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Aviation and the Costs of the European Emission Trading Scheme: The case of Italy

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Abstract

The attention of policy makers on aviation environmental impacts has increased meaningfully over the last years. In order to limit the sector’s CO₂ emissions, the EU has broadened the aviation industry part of the European Union Emission Trading Scheme (EU-ETS), from 1st January 2012 with the Directive 101/2008/EC.

The aim of this paper is to provide an estimation of the direct costs linked to EU-ETS that the aviation sector is standing, reporting the case of Italy. In details, this work proposes a calculation of the EU-ETS direct costs that Italian airline companies, under the scheme, afforded over the period 2012-2014. Then, it presents a forecast of the EU-ETS direct costs for the years 2015-2016, referring to three scenarios related to different hypotheses on emission permit price (low, medium, high bounded scenarios), and on pass-through of those costs onto final passengers. Finally, the paper measures the effects of those costs in terms of change in airfares, revenues, and social costs. The calculations are obtained by following an economic model designed by the authors, which can also be extended to investigate other sectors covered by the EU-ETS.
**Keywords:** aviation; climate change; cost estimation; European Union Emission trading scheme (EU-ETS); Italy.

**Highlights**

- Aviation industry has been part of the European Union Emission Trading Scheme (EU-ETS) since 2012
- Aviation companies complained about the additional costs linked to the EU-ETS
- An economic model is proposed to calculate these costs, illustrating the case of Italy
- Results show that the total direct costs of EU-ETS and their effects on airline companies and society are still limited

**Abbreviations**

Carbon Dioxide (CO$_2$); Greenhouse Gases (GHG); European Union (EU); European Union Emission Trading Scheme (EU-ETS); European Economic Area (EEA); International Civil Aviation Organisation (ICAO); International Air Carrier Association (IACA); Community Independent Transaction Log (CITL); European Commission (EC); National Allocation Plan (NAP); European Environmental Agency (EEAg); Abatement Marginal Cost (AMC); Total Direct Cost (TDC); Gestore dei Servizi Elettrici (GSE)
Aviation and the Costs of the European Emission Trading Scheme: The case of Italy

1. Introduction

The attention of global policy makers on the aviation environmental impacts has increased meaningfully over the last years. In fact, the growth of the sector has induced significant drawbacks in terms of climate change, local air pollution, land contamination, and noise pollution. The primarily source of these negative externalities is the emission of carbon dioxide (CO₂), directly computed as a proportion of burned fuel (Dessen et al., 2014).

In Europe, the aviation sector currently accounts for about 5 and 27 per cent of total and transport greenhouse gas (GHG) emissions respectively. In particular, CO₂ emissions are still growing at a rapid pace and have more than doubled over the last two decades, producing more than six times the emissions of the rail sector (Brack, 2013).

This expansion is primarily due to a substantial increase of the air transport demand, expected to rise by 3,7 per cent per annum in the next years (Rothengatter, 2010; Cappoccitti et al., 2010) and driven by several factors. First of all, the gradual change in consumers’ behaviours has determined a growth in both tourism and trade flows (Gössling et al., 2012). In addition, the liberalization policies started in the Eighties have encouraged the entrance of low-cost competitors, lowering airfares and making this type of transport accessible to a wider range of passengers (Fu et al., 2010).
In order to prevent and limit sector emissions and to meet the European environmental goals for 2020 and beyond, the European Union (EU) has broadened the number of industries belonging to the European Union Emission Trading Scheme (EU-ETS), namely the first and largest international emissions trading scheme (Ellerman and Buchner, 2007; Meleo, 2010), including aviation from 1st January 2012 (Directive 101/2008/EC). In this way, air carriers have been asked to contribute to the reduction of GHG, implying additional costs (environmental costs) to manage.

The aim of this paper is to provide an estimation of the direct costs linked to EU-ETS stood by the aviation sector\(^1\) and their market equilibrium effects.

In details, the Directive 101/2008/EC sets that all flights departing and arriving in an airport located within the European Economic Area (EEA)\(^2\) must be covered by the EU-ETS, regardless of the airline nationality\(^3\). The Directive has raised two

\(^1\) The EU-ETS indirect costs originated by the electricity sector pass-through are not considered in this paper.

\(^2\) The European Economic Area includes the 28 EU Member States, Iceland, Liechtenstein, and Norway.

\(^3\) As for industrial plants, following a “top-down” mechanism (Meleo, 2014), the European Commission (EC) is responsible to set an emission cap for the aviation sector that is independent from the cap set for the other energy-intensive industries under EU-ETS. For 2012, the EC had to distribute a number of permits corresponding to 97 per cent of the aviation sector average historical emissions registered in the period 2004-2006 in Europe. In the following years (2013-2020), the cap has been reduced to 95 per cent of the same average historical emissions. As regards the method of allocation, in 2012 the total permits issued by the EU had to be auctioned by 15 per cent and distributed 85 per cent for free, while in 2013-2020, 82 per cent of the cap has to be allocated for free, 15 per cent by auctions, and 3 per cent collected in a special reserve for new entrants.
different reactions. At first the opposition of non-European airlines, aviation lobbies, and extra-European policy makers. They were concerned about the additional costs that the EU-ETS would have caused (mainly the purchase of emission permits, new green investments, and administrative costs), and the likely distortion of the competitive equilibrium (Mitra, 2012; Preston et al., 2012). In addition, they claimed that the EU had applied a charge to flights outside its borders, without any previous agreement, apparently violating the Chicago Convention on International Civil Aviation signed in 1944. The political and judicial debate that followed the Directive has lead the European Commission (EC) to introduce the so-called “stop the clock” derogation of 2013 (Decision 2013/337/EU), followed by the Regulation 2014/421. These actions have suspended the Directive 2008/101/EC, waiting for an international agreement to set a single global market-based measure by 2020.

