 and 210 megatonnes per year in the years 2013 to 2020. Assuming an estimated growth in the aviation sector of 3.5% per year and an autonomous efficiency improvement of 1% per year, aviation emissions in 2020 will amount to about 296 megatonnes (see Figure 2.3).

Because the total number of free emission allowances allocated to the airlines and the allowances they can purchase by auction are insufficient to cover their actual emissions, airlines will have to take mitigating measures or buy allowances from other sectors in the ETS, which will in turn themselves have to take mitigating measures. The relative scarcity of emission allowances will determine their price, and therefore which companies or which sector can reduce emissions most cost effectively. Irrespective of the question of whether mitigating measures can be taken within the aviation sector or not, the reductions can be attributed to aviation, because it is the participation of the aviation sector in the ETS that will drive these reductions somewhere in the system as a whole. The difference between the expected aviation emissions and the contribution the sector makes to the total cap in 2020 is about 86 megatonnes. Compared with the expected emissions, this amounts to a reduction of about 29%.

Figure 3.5
The cost of a litre of kerosene in the period from July 2007 to January 2012 and the additional costs when the price of emission allowances is 10 and 50 euros per tonne CO_2.



At a price of 10 euros per tonne of CO_2 the participation of the aviation sector in the ETS will probably not lead to a large reduction in emissions by the aviation industry itself, because the additional stimulus of the price of emission allowances is relatively small. The current high price of kerosene is a much greater incentive to increase the fuel efficiency of aircraft. In January 2012 the price of kerosene was about 63 euro cents per litre. This is more than twice the price at the beginning of 2007, when kerosene cost 25 euro cents per litre (IATA, 2012). Figure 3.5 shows the trend in kerosene prices since July 2007. The two lines show the cost increase in terms of the price of a litre of kerosene when the price of emission allowances is 10 and 50 euros per tonne of CO_2.

The aviation sector will already take as many efficiency measures as it can, as long as the value of the fuel savings exceeds the costs of the measures themselves. The additional incentive of the cost of emission allowances at 10 euros per tonne is comparable with a rise in the price of kerosene of 2.5 cents per litre, which is 4% of the current price. At an emission price of 50 euros per tonne, the incentive is comparable with a rise in the price of kerosene of 12.5 cents per litre. At that price, emission reduction measures that are currently not worthwhile may become financially attractive.[34]

Various parties in the aviation sector have expressed the fear that the ETS will lead to an increase in actual CO_2 emissions instead of a decrease, because passengers and/or airlines will avoid Europe and redirect routes outside European airspace. In the previous sections we have seen that more passengers than before will indeed choose flights that entirely or partially fall outside the ETS, leading to an increase in CO_2 emissions outside the ETS area. At a price of 10 euros per emission allowance, this increase in emissions will be 0.5 to 1.1 megatonnes of CO_2 in 2020, depending on whether only the costs of purchased allowances are passed on to the passengers or the value of the free emission allowances is also passed on. At a price of 50 euros per emission allowance, the increase will be 2.4 and 5.5 megatonnes respectively. Compared with the previously mentioned reduction of 86 megatonnes within the ETS in 2020, this increase in emissions outside the ETS is relatively small. Within this price range, participation by the civil aviation sector in the ETS will therefore lead to a net reduction in CO_2 emissions compared with the situation in which aviation is not included in the ETS.

[34] An analysis of cost-effective measures was outside the scope of this study.

4 Other effects of the ETS

4.1 Proceeds from the auction may be spent in various ways

If the member states do not harmonise the uses to which they put the proceeds of the auction, competition within the aviation industry could be distorted. The ETS mechanism has been designed with the aim of preventing any disruption to competition in the aviation sector,[35] which is why the system also applies to flights to and from Europe operated by non-EU airlines. However, second-order effects could arise, because there appears to be no policy harmonisation between the various member states on how the proceeds from the auction are to be spent. If this leads to a mishmash of national regulations on expenditure of the proceeds, it is possible that the competitive positions of airlines from different member states could be disrupted 'via the back door', affecting not only competition between EU and non-EU airlines, but also between EU airlines.

Directive 2009/29/EC cannot prevent differences in the way this money is spent. According to this directive at least 50% of the proceeds from the auction of emission allowances should be used on measures for limiting greenhouse gas emissions, adapting to climate change, financing research and development for reducing emissions, and developing renewable energy. In addition, some of the proceeds should be used to mitigate climate change in the European Union and other countries and to cover the administrative expenses of the management of the trading scheme. In practice, member states may deviate from the provisions in this directive under the subsidiarity principle and make their own decisions on how to spend the proceeds.

Auction proceeds

A total of more than 32 million emission allowances will be auctioned for the trading year 2012; for the years 2013 to 2020 the number will be about 38 million. If the auction price is 10 euros per emission allowance, the total auction proceeds will be 320 million euros for 2012 and 380 million euros each year in 2013 and subsequent years. Data from the Dutch Emissions Authority (NEa, 2012) indicate that in the trading year 2012 the Netherlands will auction almost 2.5 million aviation emission allowances and in each subsequent trading year a little over 2.9 million allowances. The proceeds will then be 25 million euros in 2012 and 29 million euros per year in 2013 and subsequent years.[36]

Under Dutch budgetary policy, the proceeds will accrue to general resources. From a macro-economic perspective this generally makes the biggest contribution to public welfare, as long as the proceeds from the auctioned emission allowances are used to reduce the marginal tariffs of other distorting taxes. However, considerations other than social efficiency may also play a role in the political debate on how to spend these proceeds.

It is not known what other member states will do. They may choose to invest all or part of the proceeds in the aviation sector, for example to protect the competitive

[35] The fact that airlines from Asian countries in particular have a different opinion on this is discussed in section 4.2.
[36] The real proceeds may deviate from these estimates and depend on the market price at the time of the auction.

position of the sector[37] in order to build support or cultivate a general sense of justice. In its maximum form, the introduction of the ETS is a budget neutral measure and all proceeds from the auction will find their way via other routes back to the sector, for example by reducing other costs. A disadvantage of this approach is that it limits the environmental benefits. Although there will still be an incentive for individual airlines to reduce the environmental impacts of flights, and thus to seek a better balance of expenses and compensation, financial compensation measures will reduce the net incentive.

Given that the purpose of the ETS is to reduce the external impacts of aviation, a valid option is to use the auction proceeds to fund additional emission reduction measures. This would mean that more flights would be possible within the same environmental capacity limit, because the emission cap would not change. The available environmental capacity may be increased in two possible ways (ICAO, 1988):

1. through technological measures which cost the aviation sector less than the revenue from the extra activities they make possible;
2. through technological measures paid from the proceeds of the levy, as long as their social costs are not higher than the social benefits.

The fact that some possible measures have social benefits but no commercial benefits is often due to the difficulty of reaping the rewards of research and innovation. This obstacle to innovation can be removed with the proceeds from the ETS.

To obtain a positive welfare effect it is important that measures paid for with the proceeds are indeed innovative, that these innovations have a positive effect for society as a whole, that they would not have taken place without the financial contribution from public funds (OECD, 2007), and also that the social costs do not exceed the social benefits. It should be noted that much information is needed in order to assess whether measures meet these conditions.

4.2 Retaliatory measures and aviation policy aspects

Another second-order effect arises from the fact that the EU ETS has met with considerable opposition from airlines and governments in other countries, which are considering taking retaliatory measures. With the adoption of Directive 2009/29/EC the EU has taken upon itself a task that was assigned to the International Civil Aviation Authority (ICAO) under the Kyoto Protocol. According to the Kyoto Protocol, the participating countries must achieve the reduction in greenhouse gas emissions from aviation in cooperation with ICAO. However, the EU has decided to take unilateral action because it saw no prospect of achieving a result within the ICAO. However, other countries dispute the right to pursue a unilateral initiative (Mendes de Leon, 2012).

Moreover, non-EU airlines insist that they are being discriminated against. Asian airlines in particular claim that the EU ETS exerts relatively more pressure on them to purchase additional emission allowances than their Western competitors, given

[37] Governments could choose to maintain the network of connections from a certain airport because of the direct and indirect benefits they bring to the national economy.

their more recent growth and higher growth expectations over the coming years (Mendes de Leon, 2012).

