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# Flights and their Economic Impact on the Airport Catchment Area: An Application to the Italian Tourist Market

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**Abstract.** Traditionally, in the field of air transportation management airlines have been the main actors in the process of deciding which new flights to open in a given airport, while airports acted only as the managers of the operations. The changes in the market due to the introduction of low cost companies, with the consequent reduction of airports fares, as well as the increase in density of regional and secondary airports in many European countries are modifying the mutual roles of airlines and airports. Today, the final decision on new flights to be opened is the result of a negotiation between airlines, airports and public stakeholders. The airports must prove the sustainability on the new routes and forecast the economic impact on their catchment area. This paper contributes to advance the current state-of-the art in that; it provides a standard methodology to analyze the economic impact of flights and new airport routes. Subsequently, the methodology is applied to the summer tourism market in Sardinia and the winter tourism market in the North of Italy, in order to verify the adaptability of our approach to different characteristics of the tourist market.

**Keywords.** Multinomial logit, simulation-optimization, air flow forecast, economic impacts.

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# 1 Introduction

In the field of air transportation management, decisions on the flights that should be opened in a given airport involve studying the demand, supply and the economic and spatial relationship between the different actors (airlines, airport management, passengers, public stakeholders). Traditionally, airlines have been the main actors in this process, while airports acted only as the managers of the operations. The changes in the market due to the introduction of low cost companies, with the consequent reduction of airport fees, as well as the increase in density of regional airports in many European countries are modifying the mutual roles of airlines and airports. Today, the final decision on new flight to be opened is the result of a negotiation between airlines and airports, due to the incidence of airport fees on the final flight price and reduced marginal profits [1].

On one hand, airports must ensure the sustainability of the new routes and satisfy the primary needs of the passengers in their catchment area. On the other hand, public stakeholders (regional councils and municipalities) require airport management to measure the economical impact of opened flights in order to grant financial support [2, 3]. Hence, passengers have a double nature: they are both users of airport services and investors through the public stakeholders. Similarly, evaluating airport efficiency can be seen from two different perspectives: on the one hand airports aim to evaluate the passenger flows, the market share, the passenger satisfaction; on the other side, public stakeholders are interested in evaluating the return of investments in terms of gains for the territory (for instance, through tourism).

Airport management becomes an active player in the process. It can directly contact the airlines that are more suitable for their stakeholders or, due to scarcity of financial resources, choose from a list of possible destinations provided by the airlines. To facilitate this process, specific workshops such as Routes Europe have recently been introduced. In these meetings, airlines, airports, public stakeholders and tourist authorities meet, in order to share common growth strategies, negotiate deals and build relationships [4].

In order to understand this important phenomenon, it is necessary to model the competition in the system and measure the impact of the transformations in it. Furthermore it is also necessary to develop new methods for dealing with decisions inherent to the potential profit and to the increase of traffic caused by changes in the system [5, 6]. This issue is interesting not only from a practical point of view, due to its relevant economic impact, but also from the point of view of research. In fact, the complexity of the systems considered and the strong relationship be-

tween the different actors make the problem of interest for transportation systems research.

Extending AirCAST, a simulation-optimization framework based on Multinomial Logit models [7], this paper analyzes the economic impact on two Italian tourism case studies, where the airport flights schedules play a key role: the summer tourism market in Sardinia and the winter tourism market in northern Italy. From a socio-economic point of view, the two markets differs in customer behavior and demand elasticity. From the optimization point of view, this paper introduces in AirCAST a new Two-Level Multinomial Logit model able to describe the interaction between the tourists using the flights and the corresponding destination airports and the catchment area of the airports themselves.

This paper contributes to advance the current state-of-the-art in that, it provides a standard methodology for analyzing the economic impact of flights and new airport routes. Subsequently, the methodology is applied to the tourist case studies cited above in order to verify the adaptability of our approach and, in particular, of the AirCAST framework to different characteristics of the tourist market. The key contribution of this paper is that it constitutes the first study to consider the demand on Italian airports [8]. All the results have been validated by BDS s.r.l., an Italian leader in the customer satisfaction, customer profiling and airport management consultancy.