The inclusion of the aviation sector within the scope of the EU-ETS has also raised concerns among many European airlines. In fact, the economic impact of the EU-ETS on competitiveness is still one of the main debating points among firms and policy makers (International Air Carrier Association-IACA, 2008; Scheelhaase et al., 2010; Kopsch, 2012; Meleo and Morelli, 2013). This has been especially true since

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4 The Convention prohibits the introduction of unilateral measures in the aviation field by the signatory countries.

5 In details, Regulation 2014/421 indicates that: emissions from flights within the EEA are subjected to EU-ETS; the other flights are exempted for 2013; from 2014 EU-ETS will be enforced also for flights outside the EEA for the portion of the flights realised within the border of the EEA; flights that involve less developed countries are regulated with specific dispositions. After the 2013 Decision, almost 59 per cent of the original free allowances returned to the EC (Sandbag, 2013).
the adoption of Regulation 2014/421 as the EU airline carriers are required to obtain the highest number of allowances, given that their flights are primarily delivered in the EEA. In details, literature has found that the EU-ETS direct costs can affect the market equilibrium through a loss of market share (Faber and Brinke, 2011; Anger and Köhler, 2010), a change in entrance barriers (Barbot et al. 2014), or a reduction of profit margins (CE Delft, 2007; Frontier Economics, 2006; Malina et al., 2012; Girardet and Splinler, 2013). As a consequence these effects could be amplified for those companies that could not offset the decrease in profits charging passengers (pass-through), or using any additional profits gained from extra-European flights⁶.

In the context of this scenario, this paper estimates the EU-ETS direct costs reporting the case of the Italian aviation sector. The focus on Italy is significant because of the different attraction factors that sustain the demand of flights to and within the country, such as the historical, cultural and natural heritages as well as the “Made in Italy” productions. Given the lack of similar studies on Italy, this analysis is interesting and it may represent a starting point to serve further studies and policymaking in Italy and Europe.

In details, this paper provides a calculation of the EU-ETS direct costs that Italian airline companies have faced over the period 2012-2015, based on the actual emissions verified by the European Commission, namely verified emissions⁷ (see

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⁶ Actually, the pass-through on final prices is a strategy that was announced and enforced by Ryanair that charged fare by 0,25 Euros per flight. Estimations indicated that Ryanair earned important windfall profits.

⁷ Verified emissions represent the emissions communicated by firms to the European Single emission registry. These emissions are certified by accredited verifiers accordingly to the Monitoring and Reporting Regulation and to the Accreditation and Verification Regulation.
the Community Independent Transaction Log-CITL). Then, it presents a forecast of the EU-ETS direct costs for 2016, referring to three scenarios, more or less conservative, related to different hypotheses on emission permit price (low, medium, high bounded scenarios). Moreover, particular attention is drawn to the pass-through of these costs onto final passengers. Finally, the paper measures the effects of these costs in terms of changes in flight fares, revenues, and social costs.

The rest of the paper is organized as follows. In section 2, it is outlined the methodology used in the analysis, providing an estimation procedure and, for years in which emissions are still to verified, a forecasting model. Section 3 presents the data used to analyse the Italian case. To better represent the selected case, some hypotheses and simplifying assumptions are introduced. Section 4 proposes an application of the constructed theoretical framework analysing the Italian aviation sector case. Finally, some policy considerations conclude the work.

2. Methods

2.1. The economic model

The EU-ETS is designed in order to reach the environmental goal of reducing CO$_2$ at the least possible cost option (cost effectiveness). It means that firms can buy permits from the carbon market and/or realising investments in new or sunrise technologies depending on the comparison between allowances price and marginal
abatement cost\textsuperscript{8}. In both cases, firms incur in the so-called environmental costs or compliance costs that could negatively affect their competitiveness.

In order to measure the effect of those compliance costs on firms’ performance, an important factor has to be considered, namely the ability of firms to pass those additional costs onto final consumers (pass-through) (Meleo, 2010, 2014). Where companies can pass on the full EU-ETS direct costs on to final price, there are not significant negative impacts on competitiveness, but some distributional effects arise. Otherwise, the pass-through to final price could lead firms to lose competitiveness as consumers could divert their demand to cheaper products, accordingly to demand price elasticity\textsuperscript{9}; this is especially true if profit margin cannot absorb those costs. In this latter case, the only feasible solution is reducing the output (in this case, the number of flights) and thus incurring in significant allocative and productive inefficiencies (Meleo, 2014). As a consequence, it is important to consider the ability of firms to pass-through assessing by the “net direct costs” that burden on firms under EU-ETS. In this case this operation is realised taking into account, among the other variables, demand price elasticity\textsuperscript{10}.