As a consequence of all these objections, various legal, economic and policy measures are being prepared, and some have been implemented. The main actions are summarised below.

Legal

- The American Air Transport Association and three of its member airlines – American Airlines, Continental Airlines and United Airlines – instituted legal proceedings in the United Kingdom against the Aviation EU ETS. The British judge referred the case to the European Court of Justice. On 21 December 2011 the European Court ruled that the participation of non-EU airlines in the EU ETS does not contravene international law (European Court of Justice, 2011).
- Four Chinese airlines – Air China, China Eastern Airlines, China Southern Airlines and Hainan Airlines – have announced they will take legal proceedings against the European emissions trading scheme (ETS). The airlines are being supported in their case by the China Air Transport Association (CATA), which has called upon the Chinese airlines not to take part in the ETS. It is not known which court the case will be submitted to or when (Zakenreis.nl. 2011).
- In the US legislation is being drawn up prohibiting US airlines from taking part in the EU ETS: the European Union Emissions Trading Scheme Prohibition Act of 2011 (US, 2011). If this law is passed, the US Minister of Transport will be mandated to prevent US airlines from taking part in the EU ETS if the minister judges that participation runs counter to American interests. The draft law also states that the American government will 'conduct international negotiations and take other actions necessary to ensure that operators of civil aircraft of the United States are held harmless from any emissions trading scheme unilaterally established by the European Union'. This could lead to US airlines submitting claims for damages to the United States Government should they have to make payments under the EU ETS (Mendes de Leon, 2012).

Economic

- The Chinese government also seems to be threatening to take retaliatory measures of an economic nature. It is thought to have blocked the order of ten Airbus A380s by Hong Kong Airlines in the summer of 2011. This order would have been announced at the annual Paris Air Show (Air Transport World Online, 2011). In the end, the order was placed in January 2012 (CCIFC, 2012).

Aviation policy

- India is considering reviewing its bilateral aviation agreement with the EU to the detriment of the EU airlines (Mendes de Leon, 2012).
- Russia has stated that it will never accept the ETS unilaterally imposed by the EU and indicated it may increase the tariffs for trans-Siberian overflight fees as a possible sanction (see text box for an illustration of this case). Russia is threatening to triple these fees, which would increase the costs to

KLM by 160 million euros per year (Ministerie van Infrastructuur en Milieu, 2011).

The above examples illustrate a wide variety of possible retaliatory measures. It is not clear whether such measures would be legal. In principle, any retaliatory measures must not be contrary to international aviation law and other international legislation. However, the countries concerned are of the opinion that the EU itself has acted outside the international rule of law by applying the EU ETS to non-EU airlines. It therefore remains to be seen whether other countries will be prepared to stick to this principle (Mendes de Leon, 2012).

There is a risk that the unilateral introduction of the ETS for aviation will lead to escalating retaliatory measures which may erode the competitive position of European airlines, and Dutch airlines in particular (see text box).

Russia threatens to triple costs of Siberian overflight fees
European airlines pay about 350 million euros each year for the right to fly over Siberian airspace (European Voice, 2011). The cost to KLM is about 80 million euros per year (Ministerie van Infrastructuur en Milieu, 2011). This amount consists partly of en-route tariffs for air traffic services and partly of royalties due under the agreement with the Russian carrier Aeroflot imposed by the Russian authorities. The royalties were introduced at the end of the 1980s to protect Aeroflot against the threat of non-stop flights to Asia following the introduction of the Boeing 747-400 aircraft.

Tripling the cost of trans-Siberian overflight fees is out of proportion to the costs of the ETS to Russian airlines and/or passengers. In 2012 the aviation sector as a whole will have to purchase a total of about 600 million euros worth of emission allowances. In comparison with this, the increase in the overflight fees to KLM alone of 160 million euros appears to be excessively high – even if this was a measure directed only at KLM in retaliation for all ETS costs to the Russians.

Nevertheless, a retaliatory measure by Russia is not inconceivable. In the past Russia has proved that it is prepared to carry out its threats. When the EU 1999 noise regulation (925/99) was adopted Russia took specific retaliatory measures directed exclusively at the Netherlands. This was because the regulation meant that various Russian aircraft had to be refused access to Schiphol. As direct retaliation for this the Russian government reduced the frequency of KLM flights to St Petersburg from 7 to 3 per week from April 2002. This number equaled the number of flights to Schiphol operated by the airline company Pulkovo with aircraft that met the new rules. The other four flights were with Russian-built aircraft (Tupolevs) that no longer met the required standard. This situation led to a freezing of civil aviation relations between the Netherlands and Russia from 2002 to 2004. A ministerial visit to Russia in 2004 brought about a thaw in these relations, after which the frequency of flights was gradually restored to 7 per week in 2009 (Mendes de Leon, 2012). According to KLM this situation led to a loss of turnover of 25 to 30 million euros between 2002 and 2009.

In the above case Russia only took retaliatory measures against the Netherlands. It is possible that it could afford to take those measures against the Netherlands, but not against countries like Germany or the United Kingdom. In the area of market access, Russia can take measures against individual states under bilateral aviation agreements and therefore discriminate between EU member states. Airlines based in smaller EU states could, for aviation policy reasons, be more readily affected by such measures than those based in larger EU states. In contrast, under international regulations tariffs must be non-discriminatory. However, it remains to be seen whether that will happen in this case (Mendes de Leon, 2012).

It is uncertain how realistic the chance is of Russia retaliating by raising the fees for flying over Siberian airspace. In exchange for European support for the accession of Russia to the WTO, it was agreed that overflight fees would be abolished by 1 January 2014 at the latest and that any new aviation agreements after 1 January 2012 would no longer contain any provisions concerning overflight fees. For all practical purposes this means that the tariffs for existing aviation rights cannot be increased any more (European Voice, 2011), but the fact remains that retaliation in another form is still possible.

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Appendix A Aviation EU ETS

A brief history
International negotiations on setting up a global system for curbing greenhouse gas emissions from aircraft have been continuing for at least 15 years. The subject was put on the agenda as early as 1995 at the first Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC). However, international aviation emissions were not included in the reduction targets agreed in the Kyoto Protocol due to political and methodological difficulties in allocating these emissions to individual countries (Kulovesi, 2011). Nevertheless, the Protocol states that the developed countries will seek to reduce these emissions, working through the International Civil Aviation Organization (ICAO) (EC, 2008). The ICAO is a UN specialised agency.

Over the years numerous discussions have been held within the ICAO on the development and deployment of market instruments, including a worldwide emissions trading system, but no scheme has yet emerged that all the parties could agree to. In 2002 the European Parliament and the Council of the European Union decided to take action if in that year no agreement could be reached through the ICAO process (EC, 2008). In 2005 the EU launched an emissions trading scheme for the industrial and energy sectors as a practical application of one of the Protocol’s flexible mechanisms.[38] This European Emissions Trading Scheme was established by EU Directive 2003/87/EC. At the end of 2008 the scheme was amended by Directive 2008/101/EC, which brought the aviation sector within the existing EU ETS for stationary installations per 1 January 2012.[39]

Aviation activities in the EU Emissions Trading Scheme
All flights arriving and leaving airports in the member countries of the European Economic Area (the EU member states plus Iceland, Lichtenstein and Norway) fall within the Emissions Trading Scheme.
Exceptions to this include (EC, 2008):

- flights carrying government ministers from non-EU countries;
- military flights, police flights, search and rescue, humanitarian and emergency services flights;
- training flights, flights for scientific research purposes and test flights for certifying aircraft;
- flights by aircraft with a certified maximum take-off mass of less than 5,700 kg;
- airlines with fewer than 243 flights per period for 3 successive periods of 4 months (which amounts to about 2 flights per day to or from an EEA airport);
- airlines with annual emissions of less than 10,000 tonnes of CO_2.

[38] The Kyoto Protocol established three flexible mechanisms: emissions trading, Joint Implementation (JI) and the Clean Development Mechanism (CDM).
[39] The operation of the EU ETS for the period 2013–2020 for the whole Community is set down in Directive 2009/29/EC.