The paper is organized as follows. Section 2 gives a insight on the problem as well as offering a literature review on the issue. The overall scheme of the AirCAST and the model used in the framework are reported on Section 3. Case study on the summer and winter tourism market are presented in Section 4 and 5, respectively. Finally, Section 6 presents the conclusions.

## **2 Problem definition and state-of-the-art**

Let us consider a set of airports and their flights as well as their flight schedule and overall passenger flows of each flight connection. Moreover, we consider a set of tourism areas, directly connected with airports, for which we know the accommodation and travel costs. Furthermore, we define the tourist perception of the area, in terms of number of hotels, quality of public services and access modes. Airports and tourist areas compose the air transportation system under analysis.

Passengers in the catchment area of each airport are unknown, but some forecasts on this data can be deduced from public database [3]. Then, the number

of passengers is a stochastic variable with unknown probability distribution. For each flight, we deduce the mean cost paid by a single passenger for taking the flight, as well as the quality parameters of the airports. More in detail, the quality involves the time needed to reach the airport from the nearby areas and the time interval for performing internal operations such as security checks and luggage delivery.

Our aim is to predict the flows and the economic impact on the tourism areas caused by the changes of existing flight schedules or by the opening of a new route between a pair of airports. With this purpose, the present paper provides a standard methodology to assess the relationship between the air transport sector and the tourism market.

While several applications of Multinomial Logit Models can be found in other research field, such as location and transportation [9, 10, 11], the literature on airport-choice modeling mostly focused on large and hub airports [12]. In particular, latest papers consider two geographical areas: the San Francisco bay area and the United Kingdom one. For what concerns the San Francisco bay area, Nested Logit models based analysis on the correlation between the choice of airport and airline [13] and on the sensitivity to the airport access mode on the user choice [14]. More recent studies introduced Mixed Multinomial Logit models for analyzing the joint choice of airport, airline, access modes and random taste heterogeneity [15, 16, 17]. Multinomial Logit Models has been realized for airport choice in the UK in order to study the most important attraction factors to airports [18, 19] and market share forecasts for a new airport [20]. More recently, a Cross-Nested Logit model has been introduced in order to model the choice of airport, airline and access-mode on the Greater London area, showing improvements over the previous Nested and Multinomial Logit models [21].

These methods show two main drawbacks. On one hand, their focus on specific typologies of airports (large-sized and hub), not considering challenging settings such as the competition of regional airports. Moreover, these methods limits the possibility to apply the same models to systems characterized by medium sized and regional airports placed in a geographic region with a high density of such airports [7]. On the other hand, the only source of stochasticity is the passenger choice. This assumption is sufficient when only hubs and large airports are considered in the system, which maintain historical data. Other source of uncertainty, due to lacks of data and data estimation, should be explicitly taken in account when the system involves many smaller airports.

In addition, these studies are more focused on the pure transportation issue and marginally, consider the financial impact of the changes in the airport schedules

on the surrounding area. Furthermore, they do not give a detailed description of how the economic data have been gathered [7].

From the point of view of tourism management, several papers deal with demand modeling and forecasting. Unfortunately, they consider large macro-areas (usually a whole country) and no study considers the Italian tourism. Moreover, these papers marginally consider the transportation issues and their effects on the demand splitting between different regions (see [8] for a survey). Thus, to our knowledge, this paper is the first study dealing with transportation and tourist issues at the same time.

### **3 The AirCAST framework**

The base of this paper is an economic and spatial interaction Logit model aimed to model the dependency between the players of the air transportation system. This kind of model shows an high adaptability and a wide efficiency, demonstrated in many fields, including transport and retail [22]. Moreover, the method is applied to areas with a larger number of regional airports, where the catchment areas are strongly intersected with each others. Modeling the system requires the introduction of an analytical tool able to evaluate the behavior of the entire system and to deal with uncertainties of the system.

The framework combines an optimization model with the simulation. This approach is able to make an analysis of the financial impacts of a change in the flight schedule or in the features of one or more airports interacting in a given area. Moreover it is able to deal with the stochastic components of the system.