In the context of these issues, an economic model-based approach suitable to assess the effects of EU-ETS in terms of change in costs, revenues and profits is defined. In order to model the profit function, a relation among the quantity of

\textsuperscript{8} The marginal abatement cost indicates the additional costs a firm has to manage when increasing one emission reduction. It is a convex curve; this implies that the more a firm has introduced actions to reduce pollution, the higher the MAC for additional actions will be (Meleo, 2014).

\textsuperscript{9} The higher the elasticity, the less pass-through strategy is profitable.

\textsuperscript{10} In general, other factors influence the possibility to pass-through environmental costs on final prices, such as the exposure to international competition and market concentration (Meleo, 2014).
passenger-kilometres flown in period \( t \) \((Q_t)\) and the emission level in the same period \((E_t)\) is pointed out such that: \( E_t = a_t Q_t \). The coefficient \( a \) represents a multiplier which approximates the average level of emissions per quantity in the \( t^{th} \) year. If \( a \) is lowering from \( t_n \) to \( t_{n+1} \), then the firm is making environmental improvements, implementing new green technologies e.g. In this paper, a simplified assumption is introduced fixing \( a_t = 1 \) for every \( t \) so that \( E_t = Q_t \).

Given this hypothesis, the profit function for the aviation industry can be modelled. Before the inclusion of aviation sector in scope of the EU-ETS, in year \( t \), profit function was

\[
(1) \quad \pi_t = Total \ Revenues - Total \ Costs = P_t Q_t - ATC_t Q_t
\]

where \( ATC_t \) is the average total cost\(^{11} \), \( P_t \) is the price and \( Q_t \) is the quantity of passenger-kilometres flown in the \( t^{th} \) year. After the inclusion of the aviation sector under the EU-ETS, the profit function is reduced by EU-ETS total direct costs \((TDC_{ETS, t})\), and becomes as below

\[
(2) \quad \pi_{ETS, t} = P_{ETS,t} Q_t - ATC_t Q_t - ADC_{ETS,t} Q_t
\]

where \( TDC_{ETS, t} = ADC_{ETS,t} Q_t \). As far as revenues are concerned, they are influenced by the ability of the company to pass-through the EU-ETS direct costs on to finale price \((P_{ETS,t})\). \( P_{ETS,t} \) includes a component linked to the pass-through which is influenced by many variables such as demand price elasticity, market structure, and international openness. This means that total revenues and, as a consequence, airline profits could be reduced in case firms try to charge environmental costs

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\(^{11}\) Notice that total non-ETS costs can vary accordingly to the reaction of the demanded quantity.
onto final price\(^\text{12}\). To include this point, a coefficient \(b\) with value in \([0,1]\) to measure the pass-through realised for the average total EU-ETS direct cost \((ADC_{ETS,t})\) is introduced. In this way, \(P_{ETS,t}\) depends both on the price before the EU-ETS \((P_B)\) and on the percentage of the average EU-ETS direct cost passed-through:

\[
(3) \quad P_{ETS,t} = P_B + b_t ADC_{ETS,t}
\]

In terms of total revenues, this means that:

\[
(4) \quad TR_{ETS,t} = P_B Q_t + b_t TDC_{ETS,t}
\]

Given the revenue function, in order to describe \(TDC_{ETS}\), three basic assumptions are discussed below:

i) most firms show AMC higher than the price of a single emission unit, being net buyers of permits;

ii) residual firms make investments to reduce CO\(_2\) (e.g. investments to improve energy efficiency), being net sellers of permits;

iii) the AMC is higher than the abatement cost of one pollution unit for most of the firms.

\(^{12}\) In fact, the variation of the latter also depends on the demand and, in particular, on its price elasticity. It is intuitive that, given a linear demand function \(Q_t = a_0 - a_1 P_t\), consumer reaction to an increase of \(P_t\) is a reduction of \(Q_t\), with a magnitude that depends on \(a_1\). In particular, the demand price elasticity can be modelled as below:

\[
e_d = \left(\frac{\partial Q}{\partial P}\right) \left(\frac{P}{Q_t}\right) = - a_1 \left( P_B + b_t ADC_{ETS,t} \right) / \left( a_0 - a_1 P_B - a_1 b_t ADC_{ETS,t} \right)
\]

If \(b_t\) increases (i.e. there is an increase in the pass-through effect) then \(e_d\) decreases as well as if \(ADC_{ETS,t}\) increases.
These assumptions indicate that the offer of emission permits is less than or equal to the demand in carbon market. Such hypothesis is reasonable given that the aviation industry has already made important investments aimed to reduce fuel consumption (thus dropping CO₂) and to limit the incremental costs due to the rise of kerosene price over the last years. As a consequence, given the shape of the AMC curve, additional investments aimed at reducing CO₂ emissions, could result in very high costs, difficult to manage in the short run. It implies that the AMC could be easily higher than the cost of one emission permit. This assumption is even more realistic when considering the average permit price recorded after 2008 which dropped off because of the allowance oversupply resulting from the economic crisis: spot price lowered from 22 Euro/t CO₂ to 6 Euro/t CO₂ on average in 2008 and 2014 respectively.