Number of emission allowances
Aviation activities that fall within the EU ETS are initially allocated a certain number of emission allowances. The airlines are awarded some of these allowances free; the others can be bought by the airlines at an auction for the aviation sector. The total number of allowances available to the aviation sector via these routes is 215 million in 2012, and 210 million in 2013 and subsequent years. These amount to 97% and 95% respectively of the historical emissions, calculated as the average of the annual emissions in 2004, 2005 and 2006. If airlines need more emission allowances, they can purchase additional allowances on the market for emission allowances.

Different types of emission allowances
Airlines can surrender various types of emission allowances to meet their obligations under the EU ETS: EU Aviation Allowances (AEUAs), EU Allowances (EUAs), and to a limited extent also Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs).

Only limited use of CERs and ERUs is permitted. For the trading year 2012 a maximum of 15% of the surrendered emission allowances may consist of CERs and/or ERUs. For the trading period from 2013 to 2020 this maximum will be at least 1.5%. The exact percentage will be announced by the European Commission at a later date (NEa, 2011).

CERs and ERUs are emission credits from projects carried out under the Clean Development Mechanism (CDM) and the Joint Implementation (JI) scheme. In these mechanisms, parties invest in projects in which greenhouse gas emissions in another country are reduced. Projects under the Joint Implementation scheme are carried out in countries which also have to meet reduction targets under the Kyoto Protocol. In practice, most of these projects are in Russia and Ukraine. Clean Development Mechanism projects are in countries without an obligation to meet reduction targets (mostly developing countries). The difference between AUEAs and UEAs on the one hand and CERs and ERUs on the other hand is relevant because there are differences in the conditions for their use and therefore in the price of the allowances or credits arising from such projects.

Timetable and enforcement
A trading year runs from 1 January to 31 December. On 31 March at the latest in the year following the trading year the airlines must submit an emission report, verified by an independent party, to their national emissions authority. A number of emission allowances equal to the verified emissions must be surrendered no later than 30 April.

The free allowances are issued to the airlines each year by 28 February of the current trading year. Allowances obtained for trading year X may be surrendered as compensation for emissions in trading year X-1, as long as both years fall within the same trading phase. Trading year 2012 is part of phase 2 of the EU ETS and trading years 2013 to 2020 are in phase 3. For the aviation sector, this means that allowances obtained in February 2013 may not be surrendered with the allowances required for 2012. Emission allowances obtained in 2014, on the other hand, may be used to make up the required number of allowances to be surrendered for 2013

(NEa, 2011). For each tonne of emitted CO_2 that is not covered by emission allowances, the airlines are fined 100 euros.

Equivalent measures
There is resistance to the EU ETS within the aviation sector and among governments of non-EU countries because the measure has been imposed unilaterally. The European Commission defends its actions by pointing to the possibilities for 'equivalent measures'. Directive 2008/101/EC (EC, 2008) states that if third countries adopt measures which have an environmental effect at least equivalent to the EU ETS for flights to the EU, the EU will consider the options available for optimal interaction between the two systems, after consulting with the countries concerned. According to Scott and Rajamani (2011), airlines will in that case be exempted from surrendering emission allowances for flights to the EU, but emissions from fights from the EU will still have to be covered by emission allowances. So far, no agreement has been reached with third countries on equivalent measures and exemptions.

EU ETS for stationary installations
The EU ETS for stationary installations came into force on 1 January 2005. The system covers installations above certain threshold values, including electricity production, oil refineries, coke ovens and the following industries: iron, steel, cement, glass, lime, bricks/mortar, ceramics, paper, board and pulp. These sectors together account for about 40% of the total greenhouse gas emissions in the EU. From the third trading period, which starts in 2013, the petrochemical, ammonia and aluminium industries will also be included in the emissions trading scheme for CO_2.

The European Commission's preliminary estimate, based on only the original ETS sectors, is that in 2013 about 1.97 billion emission allowances (1,970 megatonnes of CO_2-eq.) will be issued. This number will decline to about 1.72 billion emission allowances (1,720 megatonnes of CO_2-eq.) in 2020. Over the whole phase, this is on average 11% less than in the second trading phase, which ran from 2008 to 2012. These estimates take no account of the emission allowances for aviation, which joins the scheme in 2012, or with the number of allowances for other sectors joining the scheme in the third trading period. Neither are the emissions from Norway, Iceland and Lichtenstein included in these estimates (EC, 2011c).

Appendix B Passing on costs and additional cross-subsidies

Passing on costs
Useful information on passing on costs can be found in two recent comparative studies of the literature currently available on this topic: Morrell (2009)[40] and Bloomberg (2011)[41].

Morrell (2009) considers it likely that a certain amount of the costs of the EU ETS (both out-of-pocket costs and opportunity costs) will be passed on, without mentioning a specific percentage. Like fuel costs, ETS costs will most probably be passed on to the customer, but the degree to which these costs will be passed on depends on the specific market segment. In markets in which there is stiff competition, airlines could choose to lower their profit margins or reduce other costs (such as labour costs).

In addition, ETS costs could be disproportionately distributed across markets, with one market bearing more of the costs than another, depending on the price-sensitivity of the various markets. This ‘cross-subsidisation’ is a normal phenomenon in the aviation sector. For example, business class passengers pay much more for their tickets than economy class passengers; the same goes for passengers that book their flights relatively late. In general, airlines seek to maximise their profits. Network airlines like KLM do not usually apply this principle to separate routes, but within a network of multiple flights and routes. This means that the prices of short-haul flights with an important feeder function for long-haul flights will probably be kept low in order to attract customers for the longer flights. Such cross-subsidisation is quite separate from the ETS.

The second review study, by Bloomberg (2011), critically examines the arguments for and against passing on costs used in the various studies. On the basis of this, Bloomberg estimates that in the short term airlines will on average pass on 30% of their out-of-pocket costs and opportunity costs and in the longer term 60% of these costs. The reason for this distinction between short and long term is that it will be more difficult for airlines to pass on costs in the short term because a large proportion of the total costs consist of fixed costs, which cannot be driven down quickly. In practice, the out-of-pocket costs, averaged over the period from 2012 to 2020, make up about a third of total costs. The 30% therefore boils down to the ability to pass on out-of-pocket costs and the 60% reflects the passing on of out-of-pocket costs plus a considerable proportion of the opportunity costs.

Arguments for passing on costs in specific market segments

Arguments for passing on 100% of the costs
The arguments for this mentioned most frequently in the literature are:

[40] In his analysis Morrell drew on the following sources: EC (2006); Wit et al. (2005); Ernst & Young (2007); Vivid Economics (2008); Frontier Economics (2006); Merrill Lynch (2008).
[41] Bloomberg used the following studies for his analysis: Oxera (2003); PWC (2005); Wit et al. (2005); Vivid Economics (2007); IATA (2007); Ernst & Young (2008).

- There is stiff competition within the aviation sector. According to economic theory, in a situation of fierce competition marginal prices are equal to marginal costs (see for example, Vivid Economics, p.21). These include both the out-of-pocket costs and the opportunity costs of emission allowances.
- Airlines do not make excessive profits. To avoid making a loss, a sector with low profit margins, such as the aviation sector, will have to pass on a greater part of its costs than a sector with larger profit margins.