The framework, depicted in Figure 1, is composed by a simulator, a module for the georeference and a post-optimization software. Given the distribution of the total supply of each airport and how it is split among the existing flights of the airport, the simulator generates a series of scenarios. Each scenario is then used by the Logit model to calibrate the flow matrix (step 1), to simulate one or more changes in this matrix and to predict the new passenger flows. From the results of scenarios, the simulator forecast the new flow of the system (step 2) and perform a statistical analysis on the aggregate results (step 3). In order to make a more accurate definition of travel times and cost matrices, the georeference module is used. The georeference feature is implemented by means of Google Earth APIs and it is also used to graphically represents the results of the AirCAST itself.

Finally, a post-optimization software module is devoted to choose the best features of the new flight (e.g. the kind of aircraft, the number of flight). Given

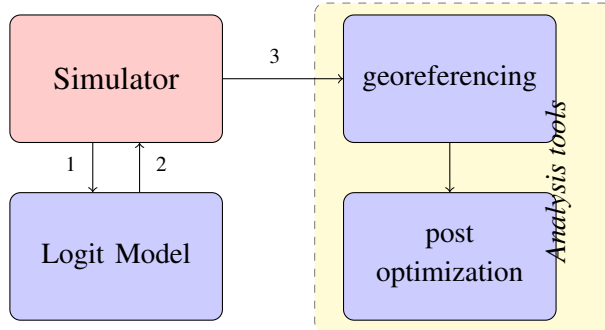


Figure 1: Block diagram of the framework.

the estimated passenger flows, the type of flight (domestic, European, etc.), and the constraints of single airports, gives a list of possible aircraft schedules.

In the following we focus our discussion on the Logit model in order to give an highlight of the optimization core of the framework.

### 3.1 Two-level Logit model

The framework supports different variants of transportation Logit models. In this paper we will use the intermodal Logit model presented in [7]. The model is a two-level model and represents intermodal or transshipment transportation networks. The structure of the system is showed in Figure 2, where airports and their catchment areas are the transshipment nodes  $H_k$ , while flows are originated from countries  $O_i$ . Finally,  $D_j$  are the final destinations and the surrounding area of the airport  $k$ . In this study, the set of destinations contains only one macro destination representing the tourist market in Italy, which collects all flows. Thus, the interpretation of the flow from the origin  $i$  to the destination  $j$  through the intermediate point  $k$  is the amount of tourists from country  $i$  using airport  $k$  to spend their vacation in the destination  $d$ . In the following, we refer to this model as two-level Logit, which measures the financial impact of a new route on destination areas.

Throughout this section  $x$ ,  $\mathbf{x}$  and  $\mathbf{X}$  denote a generic scalar, vector (lowercase and boldface), and matrix (uppercase and boldface), respectively. Superscript  $\hat{\phantom{x}}$  and  $\tilde{\phantom{x}}$  will stand for the observed and estimated values, i.e. the values given to the Logit model as input by simulator and flows obtained after a parameter calibration, respectively.

Given a set of  $n$  origins, a set of  $m$  intermediate points and a set of  $l$  destina-



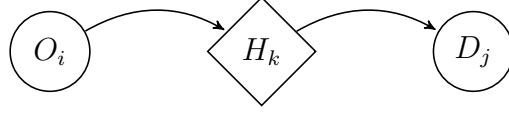


Figure 2: A representational of a two-level transportation networks.