Given this framework, the estimation of the EU-ETS total direct costs \( TDC_{ETS} \) in a specific year \( t \) is obtained by referring to the equation (5). Here the \( TDC_{ETS} \) simplifying the notation is proposed, by dropping the year indicator. In short, these costs are obtained as the sum of the costs to purchase auctioned allowances, those to purchasing permits on the market and those associated to the civil penalties (imposed in case not having surrendered allowances for a number equal to the verified emissions by the deadlines indicated by the Directive). Moreover, \( TDC_{ETS} \) are reduced by all revenues realised by selling allowance surplus on carbon market. The equation below sums up the component of the \( TDC_{ETS} \):

\[
(5) \quad TDC_{ETS} = \sum_{i=1}^{n} (p_a Q_{ai} + p_m Q_{mi} + s Q_{ni} - p_m Q_{vi})
\]

where the variables introduced represent:

- \( p_a \) = allowance auction price
- \( Q_{ai} \) = number of allowances purchased by the \( i^{th} \) operator by auctions
- \( p_m \) = allowance market price on the secondary market
- \( Q_{mi} \) = number of permits purchased on the secondary market by the \( i^{th} \) operator
- \( s \) = penalty applied to emission units not covered by allowances (or applied to allowances that are not returned)
- \( Q_{ni} \) = number of allowances not returned by the \( i^{th} \) operator
- \( Q_{vi} \) = number of allowances sold by the \( i^{th} \) operator
- \( E_i \) = actual or verified emissions of the \( i^{th} \) operator
- \( Q_{tfi} \) = total free allowances for the \( i^{th} \) operator

The number of permits not surrendered can be written as \( Q_{ni} = E_i - Q_{tfi} - Q_{ai} - Q_{mi} + Q_{vi} \). This recursive derivation of \( Q_{ni} \) depends, first of all, on the relationship among variables \( E_i \) and \( Q_{tfi} \). If \( E_i - Q_{tfi} \) is a negative quantity, then, there are more allowances than what is needed. In other words, in this case it is expected that \( Q_{ai} = Q_{mi} = 0 \) as well as \( Q_{ni} > 0 \). The other way round, if the difference among emissions and free allowances is positive, then \( Q_{vi} = 0 \) and all the other quantities \((Q_{ai}, Q_{mi}, Q_{ni})\) are positive. Moreover, three other assumptions regarding \( TDC_{ETS} \) variables are introduced as described below:

i. the number of permits purchased on the secondary market has to be less than the actual \( \text{CO}_2 \) emissions for the \( i^{th} \) operator \((Q_{mi} < E_i)\);
ii. the emission level for the single operator can be greater or equal to the sum of the total number of purchased allowances \((Q_{ai} + Q_{mi} \leq E_i)\);
iii. the number of allowances sold is less than the number of allowances purchased on the secondary market \((Q_{mi} > Q_{vi})\).
The approach here described, based on historical data, could be modified in order to define a forecast model. This appears particularly useful where data are not available or in order to figure out some forecasts for the years to come. This model is based on the following variables:

- \( g_e = \) CO\(_2\) emission growth rate\(^{13}\);
- \( r_a = \) auctioned permit rate with respect to total emissions;
- \( r_n = \) not surrendered permit rate with respect to total emissions;
- \( r_v = \) sold permit rate with respect to total emissions.

In particular, referring to the period \( t \), the emission growth rate for the \( i^{th} \) operator and for the sector are computed respectively as:

\[
(6) \quad g_{e,t} = \frac{(E_{i,t} - E_{i,t-1})}{E_{i,t-1}} \quad \quad g_{e,t} = \frac{(E_t - E_{t-1})}{E_{t-1}}
\]

where \( E_t \) indicates the total sector CO\(_2\) emissions in period \( t \). The emission growth rate to use in such a simulation is the arithmetic mean of the \( g_{e,t} \) for a significant period of time (i.e. from \( t \) to \( t+l \)):

\[
(7) \quad g_e = \frac{\sum_{j=0}^{l} g_{e,t+j}}{l}
\]

Similarly, if a time series on the number of auctioned not surrendered and sold allowances is available, then it will be possible to easily calculate the related rates \( (r_a, r_n, r_v) \) referring to a specific period of time. Differently, some assumptions have to be introduced to define \( r_a, r_n \) and \( r_v \) that can vary accordingly to the characteristics of the sector considered for the analyses (see Section 3). Thus, if the \( TDC_{ETS} \) for the aviation sector have to be forecast for the \( t+k^{th} \) year (with \( k>l \)),

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\(^{13}\) This rate depends on several variables. Among the others, it recalls the growth in GDP, in business and tourism demand (that depends also on GDP growth), and future "green" investments.
specific assumptions over $p_a$, $p_m$, $s$, $g_e$, $r_a$ and $r_v$ are needed. In particular, the EU-ETS total direct costs can be forecast accordingly to the equation below\(^\text{14}\):

\[
TDC_{ETS,t+k} = (1+g_e)^{k-1} E_{t+l} [r_a (p_{a,t+k} - p_{m,t+k}) + r_n (s_{t+k} - p_{m,t+k}) - 2 p_{m,t+k} r_v]
\]

In Section 3 an empirical application to the Italian aviation sector of the present model is pointed out, accordingly to equations (5), and (8).