<u>Arguments against passing on 100% of the costs</u>

- As a consequence of the hub-and-spoke structure of the networks, routes that fall under the EU ETS compete with routes that do not fall under the ETS. For example, a flight from New York to Dubai via Schiphol (both legs of the journey in the ETS) competes with a direct flight from New York to Dubai (not in the ETS). The ticket price for the indirect flight cannot therefore be raised without playing into the hands of the competitor operating the direct flight. This argument is valid in principle, but the market segment involved is an important factor. Bloomberg (2011) estimates that such competition affects about 10% of the flights.
- For flights to/from a congested airport, the ticket prices are already as high as customers are willing to pay. This means that ETS-related costs cannot be passed on because that would only lead to a reduction in demand. Bloomberg (2011) does not consider this to be a valid argument, because it would mean that airlines or congested airports make excessive profits, which is empirically not the case.
- A considerable number of markets within the aviation sector are not competitive, but rather oligopolistic or even monopolistic. This is the main argument in the study by Ernst & Young and York Aviation (2007), who therefore assume that on average just 30% of the costs are passed on. Bloomberg (2011) does not agree with this because it would mean that airlines now make excessive profits.
- Some older studies put forward the argument that the regular updating of the benchmark used for allocating free emission allowances means that the opportunity costs are cancelled out by the opportunity benefits and will therefore not be passed on. This argument is no longer relevant, because it has already been decided that the benchmark will be applied on a limited number of occasions, which means that the opportunity benefits will arise later than the opportunity costs and cannot therefore be 'written off' against the costs (see footnote 1 in Davidson et al., 2008).
- Passing on costs leads to a reduction in demand and therefore to lower turnover and lower profits. An airline that seeks to maximise profits will adjust the degree to which it passes on costs accordingly, depending on the market segment concerned. The key question is: to what degree does demand react to price changes? These price elasticities are notoriously difficult to determine and estimates in the literature vary widely. For example, IATA (2007) gives a range of -0.36 to -1.96. If prices rise across a very large part of the market (as can be expected with the EU ETS, with its broad field of application), the IATA expects that the response in demand will be relatively inelastic. On the basis of IATA, Bloomberg (2011) estimates that the price elasticity across the broad range of ETS-sensitive flights and routes will fall within the range of -0.6 to -0.8. This is lower than the figures used in several other studies, particularly the studies carried out

for the aviation sector, such as the studies by Ernst & Young and York Aviation (2007) and Frontier Economics (2006).

Additional cross-subsidy

The report by CE and MVA (2007) examines the issue of additional cross-subsidisation in some depth. They introduced this term to make a distinction between the familiar forms of cross-subsidisation in the aviation industry (see previous section) and a new form. In this new form, which may be a consequence of the ETS, ETS costs are expressly passed on to travellers on flights falling outside the scope of the ETS to obtain a competitive advantage on routes covered by the ETS. The airlines with a large part of their capacity outside the ETS regime may be most able to do this.

CE and MVA (2007) consulted two international aviation experts, Professor David Gillen and Dr Peter Morrell, to establish whether it would be economically rational for airlines to make use of additional cross-subsidies. According to Gillen airlines have neither the opportunity nor the desire to do so. Morrell considers that additional cross-subsidisation can be a rational strategy. Here we briefly discuss their arguments and refer to the publication by CE and MVA for more details.

Gillen defines cross-subsidisation as a situation in which the returns from an air service are lower than the costs of operating the service. He believes the fact that airlines charge different prices for different categories of passengers and for different market segments is not a direct indication of cross-subsidisation. Gillen expects that airlines will adjust their prices, taking account of the differences in demand and supply conditions and price elasticities. Business class tickets and late bookings would then be disproportionately more expensive as a consequence of the ETS. In contrast, profit-maximising airlines will not try to charge costs to flights outside the ETS. This would lead to larger profits on flights that fall under the ETS, but profits on flights not covered by the ETS would decline. If, on balance, overall profits are greater as a result, this would also have been the case before the introduction of the ETS. The ETS is therefore more of an incentive for this change, rather than a cause.

Morrell defines cross-subsidisation as using the profits from a particular market to keep prices down in another market. This definition is broader than Gillen’s because it can also cover air services that contribute less (or nothing) to the airline’s profits, without them necessarily being sold below their cost price. According to Morrell, airlines optimise their networks is such a way that losses are acceptable on some routes or market segments because they contribute to the profitability of the network as a whole. Morrell expects that non-EU airlines will do their utmost not to pass on ETS costs to business transfer traffic, because this traffic makes a big contribution to their profits. Especially when a particular airline has few routes falling under the ETS, it will be easier for them to spread the limited ETS costs over several other markets without this having a negative effect on their competitive position in these markets.

Appendix C NetScan+

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This appendix describes the model used for this study. It first examines the working (specification) of the model and then describes how the parameters were obtained (estimation and calibration).

Model specification

The NetScan+ model calculates the generalised cost for each of the route alternatives. This consists of the cost of the travel time (by multiplying the travel time by a value of time per hour) and the cost of the ticket itself. The travel time can be obtained from the flight schedules. The travel time of an indirect flight is the total of the travel time from an origin airport to a stopover airport (for example Amsterdam), the transfer time and the travel time from there to the destination. The total travel time is then multiplied by a value of time. The value of time is 30 dollars per hour for the non-business segment and 65 dollars per hour for the business segment. In addition, the extra travel time of an indirect flight as compared to the travel time of a direct, non-stop flight, is more heavily weighted.

Determination of route alternatives

First, NetScan determines the route alternatives.[42] In this process, all alternatives between two airports are itemised, including the direct and all other indirect, single-stop connections. Connections with two stopovers are not considered. For each connection between A and B with a particular airline via a particular hub, the following are then known: the weekly frequency, the departure and arrival times of the whole journey, and therefore also the total travel and stopover times. The locations of A and B are also known (in geographical coordinates) so that the great circle distance (the flight distance 'as the crow flies') can be determined.

Determination of ticket prices

The cost of the ticket is calculated by NetScan on the basis of systematic route characteristics. A ticket price model has been estimated using MIDT data. This model estimates the ticket price based on various route characteristics, such as the non-stop distance, the additional travel time of indirect routes (circuitry time) and transfer times as appropriate, the degree of competition and the type of airline (low cost/full service). In addition, the model differentiates between flights according to journey purpose (business/non-purpose). NetScan uses the following specifications for the ticket prices[43] for a one-way flight, for the non-business and business markets respectively:

$$FARE_{A,B,h,0} = 0{,}7547 * e^{4.31+0.21*NST-0.01*GCT^2-0.09*CIRCT-0.04*TRT+0.28*CONC-0.0002*LCC}$$

$$FARE_{A,B,h,0} = 0{,}7547 * e^{4.40+0.25*NST-0.01*GCT^2-0.17*CIRCT-0.12*TRT+0.44*CONC-0.24*LCC}$$

[42] The alternatives were derived from the flight schedules (OAG) for the summer of 2010.
[43] The ticket prices were estimated from MIDT data (prices in US dollars) and then converted to euros using an average exchange rate over 2010 of 0.7547 euros to 1 dollar.

in which:

$FARE_{A,B,h,0}$ = ticket price from A to B via hub h in alternative 0
NST = the great circle distance non − stop flight time between A and B, expressed as flight hours
$CIRCT$ = the circuitry time from A to B via h, in hours
TRT = the transfer time at hub h, in hours
$CONC$ = the degree of concentration (1 for monopoly, 0 for infinite number of carriers)
LCC = dummy (1 for LCCs or charter airlines, 0 for other airlines)

The specifications show a positive correlation between the price and the great circle distance. This is not surprising, because long-distance flights are clearly more expensive than shorter flights. However, the price rises less steeply as the flight distance increases. In other words, long-distance flights are cheaper per kilometre. Moreover, indirect flights are cheaper than direct flights departing from and arriving at the same airports. And the longer the additional flight time of an indirect route and the longer the stopover time, the cheaper the flight. Lastly, there is also a significant correlation between the degree of concentration and price. Within the same distance class, it appears that prices are lower in markets with a large number of competing airlines, and higher if certain airlines are dominant in particular markets.

Determination of generalised time cost
When deciding between flight options, travellers not only take the price into account, but also the travel time. This is simulated by first determining the travel time, expressing this in money terms and then adding this sum to the price of the ticket. The total travel time consists of three time components. The first is the non-stop great circle flight distance (in hours, NST). This is travel time of a non-stop flight between points A and B. The second component, in the case of indirect connections, is the circuitry time (CIRCT), which is determined by subtracting the non-stop flight time from the total flight time. The following formula is used:

$$CIRCT_{A,B,h} = FLT_{A,h} + FLT_{h,B} - NST_{A,B}$$

in which:

$CIRCT_{A,B,h}$ = the circuitry time from A to B via h (in hours)
$FLT_{A,h}$ = the flight time from A to h (in hours)
$FLT_{h,B}$ = the flight time from h to B (in hours)
$NST_{A,B}$ = the non − stop flight time between A and B (in hours)

The circuitry time is calculated separately because it has a higher (negative) value than the actual flight distance between A and B. This negative valuation also applies to the third component; the transfer time (TRT).