tions, let us define

- identifier of origin of the tourist flow  $i \in \{1, \dots, n\}$ ;
- identifier of intermediate point  $j \in \{1, \dots, m\}$ , i.e. the airport under study and its catchment area;
- identifier of destination  $k \in \{1, \dots, l\}$ , i.e. a touristic cluster or, as in our case, a macro area representing the whole tourist demand of the system;
- observed flows matrix  $\widehat{\mathbf{T}} \in \mathbb{R}^{n \times m \times l}$ , i.e. elements  $\widehat{\mathbf{T}}_{ij}^k$  give the number of passengers depart between  $i$  and  $k$  using the intermediate point  $j$ .
- generalized flight cost matrix  $\widehat{\mathbf{C}}_{\mathbf{f}} \in \mathbb{R}^{n \times m}$ , i.e. elements  $\widehat{\mathbf{C}}_{\mathbf{f}ij}$  give the travel cost of the flight arriving in  $j$  and departing from the airport  $i$ .
- generalized travel cost matrix  $\widehat{\mathbf{C}}_{\mathbf{t}} \in \mathbb{R}^{m \times l}$ , i.e. elements  $\widehat{\mathbf{C}}_{\mathbf{t}j}^k$  give a possible travel cost between the intermediate point  $j$  and the destination  $k$  and an eventual subsistence cost in the destination  $k$ .
- average total cost  $\bar{c} = \frac{\sum_{i,j,k} \widehat{\mathbf{T}}_{ij}^k (\widehat{\mathbf{C}}_{\mathbf{f}ij} + \widehat{\mathbf{C}}_{\mathbf{t}j}^k)}{\sum_{i,j,k} \widehat{\mathbf{T}}_{ij}^k}$ .

Moreover, we define the destination-dependent supply vector  $\mathbf{o}^k \in \mathbb{R}^n$  of the origins (1), the total number of passengers  $\mathbf{d} \in \mathbb{R}^m$  at the intermediate points (2) and the total demand  $\mathbf{r} \in \mathbb{R}^l$  of the destinations (3) as follows:

$$o_i^k = \sum_j \widehat{\mathbf{T}}_{ij}^k \quad \forall i, k \quad (1)$$

$$d_j = \sum_k \sum_i \widehat{\mathbf{T}}_{ij}^k \quad \forall j \quad (2)$$

$$r_i = \sum_j \sum_k \widehat{\mathbf{T}}_{ij}^k \quad \forall j, k \quad (3)$$

The aim of the model is the estimation of the flows matrix  $\tilde{\mathbf{T}}$  considering both the avionic characteristics, as well as the peculiar features of the destinations. Moreover, it should be able to reproduce the matrix of the observed flows  $\hat{\mathbf{T}}$ .

The two-level Logit model may be formulated as

$$\tilde{T}_{i,j}^k = \cdot o_i^k \cdot \frac{e^{\alpha_w \hat{\Pi}_j + \delta_w} \cdot e^{\alpha_\psi \hat{\Omega}_k + \delta_\psi} \cdot e^{-\beta(\hat{C}_{f_{ij}} + \hat{C}_{t_j}^k)}}{\sum_k \sum_j [e^{\alpha_w \hat{\Pi}_j + \delta_w} \cdot e^{\alpha_\psi \hat{\Omega}_k + \delta_\psi} \cdot e^{-\beta(\hat{C}_{f_{ij}} + \hat{C}_{t_j}^k)}]} \quad (4)$$

subject to

$$d_j - \sum_i \sum_k \tilde{T}_{i,j}^k = 0 \quad \forall j \in \{1, \dots, m\} \quad (5)$$

$$r_k - \sum_i \sum_j \tilde{T}_{i,j}^k = 0 \quad \forall k \in \{1, \dots, l\} \quad (6)$$

$$\sum_i \sum_j (\hat{C}_{f_{ij}} + \hat{C}_{t_j}^k - \bar{c}) \tilde{T}_{i,j}^k = 0 \quad \forall k \in \{1, \dots, l\} \quad (7)$$

The model (4)-(7) considers three main criteria of choice: the cost of stay plus the travel ( $\beta$ ), the economical and structural features of the corresponding intermediate points ( $\hat{\Pi}$ ) and the economical and structural characteristics of the destinations ( $\hat{\Omega}$ ). In particular,  $\hat{\Pi}$  includes the airport facilities and efficiency ( $\pi_1$ ) and the tourist area attractiveness ( $\pi_2$ ).