3. The data used for the analysis of the Italian aviation sector

The analysis proposed in this paper covers the time period spanning from 2012 to 2016. This choice is justified firstly because 2016 represents the last year of the first EU-ETS allocation period for the aviation sector, and secondly, after 2016, some regulatory changes are expected. As mentioned in the introduction, according to 2013 settlement between EC and ICAO that led to the “stop the clock” Decision, a new agreement on a global market-based measure for aviation sector has to be reached within 2016, with possible changes in the current rules.

Calculations are based on data collected by different sources. At first, data on allocated allowances and verified emissions were obtained respectively from the Italian Committee for the management and implementation of Directive 2003/87/EC (Decisions n. 2011/36 and n. 2014/27), and the CITL.

Verified emissions are currently available for the years 2012-2014 (see CITL, last access 25\(^\text{th}\) May 2015) thus, for 2015 and 2016, it is assumed that emissions evolve at the average emission growth rate ($g_e$) registered in 2008-2012 (-1.393 per cent given equation (5)). This assumption on $g_e$ is coherent with the CO\(_2\) emissions development observed for the Italian aviation sector over the last years. In particular, considering the time span 2008-2012, without loss of generality, it is

\(^{14}\) For extra details over the model assumptions see the Appendix A.
possible to take into account the reaction of aircraft operators to several factors such as the introduction of the Directive 2008/101/EC, the economic crisis, and the latest green investments and measures implemented by the Italian airlines.

Referring to the amount of auctioned allowances, it is important to remind that in Italy there have been no auctions since 2012 ($Q_a=0$) as it has happened in the other EEA States except for Germany. This is not only due to organisational reasons (given the limited experience with regards to auctioning) but also to the regulatory uncertainty that followed the “stop the clock” Decision. As a consequence, the number of freely allocated allowances is equal to the total allowances distributed throughout to the sector. As declared by several Italian policy maker announcements (Gestore dei Servizi Elettrici – GSE, 2014), it is assumed that a part of the total allowances will be granted by 2016 auctions so a $r_s=15$ per cent as indicated by the Directive 2008/101/EC.

Permit surplus and deficit used for estimations are obtained as the difference between verified emissions and total allocated allowances (Tab. 1). In the years taken into consideration in this analysis, emissions decreased from 3.449.656 to 2.058.559 tonnes of CO$_2$ (about 40%). For the entire period of the analysis, the allocated allowances have been lower than actual emissions as it should be in order to provide airline companies with the proper incentives to reduce CO$_2$ emissions, except for 2012. This is due probably to the fact that 2012 was the first enforcement year for aviation, so a first stage to start to make further adjustments. In addition, the vast allowances distributed in 2012, compared to the ones allocated in the other years, are the result of the amendments introduced by the “stop the clock” Decision that have temporally exempted extra-
European airline companies from the EU-ETS (opt-out option). It means that the allowances previously allocated to those companies were surrendered to the EC.

As regards the differences between verified emissions and total allocated allowances, only 2012 shows a quite important permit surplus, while the data on 2013-2016 indicate a decreasing deficit that will reach 302.302 tonnes of CO$_2$ in 2016. However, it is important to remind that the deficit calculated for 2016 includes the assumption that 15% of the allowances will be auctioned in addition to the allowances to distribute free of charge.

Here Table 1

As far as the carbon prices ($p_n$) used for the calculations, the average daily price recorded for each year from 2012 to 2014 is referred to. On the other hand for 2015 the average price from the 1$^{st}$ of January to the 24$^{th}$ May is considered. In order to forecast permit price for 2016, three scenarios are considered (Tab. 2), accordingly to different permit price assumptions. In particular, scenario A refers to the current permit price equal to 7.1 Euro/t CO$_2$, while scenarios B and C consider a higher carbon price equal to 15 and 25 Euro/tonne of CO$_2$ respectively. The choice of 15 and 25 is related to a scenario in which the flight demand will increase by roughly 4% and 8% per annum (Scheelhaase et al., 2010).

The auction price is set to be the same of the market price, accordingly to the different scenario. This assumption is consistent given that, in January-July 2014, the average auction price, recorded in Germany (the only Member State which had set-up auctions for the aviation sector) was equal to 5.7 Euro/t CO$_2$ against an
average secondary market quotation of 5.6 Euro/t CO\textsubscript{2} for the same time period (German Emission Trading Authority, 2014; SendeCO\textsubscript{2} database).

These scenarios on carbon prices are divided in sub-scenario 1 (A\textsubscript{1}, B\textsubscript{1}, C\textsubscript{1}), and 2 (A\textsubscript{2}, B\textsubscript{2}, C\textsubscript{2}). Sub-scenario 1 reflects the hypothesis that the company surrenders to EC an amount of allowances\textsuperscript{15} equal to the actual emissions, so no sanction is enforced. Scenario A\textsubscript{2} assumes the opposite situation in which aviation companies cannot return to EC a number of allowances that exceed the actual emission by 10 per cent, in this case paying a sanction of 100 Euro/tonne of CO\textsubscript{2} as indicated by the Directive (Tab. 2).

Here Table 2

The estimation and forecast of the effects in Italy of EU-ETS direct costs strongly depend on the identification of the demand price elasticity for the aviation sector. As a proxy the world price elasticity demand, estimated equal to -2.03 (InterVistas, 2007)\textsuperscript{16} is selected.