To account for the additional value of circuitry and transfer times, the model calculates the perceived travel time (PTT). This perceived travel time is longer than the actual travel time because circuitry and transfer times are more heavily weighted. Moreover, this additional valuation is relatively higher for short distances than long distances: 1 hour extra flight time on a great circle flight distance of 1 hour (Amsterdam–London) is more heavily weighted than 1 hour extra flight time on a great circle distance of 10 hours (Amsterdam–Los Angeles). To express that difference, a penalty factor is introduced, which depends on the great circle distance:

$$PEN = 3 - 0{,}075 * NST$$

in which:

$PEN =$ the distance − dependent penalty
$NST =$ the non − stop flight time , in hours

This gives a penalty factor that varies between 3 and 2: for the short distance (1 hour) it is 2.92, and for the long distance (12 hours) it is 2.1. The total perceived travel time then amounts to:

$$PTT = NST + \beta * PEN * CIRCT + \gamma * PEN * TRT$$

in which:

$PTT =$ the perceived travel time
$NST =$ the non − stop flight time , in hours
$PEN =$ the distance − dependent penalty
$CIRCT =$ the circuitry time in hours
$TRT =$ the transfer time in hours
$\beta = 1.7$, both for business and non − business traffic
$\gamma = 1.5$ for business and 1.3 for non − business traffic)

From the specification of the perceived travel time, it can be seen that circuitry and transfer times have a high time penalty: circuitous routes and stopovers carry greater time costs because there is a strong preference for direct flights. For example, we take an indirect connection from Amsterdam to Los Angeles. As the crow flies (great circle distance), this is about a 10 hour flight. If a stopover in London entails an additional half hour extra flying time (1 hour to London and 9.5 hours to Los Angeles), and the stopover in London adds a further 2 hours, the total journey time will then be 12.5 hours. The perceived travel time, according to the above specification, is 17.76 hours (for the non-business segment).

The weight given to the travel time, depends on the value travellers place on 1 hour perceived travel time (value of time, VOT). The perceived travel time is then multiplied by this value of time to obtain the generalised cost of travel time (GCT).

$$GCT_{A,B,h} = PTT_{A,B,h} * VOT$$

in which:

$GCT_{A,B,h} =$ the generalised cost of travel time from A to B via h (in €)
$PTT_{\mathrm{A,B,h}} =$ the perceived travel time from A to B via hub h (in hours)
$VOT =$ value of one hour perceived travel time (in €)

The value of time is higher for business travellers than for non-business travellers. When calibrating these model parameters using MIDT data, values of 65 and 30 dollars respectively (about 49 and 22.60 euros) proved to be a good fit with the observed MIDT data.

Total generalised cost
Now that the prices of flights and the generalised cost of travel time have been determined, these can then be combined to obtain the total generalised cost. We now add a new dimension for the ‘variant’, which can be considered to be the ‘null variant’, variant 0. This null variant is the situation without the EU ETS. Later we consider a new variant, variant 1, in which the ETS is included in the calculations.

$$GC_{A,B,h,0} = FARE_{A,B,h,0} + GCT_{A,B,h,0}$$

in which:

$GC_{A,B,h,0}$ = the total generalised cost from A to B via hub h in variant 0
$FARE_{A,B,h,0}$ = ticket price from A to B via hub h in variant 0
$GCT_{A,B,h,0}$ = generalised cost of travel time from A to B via hub h in variant 0

Utility value of connections
The total generalised cost determines the ‘value of the connection’. The higher the cost, the lower the value. However, to determine this value it is necessary to make yet another assumption, about the correlation between this value and the generalised cost; that is, how much does this value (the utility to the traveller) change when the generalised cost increases or decreases by 1 euro? This change is not constant. The decline in value is smaller when the cost is high than when the cost is low: a rise in cost from 1,000 euros to 1,010 euros has less impact than a rise from 50 to 60 euros. We present this value as an index between 0 and 1. The value is 1 if the cost is equal to 0 euros. The value is 0 if the cost is infinitely high. These conditions are met if the relation between the value (W) and the generalised cost (GC) is specified as follows:

$$W_{A,B,h,0} = e^{\propto * GC_{A,B,h,0}}$$

in which:

$W_{A,B,h,0}$ = the utility value of the connection from A to B via hub h in variant 0
$GC_{A,B,h,0}$ = the total generalised cost from A to B via hub h in variant 0
α = the 'spread'-parameter: coëfficiënt describing the sensitivity of a change in the generalised cost of 1€

Additional assumptions about the value of ɑ are therefore necessary; ɑ is in any case negative, because the additional assumption ensures that the cost is infinitely high at a value of 0. When ɑ has a high negative value, the connections are only attractive when the costs are low. If ɑ has a small negative value, the connection in question still represents a certain value, even when the cost is high. When calibrating these model parameters, values of -0.01 and -0.02 for the business and non-business traffic respectively gave a good fit with the observed MIDT data.

The advantage of such a specification is that these utility values can be added up. This makes it possible to obtain the total value of all connections between points A and B, and also indicate the proportion of this total value that is attributable to a particular hub: the total value of:

$$W_{A,B,0} = \sum_{h} W_{A,B,h,0}$$

in which:

$W_{A,B,0}$ = the total utility value of the connection from A to B in variant 0
$W_{A,B,h,0}$ = the utility value of the connection from A to B via hub h in variant 0

Market share of specific route alternatives

Now that the utility values of specific route alternatives and of all alternatives between A and B have been derived, it is now possible to determine the market share (MS) of specific route alternatives. This is equal to:

$$\mathrm{MS}_{A,B,h,0} = \frac{\mathrm{W}_{A,B,h,0}}{\mathrm{W}_{A,B,0}}$$

in which:

$MS_{A,B,h,0}$ = the market share of alternative h in the market between A and B in variant 0
$W_{A,B,h,0}$ = the utility value of the connection from A to B via hub h in variant 0
$W_{A,B,0}$ = the total utility value of the connection from A to B in variant 0

Price changes of specific route alternatives

The above specifications all relate to a certain baseline situation, referred to as variant 0. The next step is to define variant 1 as the situation with the assumed changes in the network or the price structure. In this case we limit this to price rises as a consequence of the introduction of the EU ETS, leading to an increase in the generalised cost of certain route alternatives in proportion to the emissions that fall under the ETS. The new generalised cost amounts to:

$$GC_{A,B,h,1} = FARE_{A,B,h,1} + GCT_{A,B,h,1} + ETS_{A,B,h,1}$$

in which:

$GC_{A,B,h,1}$ = the total generalised cost from A to B via hub h in variant 1
$FARE_{A,B,h,1}$ = ticket price from A to B via hub h in variant 1 (equal to variant 0)
$GCT_{A,B,h,1}$ = generalised cost of travel time from A to B via hub h in variant 1 (equal to variant 0)
$ETS_{A,B,h,1}$ = ETS costs from A to B via hub h in variant 1

Changes in the price structure have two effects: market generation and changes in market shares. Before determining the market generation it is necessary to first establish the average change in generalised cost across the whole market. This is because the change in cost is not the same for all route alternatives. In the specific case of the EU ETS, only the prices of routes to, from and within the EU are increased. If the market share of these routes is small, the average price increase across the whole market will remain limited. The expected market generation can now be calculated in a number of steps:

- calculation of the average generalised cost between A and B in the baseline situation 0;
- calculation of the average (relative) percentage increase of the generalised cost between A and B across the whole market;
- calculation of the market generation.