Following [7], the parameters  $\alpha_w$ ,  $\alpha_\psi$ , and  $\beta$  are calibrated in order to reproduce the observed flows  $\hat{\mathbf{T}}$ . This is done by means of the following calibration phase:

- Initialization. Set  $\beta^0 = \frac{2}{\bar{c}}$  and  $\alpha_\psi^0 = 1$
- While the values of  $\beta$ ,  $\alpha_w$  and  $\alpha_\psi$  changes over a given threshold or a maximum number of iterations is not reached
  - Given  $\beta^{\tau-1}$  and  $\alpha_\psi^{\tau-1}$ , find the values of  $\alpha_w^\tau$  which are the roots of the system (5).
  - Given  $\beta^{\tau-1}$  and  $\alpha_w^\tau$ , find the values of  $\alpha_\psi^\tau$  which are the roots of the system (6).
  - Given  $\alpha_w^\tau$  and  $\alpha_\psi^\tau$ , find the values of  $\beta^\tau$  which are the roots of the system (7).

The calibration of  $\alpha_w$ ,  $\alpha_\psi$  and  $\beta$  is implemented by means of a fixed point algorithm. Notice that the procedure of system parameter estimation usually stops when the values of the parameters themselves at iteration  $\tau$  do not differ from the values of iteration  $\tau - 1$  more than a given threshold, set to  $10^{-3}$ .

Moreover, even accurately calibrated parameters cannot take into account all the economical and structural features of the system. Thus, these factors are considered by a perturbation matrix  $\Theta \in \mathbb{R}^{n \times m \times l}$ . This matrix is defined by the ratio of observed flow in passenger ( $\widehat{\mathbf{T}}$ ) to computed flow with Logit model ( $\widetilde{\mathbf{T}}$ ).

$$\Theta_{ij}^k = \frac{\widehat{\mathbf{T}}_{ij}^k}{\widetilde{\mathbf{T}}_{ij}^k} \quad \forall i, j, k \quad (8)$$

Each  $\Theta_{ij}^k$  measures in percentage the impact of these unknown factor on the flow  $(i, j, k)$ . Thus, the full expression of the two-level logit model, considering the perturbation matrix, is

$$\widetilde{\mathbf{T}}_{i,j}^k = \Theta_{ij}^k \cdot o_i^k \cdot \frac{e^{\alpha_w \widehat{\Pi}_j + \delta_w} \cdot e^{\alpha_\psi \widehat{\Omega}_k + \delta_\psi} \cdot e^{-\beta(\widehat{C}_{f_{ij}} + \widehat{C}_{t_j}^k)}}{\sum_k \sum_j [e^{\alpha_w \widehat{\Pi}_j + \delta_w} \cdot e^{\alpha_\psi \widehat{\Omega}_k + \delta_\psi} \cdot e^{-\beta(\widehat{C}_{f_{ij}} + \widehat{C}_{t_j}^k)}]} \quad (9)$$

### 3.2 Simulator

Given the two-level Logit model, we can compute the new passenger flows by introducing the changes (e.g. the opening of a new flight or a flight cost change). The model is able to deal with uncertainties due to passengers choices, while it only partially considers uncertainties due to the demand and the supply. To handle this, a modular simulator has been developed in order to perform a scenario-based simulation, which is integrated with the optimization block. The scenario-based simulation reduces the probability of error on the results and considers the changes in flows of passengers over time. The scenarios are created by random modifications, with chosen probability distributions, of the observed flows matrix  $\widehat{\mathbf{T}}$ .

The changes of flows are computed as the difference between the flows  $\widetilde{\mathbf{T}}$ , obtained after introducing the new flight schedules, and the observed flows  $\widehat{\mathbf{T}}$ . This gives the new catchment area of airports in terms of passengers, as well as a forecast of flows for each flight. Finally, a post optimization process checks the solution that maximizes the effects on the airport under analysis and chooses the parameters of the flight selected, i.e. flight frequency, airplane size, ticket cost.

Note that the model can evaluate more than one changes in the system at a time. In particular it is interesting that AirCAST allows to simulate reaction

policies of existing airports by assigning different values to their economical and structural features. More in detail, an airport could be chosen to reduce its prices in order to face the competition of the new flight or the price of the tourist accommodation of the surrounding area.

In order to calibrate the model and to simulate the changes due to the introduction of a new schedule we need to feed the model with the following input data: number of arrivals registered in tourist facilities, cost of the flight, cost of accommodation, cost for the rental car, presence of the direct flight and the accommodation costs. These information are the base needed to estimate the financial impact of the schedule changes.