Finally, the values 0%, 50% and 100% associated to the parameter \(b\) to describe the pass-through effect are considered. In particular, these values are coherent with the literature and with different competitive market structures reported by many authors (see Ten Kate and Niels, 2005; Zimmerman and Carlson, 2010).

\textsuperscript{15}Received at the beginning of the period or purchased from carbon market (\(Q_{m}\)).

\textsuperscript{16}They use an autoregressive distributed lag model which estimates the price elasticity, in terms of the ratio among the percentage quantity variation and the percentage price variation, to be -2.03.
4. Results and discussion

In this section the results of the analysis present the estimated EU-ETS total direct costs borne by Italian aviation sector, and their impacts in terms of change in flight price, revenues, and social costs measured with the change in consumer surplus.

Before illustrating these results, it is necessary to point out that the data described below only refer to the Italian airline companies (so extra-European aviation companies whose reference State for EU-ETS is Italy are excluded). There are 10 companies involved in this analysis. Among them, Alitalia, the biggest Italian company, owns 68,4% of the freely allocated allowances.

Table 3 shows firstly the EU-ETS direct costs over the period 2012-2015 based on the surplus and deficit calculated for each year. It is quite clear that the vast allowance surplus recorded in 2012, equal to 10.699.740 Euros, implies important potential revenues in case permits were all sold on carbon market. The dimension of these financial extra-gains represents the main reason why some extra-European airline companies do not opt-out after the exemptions introduced with the “stop the clock” Decision of 2013 (Korea air, and Nippon Air e.g.).

However, looking at the years 2013-2015, after the 2012 surplus, the trend inverted and the sector has experienced a shortage of allowances compared to the actual emissions. In details, the value of the deficit has grown from 3.369.046 Euros of 2013 to 4.221.578 Euros of 2015, with an average cost equal to 151.195 Euro per year, and a cumulative cost of 604.778 Euros (both including 2012).
Accordingly to prediction for 2016, the EU-ETS direct costs will vary between 4,02 and 15,54 million Euros, depending on the different assumptions set for allowance price, the number of auctioned allowances, and the sanction enforcement (Table 4).

In details, if $p_m$ stands at the same level registered for the first months of 2015, then EU-ETS direct costs will fluctuate between 4,02 and 6,83 million Euros. If carbon price grows to 15 Euro/t CO$_2$, then the costs will range 8,49 and 11,06 million Euros. Finally, in case of $p_m$ equal to 25 Euro/t CO$_2$, costs will raise from 12,87 to 15,14 million Euros.

If the forecasts for 2016 are included to the cumulative compliance costs calculated for 2012-2015, the value raises and varies between 4,62 and 7,43 million Euros in case of scenario A. For the same years, scenario B indicates that the estimated EU-ETS direct costs fluctuate between 48,68 and 61,53 million Euros. Finally, scenario C shows that these costs range between 13,47 and 15,74 million Euros.
In order to complete the analysis, it is necessary to evaluate the impact of the estimated compliance costs on airfares, revenues and on social costs for each year considered in this work, taking 2012 as a base year. As specified before, changes in carbon price and the consequent changes in flight prices, revenues, and social costs are strictly related to the possibility of passing through the EU-ETS costs onto final passengers.

According to the costs estimated above, the impact on flight price and on revenues appears quite limited (Tab. 7). In fact, in case the coefficient of pass-through is different from zero, there is a very limited flight price increase in case $b=50\%$, equal to 0,067\%, 0,95\%, and 0,115\% in 2013, 2014, 2015 respectively. This had led to a reduction of the revenues by only 0,069\%, 0,099\%, and 0,119\% over the same three years. Even assuming a pass-through rate of 100\%, the effects on airfares and revenues are still limited. In fact, final price increase stays under 1\%, namely 0,134\%, 0,191\%, and 0,231\% for the same period, corresponding to a revenue cut by only 0,139\%, 0,197\%, and 0,239\% once more for 2013, 2014, and 2015.

Here Table 6

For 2016, the situation appears quite similar, even if the magnitude of changes in flight price and revenues is higher than the years before (Tab. 7). Assuming three different carbon prices (7,1; 15; 25 Euro/t CO$_2$), and the sanction enforcement for sub-scenario $A_2$, $B_2$, and $C_2$, in case the pass-through is 50\%, flight price grows
by 0.066-0.113%, 0.140-0.182%, and 0.212-0.250%. If there is a full pass-through, airfares rise by 0.133-0.225%, 0.280-0.365%, and 0.425-0.499%. In the same way, there is a negative change in revenues, but it stays again below 1%. In fact, assuming once more the three above mentioned carbon prices, revenues decrease by 0.068-0.116%, 0.145-0.189%, 0.220%-0.258% in case of a pass-through rate of 50%, and by 0.137-0.233%, 0.290-0.378%, and 0.441-0.520% in case of full pass-through.