The average generalised cost
The average generalised cost between A and B in the baseline situation is calculated by weighting the costs of all route alternatives according to their market shares:

$$\mathrm{GC}_{A,B,0} = \sum_h \mathrm{MS}_{A,B,h,0} * \mathrm{GC}_{A,B,h,0}$$

in which:

$GC_{A,B,0}$ = the average generalised cost from A to B in variant 0
$MS_{A,B,h,0}$ = the market share of alternative h in the market between A and B in variant 0
$GC_{A,B,h,0}$ = the total generalised cost from A to B via hub h in variant 0

Change in the average generalised cost
To determine the change in the average generalised cost, the new total utility value in variant 1 must first be calculated. As in variant 0, this is obtained by adding up the utility values of all route alternatives.

$$\mathrm{W}_{A,B,1} = \sum_h \mathrm{W}_{A,B,h,1}$$

in which:

$W_{A,B,1}$ = the total utility value of the connection from A to B in variant 1
$W_{A,B,h,1}$ = the utility value of the connection from A to B via hub h in variant 1

and in which:

$\mathrm{W}_{A,B,h,1} = \mathrm{W}_{A,B,h,0}$ als $\mathrm{h} \neq \mathrm{AMS}$
$\mathrm{W}_{A,B,h,1} \neq \mathrm{W}_{A,B,h,0}$ als $\mathrm{h} = \mathrm{AMS}$

The total welfare effect, expressed in euros, can now be determined by comparing the two utility values:

$$\mathrm{DW}_{A,B,1} = \frac{\mathrm{LN}(\mathrm{W}_{A,B,1}) - \mathrm{LN}(\mathrm{W}_{A,B,0})}{\alpha}$$

in which:

$DW_{A,B,1}$
= welfare effect in the market between A and B in variant 1 compared with variant 0, expressed in €
$W_{A,B,1}$ = total utility value of the connection from A to B in variant 1
$W_{A,B,0}$ = total utility value of the connection from A to B in variant 0
α = spread' − parameter

Because the change in welfare is now expressed in euros, it can be compared with the average generalised cost in the baseline situation. The market generation can then be calculated as follows:

$$\mathrm{MG}_{A,B,1} = [1 + \frac{\mathrm{DW}_{A,B,1}}{\mathrm{GC}_{A,B,0}}]^{\delta} - 1$$

in which:

$MG_{A,B,1}$ = the marketgeneration between A and B in variant 1

$DW_{A,B,1}$ = the change in utility value between A and B in variant 1, in €'s

$GC_{A,B,0}$ = the average generalised cost from A to B in variant 0

δ = the generalised-cost-elasticity

When calculating the market generation, an additional assumption is required about the elasticity δ, which describes the correlation between the change in the average generalised cost and the change in the size of the market. This model specification therefore contains no explicit assumption about the price elasticity, but does contain an explicit assumption about the 'generalised-cost elasticity'. This is because it is not only changes in price that lead to market generation, but also network and other changes, and therefore also the time components. The price elasticity for the whole market between A and B (the 'generic-price elasticity') is smaller than the 'generalised-cost elasticity', because the price component makes up just a small part of the total generalised cost. The generic-price elasticity between A and B therefore depends on how much of the total generalised cost consists of the price component. If this proportion is small (in other words, if the generalised cost consists largely of the time component), the generic-price elasticity will also be small.

Explicit assumptions are therefore required for the size of the generalised cost elasticity δ. However, this is calibrated such that it correlates with generic-price elasticities in the order of between -0.1 and -0.4 for the business segment and between -0.5 and -1 for the non-business segment. In this model specification, δ therefore has a value of -0.5 for the business segment and -1.5 for the non-business segment.

Determination of the new market shares

With the utility values in variant 1 now determined, the new market shares in variant 1 can be calculated in a similar fashion:

$$\mathrm{MS}_{A,B,h,1} = \frac{\mathrm{W}_{A,B,h,1}}{\mathrm{W}_{A,B,1}}$$

in which:

$MS_{A,B,h,1}$ = the market share of alternative h in the market between A and B in variant 1

$W_{A,B,h,1}$ = the utility value of the connection from A to B via hub h in variant 1

$W_{A,B,1}$ = the total utility value of the connection from A to B in variant 1

Route-specific changes

The above-mentioned specifications now make it possible to determine the volume change for all the route alternatives. The change in volume is obtained by again multiplying the market generation by the change in market share:

$$\mathrm{VM}_{A,B,h,1} = \frac{(1+\mathrm{MG}_{A,B,1}) * \mathrm{MS}_{A,B,h,1}}{\mathrm{MS}_{A,B,h,0}} \quad -1$$

in which:

$VM_{A,B,h,1}$ = the volume change of alternative h between A and B in variant 1
$MG_{A,B,1}$ = the market generation between A and B in variant 1
$MS_{A,B,h,1}$ = the market share of alternative h in the market between A and B in variant 1
$MS_{A,B,h,0}$ = the market share of alternative h in the market between A and B in variant 0

For example, if the market generation is negative and the total volume declines by 1%, and in addition the market share of route alternative h also falls from 50% to 40%, then the volume of alternative h will fall by 21% (1% market loss plus an additional 20% loss of market share).

Finally, from this we can then derive the 'specific-price elasticity'. This is calculated by dividing the volume change by the price change:

$$\mathrm{PE}_{A,B,h,1} = \frac{\mathrm{VM}_{A,B,h,1}}{\mathrm{PM}_{A,B,h,1}} \quad -1$$

in which:

$PE_{A,B,h,1}$ = the specific price elasticity of alternative h between A and B in variant 1
$VM_{A,B,h,1}$ = the volume change of alternative h between A and B in variant 1
$PM_{A,B,h,1}$ = the change in ticket price of alternative h between A and B in variant 1

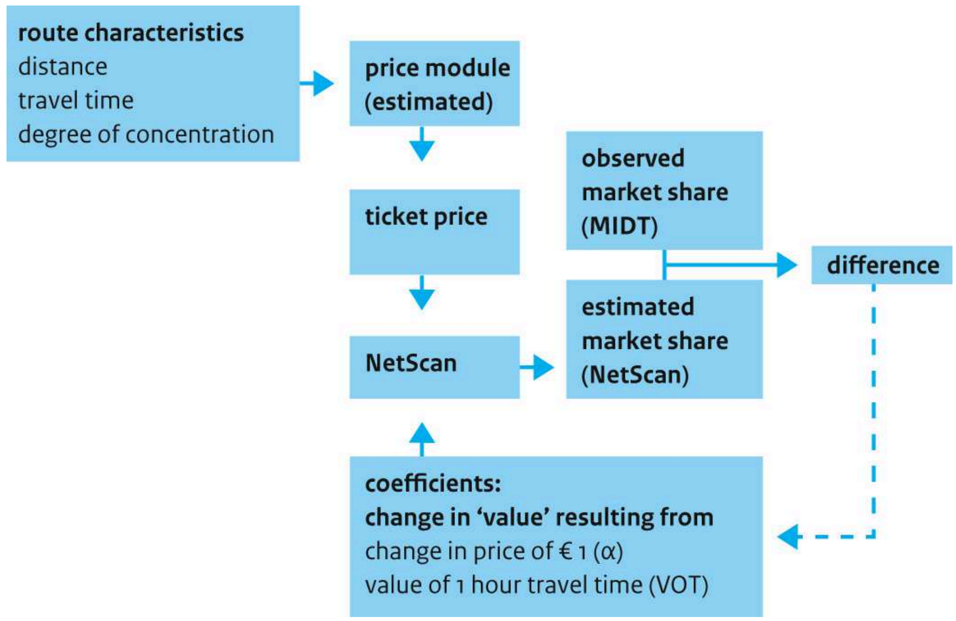
From this it is clear that the price elasticity PE is not an input parameter, but is specific to the market between A and B and also to route alternative h. The size of the specific-price elasticity therefore depends primarily on the share of the total market between A and B held by alternative h.

Estimation and calibration
This section describes the method of determining the parameters for the NetScan model. The process is illustrated schematically in Figure C.1

Price module
Generally speaking, the prices of air tickets tend to fluctuate from day to day. The airlines' advanced revenue management systems monitor bookings for flights almost continually and make use of systems that can compare the actual and expected bookings over time. Airlines adjust prices daily in an attempt to maximise revenues from their flights. As a result, there are often numerous different prices for seats, even on the same flight. This makes it virtually impossible to obtain systematic price information.

However, there is an MIDT database available with data derived from reservation systems (Sabre, Amadeus, Worldspan, Galileo, Abacus, TravelSky, etc.) and third-party booking sites (such as Orbitz.com) from which sample data can be obtained for particular markets. Such sample surveys were used to analyse which systematic factors are responsible for the levels of the average prices. These in turn were used to formulate a price module, which is specified in the next section.

Figure C.1
Flow diagram of the process of estimating and calibrating the parameters for the NetScan model.