In the following sections, we present how the different quantities can be deduced from public database and how the simulated results are analyzed.

## **4 Economic impact of Cagliari airport routes : the summer tourism market in Sardinia**

In Sardinia there are three airports: Alghero, located in the north-west of the island in the province of Sassari, Olbia Costa Smeralda, in the province of Olbia-Tempio, situated in the north-east, and Cagliari (CAG in the following), in the southern area. Cagliari is the most important airport in the island in terms of traffic and size. In fact, it operates about 50% of Sardinia air traffic and can serve up to 4 million passengers/year. In 2009, as well as in the recent past, the sustained growth trend in air traffic was matched by high quality standards. Thanks to consolidation of national and international direct links and the opening of 21 new routes, the CAG Airport has for the first time reached the 3 million passengers mark, 13% more than in the previous year.

The logic of airport development is based on the possibility to properly identify and profile its potential customers, which allow increasing sales volume and airport profitability with direct and indirect economic benefits for the area where the airport is located. In order to identify potential groups of users, it is essential to consider the characteristics and attractiveness of the area. These aspects may confer a particular specialization at the airport.

Airports in Sardinia, being the island an important destination for summer vacations for Italian and European tourists, have the majority of their air traffic concentrated during the summer and closely linked to tourism. To identify new potential routes to open, the starting point is the analysis of Sardinia airports data

to outline a general idea of the airport and situation of the region. Historical data [23, 24] show that, although Cagliari attracts more passengers than the other two airports in Sardinia, the distribution of flights is quite different. The only routes that are shared by all airports are from Austria, Belgium, France, Germany, Great Britain and Spain. These data are confirmed by the analysis of the current schedules and by an estimation of the loading factors of the airplanes given by the mean loading factors in the past three years [23, 24, 25]. On some routes, the offer of flights is small or even absent. In particular, Cagliari does not offer any direct flight with northern countries of Europe such as Sweden, Norway, Finland, and the Netherlands.

#### **4.1 Analysis of the tourists flows**

Due to the strong dependence between the presence of direct flights and the impact on tourism and aviation, we compare the airport data with the analysis of tourism in Sardinia. The analysis, carried by means of the data by ISTAT, shows that in 2009 more than 60% of tourists from Finland, Sweden, Denmark and Ireland stayed in the macro area of Alghero. Infact, Algher operates almost exclusively the connections to and from these countries [26, 27]. Besides, 27% of tourists from the Netherlands stay in Cagliari, even though it lacks an air link, while only 24% goes to Alghero, which handles 73% of connections Sardinia-Netherlands. Thus, it follows that the opening of new routes to the Northern countries of Europe and to the Netherlands could be a potential development for the airport of Cagliari. In addition, to prefer Cagliari as tourist destination are mostly people from Russia, Eastern Europe (even if they constitute a very small amount), Belgium and the United Kingdom. In particular, 68% of Russian tourists in Sardinia went to Cagliari in 2009. This percentage corresponds to more than 60 thousand Russians registered in the tourist infrastructures of the macro area of the capital.

The introduction of a route Cagliari-Russia represents a further and more interesting development for the airport of Cagliari. Providing this direct connection, Cagliari could reach a large pool of potential customers, distinguishing itself from the airports of Olbia and Alghero, which do not handle any connections with any of Russian airports. This new potential flight is not going to establish a competition in air traffic with the two other airports in Sardinia, but rather expands the scale of competition at airports in other regions (and therefore defined external competitors).

Examining the tourist data of Russia, Russian people choosing Italy as their holiday destination are concentrated especially in Emilia-Romagna, with 118,850