In light of the recorded change in flight prices and revenues, it is useful to provide a picture of the effects that these costs have had on the final consumer, in order to quantify also the social costs linked to the inclusion of aviation under the scope of EU-ETS. As mentioned above, the social costs are measured as the change in consumer surplus (W). Table 8 provides this information referring as before to three different assumptions on the pass-through rate $b$ (0%; 50%; 100%). In the intermediate scenario ($b=50\%$), the change in consumer surplus is quite limited but still higher than the change in airline operators’ revenues. It generates an increase of social costs equal to 1,341, 1,904, and 2,301% in 2013, 2014, 2015 respectively. In the high bounded scenario where EU-ETS costs are entirely reversed into final prices, social costs increased by 2,676, 3,796, and 4,587% over the same years. It indicates that, even in case of full pass-through, the costs of society for the internalisation of the air pollution costs linked to flights stay below 5%.

Here Table 8
The change in social costs due to the EU-ETS is measured also for 2016, according to the assumptions used before on carbon prices, auction prices and sanction enforcement (Table 9). Again, the estimation for 2016 indicates that, in case of a 50% pass-through rate, social costs increase by 1,323-2,244%, 2,788-3,628%, 4,129-4,957% for scenario A, B, and C respectively. In case of full pass-through, social costs grow by 2,640-4,4473%, 5,553-7,215%, and 8,383-9,837%. These results show again that the higher the carbon price is, the more social costs are progressively significant.

Here Table 9

Summing up, from the data illustrated, at the moment, EU-ETS direct costs appear quite limited as well as their impacts in terms of social costs. However, in order to broaden this analysis and to provide further information about the effects linked to EU-ETS compliance costs, the remaining of this section will show what could happen in case of wider changes in compliance costs, demand price elasticity, and pass-through rate.

The Figures below provide some plots related to different scenarios. First of all, it is assumed the coefficient of pass-through $b$ varying between 0 and 1\textsuperscript{17}. The extreme values represent, respectively, no pass-through or full pass-through. For the sake of simplicity, different EU-ETS costs as percentage of the initial flights

\textsuperscript{17} Specifically, $b$ is set to be equal to 0.0; 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; 0.9; 1.0.
price $p_0$ are assumed and in this case a change from 0.0 to 0.1 is considered (e.g. $C=%p_0$).

In particular, in Figure 1 the change in flight price is plotted according to the different pass-through rate ($b$), and to different compliance costs. The lines in the chart identify the latter. With the black line a situation in which EU-ETS costs are 0 is indicated. These costs grow, as the lines get lighter. It is to notice that the change in price is quite limited regardless the EU-ETS direct cost dimensions where the pass-through stays roughly below 0.05. In fact, in this case, price variation is always less than 1%. An increasing pass-through rate causes a more than proportional price rise accordingly to the different cost level taken into account.

Here Figure 1

In addition, Figure 2 explains the change in revenues according to different hypotheses on the EU-ETS direct cost levels (again expressed as percentage of the initial price $p_0$, and in a business as usual scenario). The lines in the figures indicate the pass-through rate; the black line refers to a situation in which pass-through rate is zero, while this rate grows as the lines get lighter. In the most conservative scenario (EU-ETS direct cost equal to 1% of the price), revenues do not vary significantly if demand price elasticity stays at very low levels, again below about 4-5%, independently from the pass-through rate. However, when demand price elasticity grows further, the revenues can vary significantly according to the different hypotheses on compliance costs magnitude. Notice, in particular, that for low levels of the pass-through and the demand elasticity, positive revenue variations are registered. On the other side, when they reach
higher levels, the demand drops to zero and revenue variations settle down to the -100%. It is important to remind that the demand price elasticity is quite low at the moment and it is not expected to vary significantly in the short-medium run; it means that revenue variation will stay roughly under 5%.

Here Figure 2

Finally, Figure 3 proposes the social cost variation related to the pass-through of the ETS costs. Higher variations are registered if, in absolute value, the demand price elasticity is low. Moreover, the remarkable change in curve slope is associated, also in this case, to the fall in market demand.

Here Figure 3

In light of these results, some considerations are necessary. As highlighted, EU-ETS direct costs have had limited impacts on both airline companies and consumers up to now. This situation appears to be in contrast with companies concerns about the alleged distortive effects that including the aviation sector under the purposes of EU-ETS would have implied in the short run. Referring to the Italian scenario, this represents “good news” given the economic performance of the ten Italian airline companies part of the EU-ETS, in particular of Alitalia, the flag carrier, former public company, late privatised in 1998. In fact, in 2013 (latest data available on AIDA database), 8 companies out of 10 recorded negative profits, and 6 out of 10 recorded negative EBITDA as well. In particular, Alitalia, as
mentioned the company owning a share of free allowances equal to 68.4% with the highest permit deficit in 2013-2014 (CITL database), has recorded negative EBITDA over the last 10 years except for 2010 and 2011. This is primarily due to several factors not related to EU-ETS. In fact, after years of serious deficit, in 2008-2009 it went bankrupt and was merged to another bankrupted Italian company, Airone, and acquired by a consortium of Italian entrepreneurs (CAI). CAI purchased the capital formerly owned by the Italian State. However, in 2013, after recording new losses, in order to re-launch the company, 49% of the capital was acquired by Ethiad airways, the Abu-Dhabi flag company, while 51% is still in the hand of CAI.