The price module was estimated using MIDT data on journeys between Schiphol and the rest of the world in 2009. These MIDT data contain information on both the number of passengers and the average prices from Schiphol by airline, route and seat class (business, economy). In addition, the route alternatives from Schiphol were determined by NetScan.[44] To this end, all alternatives between two airports were itemised, including the direct and all other indirect, single-stop connections. By linking the prices from the MIDT database with the route alternatives determined by NetScan and their characteristics, a statistical correlation between the level of the ticket prices and certain route characteristics can be estimated.

The travel times are the key factors in this correlation, including not only the flight duration, but also the circuitry and transfer time in the case of indirect connections, because these lead to lower ticket prices: the more circuitous the route and the longer the stopover time, the lower the ticket price. In addition, the degree of concentration also needs to be considered. The larger the number of competing alternatives between A and B (competing airlines and hubs), the lower the price.

Time costs
The ticket price maintained by a particular airline in a competitive market determines to a certain extent the market share that airline can achieve. Travel time is also a factor. It has already been established that prices are lower when flights involve a more circuitous route and longer transfer times. Apparently, airlines also realise that more roundabout routes and stopovers depress the level of market share they can obtain. To account for this, the travel times of these connections are translated into a 'generalised cost of travel time'. To do this, additional assumptions have to be made about the value of 1 hour travel, circuitry and stopover time. Then

[44] The alternatives were derived from the flight schedules (OAG) for the summer of 2009.

the total generalised cost can be determined by adding the estimated ticket prices to the generalised cost of travel time.

Total generalised cost
The total generalised cost determines the 'value of the connection'. The higher the cost, the lower the value. However, to determine this value it is necessary to make yet another assumption, about the correlation between this value and the generalised cost; that is, how much does this value change when the generalised cost increases or decreases by 1 euro?

Market shares
Several additional assumptions still have to be made before the market shares can be calculated: how much does the generalised travel cost rise as the travel time (including possible circuitry and transfer time) increases by 1 hour? Furthermore: how much does the value of a particular connection decline if the travel cost increases by 1 euro? Alternative assumptions regarding these parameters obviously lead to different estimates of market shares. However, a 'multi-dimensional grid-search technique' can be used to determine values such that the differences between the market shares calculated by NetScan and the observed market shares derived from the MIDT database are minimised. This finally resulted in a set of plausible parameters which give rise to the lowest possible differences between the calculated and observed market shares.

Appendix D ETS costs per passenger per return flight

The benchmark for the allocation of free emission allowances is defined by the EU as (EC, 2011a):

Benchmark 2010 = RTKs 2010 / free emission allowances 2012

The benchmark for 2010 is 0.6797 emission allowances per 1,000 revenue tonne kilometres (RTKs). The number of free emission allowances allocated in 2012 is equivalent to 182.6 megatonnes of CO_2. From this it follows that the number of RTKs flown in 2010 is about 269 billion.

Under the assumption that ETS costs are only attributed to passengers and not to cargo, the RTKs have to be converted to revenue passenger kilometres (RPKs). The EU employs a standard value of 100 kilograms for each passenger plus baggage.[45] From this it follows that the 269 billion RTKs convert to 2,690 billion RPKs. The growth in the number of tonne kilometres, and therefore also passenger kilometres, is on average 3.5% per year (see section 2.7), which amounts to about 2,880 billion RPKs in 2012.

The number of emission allowances to be purchased in 2012 is estimated to be about 60.4 million tonnes (see section 2.7). In a scenario with a market price of 10 euros per tonne, this results in out-of-pocket costs to all airlines amounting to about 604 million euros.[46] From this it follows that in 2012 the out-of-pocket costs per RPK will be about 0.000225 euros.[47]

<u>Examples of ETS costs per return flight</u>[48,49]

- Amsterdam–London Heathrow (371 km + 95 km) x 2 => 0.2 euros
- Amsterdam–Barcelona (1,241 km + 95 km) x 2 => 0.6 euros
- Amsterdam–New York JFK (5,863 km + 95 km) x 2 => 2.7 euros
- Amsterdam–Jakarta (11,367 km + 95 km) x 2 => 5.2 euros

The number of emission allowances to be purchased in 2012 is estimated to be about 25% of the total required (see section 2.7). If in addition to the out-of-pocket costs the opportunity costs are also passed on, all the above-mentioned amounts will be four times as large.

At an average growth rate of 3.5% per year, the number of RPKs in 2020 is expected to be about 3,800 billion. Out-of-pocket costs will then have risen to 1,236

[45] Source: Guidance for the Aviation Industry; Monitoring and Reporting Annual Emissions and Tonne km Data for EU Emissions Trading, 28 May 2009.
[46] The administrative costs were not considered because they are relatively small. Ernst & Young and York Aviation (2007) estimate these costs to be €187,000 per year for large airlines and €116,000 per year for small airlines.
[47] The figures used in this Appendix are rounded off and so recalculation will not lead to the exact same numbers.
[48] In the guidance document (mentioned in footnote 45) the EU bases its calculations of emissions on the great circle distance + 95 km.
[49] Source for distances: Great Circle Mapper: http://www.gcmap.com/

billion euros (at €10/tonne). From this it follows that in 2020 the out-of-pocket costs per RPK will be about 0.000325 euros. Other things being equal, the costs will then be about 44% higher.

Appendix E Characterisation of transfer traffic at Schiphol

In 2010 the origin–destination traffic at Schiphol accounted for 58% of total passenger numbers and transfer traffic accounted for the remaining 42%. In comparison, the transfer traffic percentage at Frankfurt was 53% and at Charles de Gaulle 32% (Kolkman, 2010a). The transfer traffic percentage at Heathrow was probably between 30% and 35% (Frontier Economics, 2011). The transfer traffic at Schiphol can be broken down in more detail using information from the Schipholenquête.

Figure E.1 shows that in 2010 about 33% of transfer passengers at Schiphol came from origins in Europe and travelled to destinations outside Europe (ICA). A further 33% made similar journeys in the opposite direction. About 22% travelled between two European destinations via Schiphol. These three groups together make up market segment 3 (indirect via EU) and accounted for about 37% of all passenger traffic at Schiphol.

Figure E.1
Origin and destination regions of transfer passengers at Schiphol in 2010. EUR stands for Europe and ICA for any other continent.
Source: Schipholenquête, 2010; adapted by KiM.

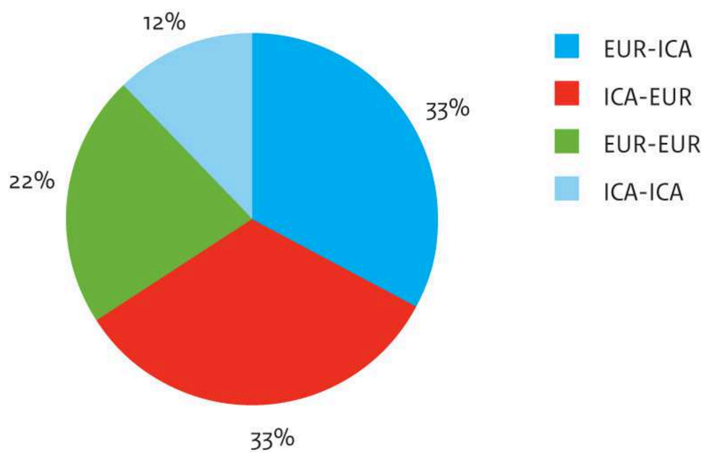
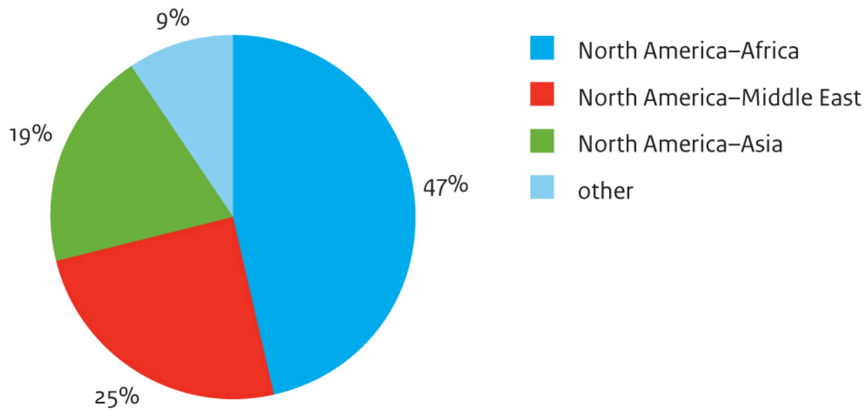


Figure E.1 also shows that about 12% of transfer passengers at Schiphol travelled between two intercontinental destinations. This group accounted for about 5.5% of all passengers passing through Schiphol.