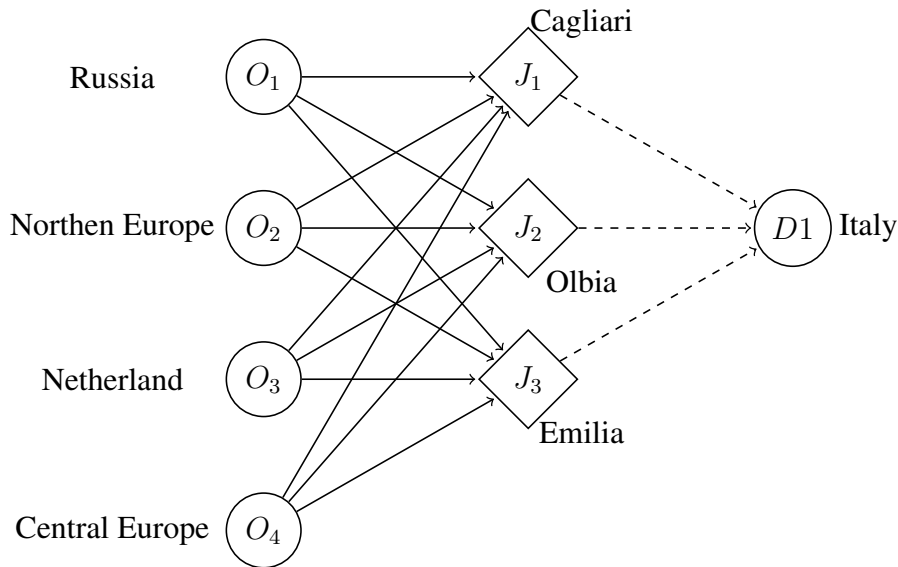


Figure 3: Representation of the system model used in this study.

arrivals 2009 [26], 75% is related to the province of Rimini. The airport of Rimini has in fact many direct links with Russia. For this reason, the new connection makes Rimini the first competitor of CAG Airport, and from that emerge the necessity of adding Rimini as an arrival airports in the model.

## 4.2 Input data and their economic aspects

The aim of this case study is to predict the effect of the opening of one or more new routes on the flow of passengers from chosen origins to CAG Airport and to measure the economic impact on the closest area. The simulations performed on CAG Airport aim to establish the route, the type of airline (regular or low cost airline) and the season (high or low) that allows attracting the highest number of tourists. Basing on all considerations explained before, we choose Russia, Northern Europe, Netherland and Central Europe as origins in the model, while the cluster of arrival airports and macro-areas for the tourist holidays has been identified in Cagliari, Olbia and Rimini. The tourist flow to the Alghero area is not comparable with the others and was not included in the simulation.

The only macro destination is Italy. In this case, Italy is a fictitious destination, necessary in order to allow exchanging of passengers between the three airports (top-level nodes). In this way the model reallocate flows from one airport to an-

other, estimating how many tourists CAG could gain by taking them off at Rimini and Olbia.

The cost of accommodation has been estimated by combining the average price of hotels in the concerned area and the average number of overnight stays of tourists. The average price of hotels was determined with telephone and online surveys of the room price to the several hotels during both high and low season. Instead, the ISTAT tourist analysis shows that a holiday in Sardinia usually lasts seven nights, while in Rimini, in medium, four nights.

The choice criteria considered by model (4)-(7) are one for the airport facilities and efficiency and one for the socio-economic situation of the tourist region around each airport. The airport criterion depends on the presence or absence of direct flights between the airport and the origins and on a measure of customer satisfaction of the destination. More in detail, the satisfaction of customers is related to the ground transportation from the arrival airport, the services offered to tourists and the cost of subsistence obtained by averaging the prices of hotels. These data have been collected by BDS Consulting s.r.l., an Italian company specialized in consultancy in airport management.

In order to identify potential overlapping of the catchment areas of the different airports, we mapped the results of a projection of the tourist data identifying which locations are most easily reached from the airports. This analysis confirmed that, from the tourist point of view, the catchment areas are poorly overlapping. Thus, the tourist destinations, represented by the set of possible destination points, are collapsed in a macro destination representing Sardinia and the eventual other tourist areas considered in this study, e.g. Rimini area (See Figure 3).

The economic impact on the territory has been estimated considering at first all the expenses which are supposed to be common to every tourist. To determinate the cost of the accommodation for each location, computed an average cost of a typical holiday. The cost of accommodation was estimated with a telephone and online survey to the several hotels to check the price during the high and the low season.