5. Conclusions and policy implications

This paper provides an estimation of the direct costs arising from the inclusion of the aviation sector under the scope of the EU-ETS, presenting the Italian case study. According to the estimation, in 2016 total direct costs for the Italian sector will vary from a minimum of 4,62 to a maximum of 15,74 million Euros. These costs have generated effects on both prices and revenues, depending on the different assumptions made on carbon price, sanctions and allowance auctions for 2016. As a consequence, the social costs generated are still not significant, and will stay below 5% in 2016.

The results highlight that direct costs linked to EU-ETS and their impact on both companies and final consumers are currently quite limited. However, these costs are expected to slightly increase starting from 2016, amplifying the impact on airfares, revenues, and social costs. This growth tendency is due to two main reasons.
First, the allowance surplus recorded for the aviation sector in 2012 is going to be absorbed; second, the increase of GHG emissions expected once the economic crisis comes to an end will ask firms under EU-ETS to buy additional permits. Both the events will push carbon and auction prices higher (average carbon spot price from January to May 25th 2015 is 7,01 Euro/ t CO\textsubscript{2} against 5,87 Euro/ t CO\textsubscript{2} of the same period for 2014). It means that, even if EU-ETS direct costs have not been so important currently due to the vast surplus allowances and to a very low carbon price, new cost increases are expected, with different effects depending on the values of pass-through, demand price elasticity and, even more important, carbon price as showed in the Figures 1 and 2.

Presented results have interesting implications to guide new policy maker actions also for stationary plants. So far, if this is the case, the functioning of the EU-ETS will probably be improved trying to reinforce the economic incentives to innovate in green solutions (with a cut of the allocated free allowances i.e.). On the other hand, if this is the EC position, policy makers should take into account the economic performance of the sector as several companies, at least in the Italian framework, have experienced prolonged financial problems over the latest decades, as well as the distributional effects of this regulatory instrument.

Assuming that carbon prices will increase as it is likely to be, then airline carriers as well as policy makers need to define a set of long-term strategies linked to sustainability, in order to protect competitiveness while preserving air quality beside the two options “buying allowances from carbon market” or “invest in green solutions”.

Companies could explore innovative solutions regarding the use of alternative energy sources such as photovoltaic, fuel cells or even green fuels (biofuels).
Actually, many companies have already moved in this direction such as, among the others, Boeing and Airbus. In 2008, the latter has partnered with Honeywell Aerospace, International Aero Engines, and Jet Blue for the development of second generation biofuels (Capoccitti et al., 2010).

In addition, following a stakeholder engagement approach, firms can involve passengers in their programs of emission reduction. The airlines could define and launch initiatives in which passengers can choose to purchase the quantity of emissions generated by their flights whose amount can vary according to the carbon footprint of the passenger (e.g. the amount of luggage, the flight distance, the environmental performance of the aircraft, etc.). This kind of strategy applies the “polluter pays” principle, but, in order to be acceptable from a social viewpoint, it should not be mandatory and should be defined to avoid the full burden of EU-ETS costs on consumers, and to prevent airline carriers from hazardous behaviours like in enforcing market distortive actions such as “windfall profit strategies”.

Finally, some efforts can be made also by policy makers in optimizing the air traffic management performance and, more in general, to rationalise the entire transport system of the country. According to the IATA (2007), a more effective global air traffic management could reduce inefficiencies by 12 per cent. This can also include the promotion of intermodal transport solutions, a strategy that many European Members have already been using. For instance, after their merging, Dutch airline and KLM abolished several flights of short distance covered by high-speed rail lines (Balch, 2009).

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APPENDIX A

Here some details on the construction and extensions of formula in Section 2 are proposed. It can be notice that, given the decomposition of the number of not returned permits as $Q_{ni} = E_i - Q_{tri} - Q_{ai} - Q_{mi} + Q_{vi}$, equation (4) can be rewritten as
\[ TDC_{ETS} = \sum_{i=1}^{n} [p_a Q_{ai} + p_m Q_{mi} + s (E_i - Q_{tfi} - Q_{ai} - Q_{mi} + Q_{vi}) - p_m Q_{vi}] \]

\[ = \sum_{i=1}^{n} [(p_a - s) Q_{ai} + (p_m - s) Q_{mi} + s (E_i - Q_{tfi}) - (p_m - s) Q_{vi}] \]

In the forecast procedure, the following structure of total direct costs is defined:

\[ TDC_{t+k} = p_{a,t+k} Q_{a,t+k} + p_{m,t+k} Q_{m,t+k} + s_{t+k} Q_{n,t+k} - p_{m,t+k} Q_{v,t+k} \]

Where, given total emissions verified \( E_{t+i} \), the following relations are considered

- \( E_{t+k} = (1+g_e)^{k-l} E_{t+l} \)
- \( Q_{a,t+k} = r_a E_{t+k} \)
- \( Q_{n,t+k} = r_n E_{t+k} \)
- \( Q_{v,t+k} = r_v E_{t+k} \)
- \( Q_{m,t+k} = (1 - r_a - r_v - r_n) E_{t+k} \)

Then, the previous equation can be rewritten in the following manner, as described in Section 2:

\[ TDC_{ETS,t+k} = (1+g_e)^{k-l} E_{t+l} [r_a (p_{a,t+k} - p_{m,t+k}) + r_n (s_{t+k} - p_{m,t+k}) - 2 p_{m,t+k} r_v] \]