Figure E.2 shows that a vast majority of that transfer traffic flew to or from a destination in North America. Almost half the transatlantic traffic was between North America and Africa, about a quarter was between North America and the Middle East and about a fifth between North America and Asia. For these flights the airports listed in Tables 3.9 and 3.9a (Appendix F) can be good alternatives to Schiphol, depending on the exact destination.

Figure E.2
Origin and destination regions of ICA–ICA transfer passengers at Schiphol in 2010.
Source: Schipholenquête, 2010; adapted by KiM.



Appendix F Results when the total costs are passed on

This appendix gives the effects for several tables in Chapter 3 when in addition to the out-of-pocket costs of purchased emission allowances, the opportunity costs – the value of the freely allocated allowances– are also passed on to passengers.

Table 3.3a
Effects on the number of passengers in the various geographical market segments for EU and non-EU airlines when total costs are passed on and the price of emission allowances is 10 euros.

Target year 2012 **Market segment**	**Type of carrier**	**Passengers** ***Total***	***No longer fly***	***Avoidance behaviour***	**Relative size of market segment**
1. Direct within the EU	EU	-0.5%	-0.5%	0.0%	50.6%
1. Direct binnen EU	non-EU	-0.8%	-0.6%	-0.2%	0.1%
2. Direct EU – non-EU	EU	-0.9%	-0.9%	0.0%	10.6%
2. Direct EU – non-EU	non-EU	-0.7%	-0.8%	0.1%	8.3%
3. Indirect via EU	EU	-1.3%	-0.7%	-0.6%	15.5%
3. Indirect via EU	non-EU	-1.8%	-0.9%	-0.9%	1.1%
4. Indirect via non-EU	EU	-0.7%	-0.7%	0.0%	0.6%
4. Indirect via non-EU	non-EU	0.6%	-0.6%	1.2%	6.2%
5. Indirect nEU-nEU via EU	EU	-5.1%	-1.0%	-4.1%	2.6%
5. Indirect nEU-nEU via EU	non-EU	-5.4%	-1.0%	-4.4%	0.7%
6. Ind. nEU-nEU via nEU	EU	-	-	-	0.0%
6. Ind. nEU-nEU via nEU	non-EU	5.3%	0.0%	5.3%	1.7%
7. Direct non-EU - non-EU	EU	-	-	-	0.0%
7. Direct non-EU - non-EU	non-EU	1.3%	0.0%	1.3%	1.9%
TOTAL	EU	-0.9%	-0.6%	-0.2%	79.9%
	Non-EU	0.2%	-0.6%	0.8%	20.1%

Table 3.4a
Effects on the number of passengers in the various geographical market segments for European full service (FSC) and low cost (LCC) airlines when total costs are passed on and the price of emission allowances is 10 euros.

Market segment	**Type of carrier**	**Passengers** ***Total***	***No longer fly***	***Avoidance behaviour***	**Relative size of market segment**
1. Direct within the EU	FSC	-0.5%	-0.5%	0.0%	32.0%
1. Direct binnen EU	LCC	-0.5%	-0.5%	0.0%	31.4%
2. Direct EU – non-EU	FSC	-1.1%	-1.0%	-0.1%	8.4%
2. Direct EU – non-EU	LCC	-0.5%	-0.7%	0.1%	4.8%
3. Indirect via EU	FSC	-1.3%	-0.7%	-0.6%	18.9%
3. Indirect via EU	LCC	-0.3%	-0.5%	0.1%	0.5%
4. Indirect via non-EU	FSC	0.7%	-0.7%	0.0%	0.8%
4. Indirect via non-EU	LCC	-	-	-	0.0%
5. Indirect nEU-nEU via EU	FSC	-5.1%	-1.0%	-4.1%	3.3%
5. Indirect nEU-nEU via EU	LCC	-	-	-	0.0%
TOTAL	FSC	-1.1%	-0.7%	-0.4%	63.3%
	LCC	-0.5%	-0.6%	0.1%	36.6%

Table 3.5a
Percentage changes in the number of passengers per airline per geographical market segment when total costs are passed on and the price of emission allowances is 10 euros.

Market segment	KLM	Air France	Lufthansa	British Airways
1. Direct binnen EU	-0.6%	-0.4%	-0.6%	-0.6%
2. Direct buiten EU	-1.7%	-0.7%	-1.1%	-2.1%
3. Indirect via EU	-2.3%	-0.6%	-1.4%	-3.3%
4. Indir. via non-EU	-2.3%	0.1%	-0.1%	-4.9%
5. Indirect non-EU - non-EU via EU	-6.0%	-3.3%	-4.8%	-8.6%
6. Indirect non-EU - non-EU via nEU	-	-	-	-
7. Direct non-EU - non-EU	-	-	-	-
TOTAL per airline	-2.2%	-0.8%	-1.3%	-2.9%

Table 3.6a
Percentage changes in the number of passengers per airline per geographical market segment when total costs are passed on and the price of emission allowances is 10 euros.

Market segment	Emirates	Swiss Airlines	Turkish Airlines
1. Direct binnen EU	-	-	-
2. Direct buiten EU	-1.1%	-0.6%	-0.6%
3. Indirect via EU	-	-	-
4. Indirect via non-EU	2.7%	5.6%	1.5%
5. Indirect non-EU - nEU via EU	-	-5.7%	-3.3%
6. Indirect non-EU – non-EU via non-EU*	10.3%	9.0%	4.1%
7. Direct non-EU - non-EU*	3.0%	3.1%	0.7%
TOTAL per airline	2.7%*	1.9%*	0.6%*

Table 3.7a
Illustration of the reduction in the number of passengers by converting the percentages in Tables 3.5a and 3.6a using the actual passenger numbers in 2011. CAPA 2012; AEA, 2011 and *Netscan[50]; adapted by KiM.

Airline	Passengers in 2011 (millions)	Relative reduction	Change in passenger numbers (thousands)
KLM	25.1	-2.2%	-550
Air France	50.7	-0.8%	-410
Lufthansa	65.5	-1.3%	-850
British Airways	37.1	-2.9%	-1075
Emirates*	8.2	2.7%	220
Swiss Airlines*	10.1	1.9%	190
Turkish Airlines*	11.1	0.6%	65

[50] The figures for the three non-EU airlines were calculated in NetScan and relate to that part of these airlines' market shares that are affected by the EU ETS.

Table 3.8a
Relative changes in the numbers of passengers per airline in three scenarios when total costs are passed on and the price of emission allowances is 10 euros.

	Costs fully passed on	Additional cross-subsidy	Boycott
KLM	-2.2%	-3.7%	-3.7%
Air France	-0.8%	-1.6%	-1.6%
Lufthansa	-1.3%	-1.9%	-1.9%
British Airways	-2.9%	-4.5%	-4.5%
Emirates*	2.7%	2.9%	2.9%
Swiss Airlines*	1.9%	2.2%	2.2%
Turkish Airlines*	0.6%	1.1%	1.1%

Table 3.9a
Relative changes in passenger numbers per airport when total costs are passed on to passengers and the market price of emission allowances is 10 euros.

Market segment	Schiphol	Paris CdG	Frank-furt	London Heathrow	Dubai*	Zurich*	Istan-bul*
Domestic market	-0.7%	-0.7%	-0.7%	-0.9%	-0.9%	-0.5%	-0.5%
Transfer traffic	-2.8%	-1.2%	-2.3%	-4.7%	4.2%	6.3%	2.1%
TOTAL	-1.6%	-0.9%	-1.6%	-2.1%	1.8%	0.9%	0.4%

*) Only that part of the market served by the airline concerned and which is affected by the ETS. The increase does not therefore apply to the total number of passengers carried by the airlines concerned.

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