By [26, 27], the typical holiday has the following characteristics:

- People who go on holiday: 2 adults;
- Accommodation type: Hotel;
- Hotel stars: three stars or four stars hotel;
- Guest Rooms: double standard room, breakfast and dinner included;

- Duration: 7 nights (one week);
- Period: a week in July and August, high season.

Comparing the estimated costs related to the accommodation with same conditions, in Rimini tourist facilities are cheaper than in Sardinia. This advantage is also taken into account in the input data indicating the tourist attractiveness. In addition, the cost of accommodation is increased by the cost of car rental services. In fact, the peculiar geography of Sardinia makes necessary for tourists to rent a car to move from one location to another one in the island. This cost contributes to value the revenues on the Sardinia territory from direct effects of the opening of new route. On the contrary, the economic impact measured by the model does not consider the impulsive purchases like souvenirs or gadgets.

### 4.3 Analysis of the results

According to the results presented in Sections 4.1 and 4.2, we focus our what-if analysis on the opening of a direct route between Russia and CAG airport. Currently, the connection with Russia requires at least one stop at Rome Fiumicino airport. In more detail, we test the following scenarios:

- CAG Airport opens a direct flight to Russia in the high season (July and August represent the period of strongest competition between Cagliari and Rimini) and in the low season (June, September, and October represent the period during which Sardinia continues to be attractive thanks to its favorable climate, while Rimini significantly decreases its attractiveness). Moreover, we measure of the reaction of Olbia Airport, which opens a direct flight to Russia.
- We make a sensitivity analysis of the system in order to estimate the changes of the potential demand. In more detail, we consider two types of demand : *High price* (HP) and *Medium Price* (MP). Moreover, we focus on the relationship between the demand elasticity and the most important driver of the system, i.e. the total cost of the tourist stay. This approach gives us the chance to model different behaviors for different market segments.

To simulate the first set of scenarios, a reduction of the cost of the ticket is considered. The flows due to the opening of the direct Cagliari-Russia flight are shown in Table 1.



Table 1: New Russia-CAG flight in high season, reaction of Olbia and low season scenario. The table reports the observed flow ( $T$ ), the flow after the opening of the direct flight Cagliari-Russia ( $T_D$ ) and its variation ( $\Delta T_D$ ) in the three scenarios

		<b>Cagliari</b>	<b>Olbia</b>	<b>Rimini</b>
<b>T</b>		6908	4534	74705
High season	<b><math>T_D</math></b>	13125	4216	68728
	<b><math>\Delta T_D</math></b>	+90%	-7%	-8%
Reaction of Olbia	<b><math>T_D</math></b>	12158	10156	63499
	<b><math>\Delta T_D</math></b>	+76%	+124%	-15%
Low season	<b><math>T_D</math></b>	22451	3627	59764
	<b><math>\Delta T_D</math></b>	+225%	-20%	-20%

The increase of Russian tourists in the Cagliari area is estimated to be about 90% in the high season. From an economic point of view, revenues on the territory from direct effects can be valued at about 12 million euros. Rimini airport, despite being the competitor that has contributed most to the flow of the new avionics offer, cannot respond to reductions of tourists as it already offers a direct flight from Russia.

Let us now assume that the new route between Russia and Cagliari has become a reality and Olbia opens a direct flight from Russia to address the cascading effects of the new offer of CAG Airport. This reaction would lead to competition within the island itself. Conversely, the simulation results shows an increase of tourists in the Olbia area of 124% and a negligible variation in the close area of Cagliari. Consequently, the two flights can coexist.

The last simulation consists in opening a direct route between Russia and Cagliari in the low season which involves, in addition to the reduction of the ticket cost, a decrease of the cost of subsistence in the territory. In fact, in this period hotels offer some discounts on their prices. The choice of this period also fits with the habits of Russian tourists in terms of holiday period. The resulting flow shows an increase of Russian tourists by 225% which, from a financial point of view, corresponds to an income of about 20 million euros.

In the second part of this result analysis, we analyze the sensitivity of flows between levels of the MP and HP demands. In particular, we discuss the proportion 80% MP and 20% HP, that corresponds to the actual proportion of the Russian demand levels in the summer market. Also the pure MP and pure HP scenarios were

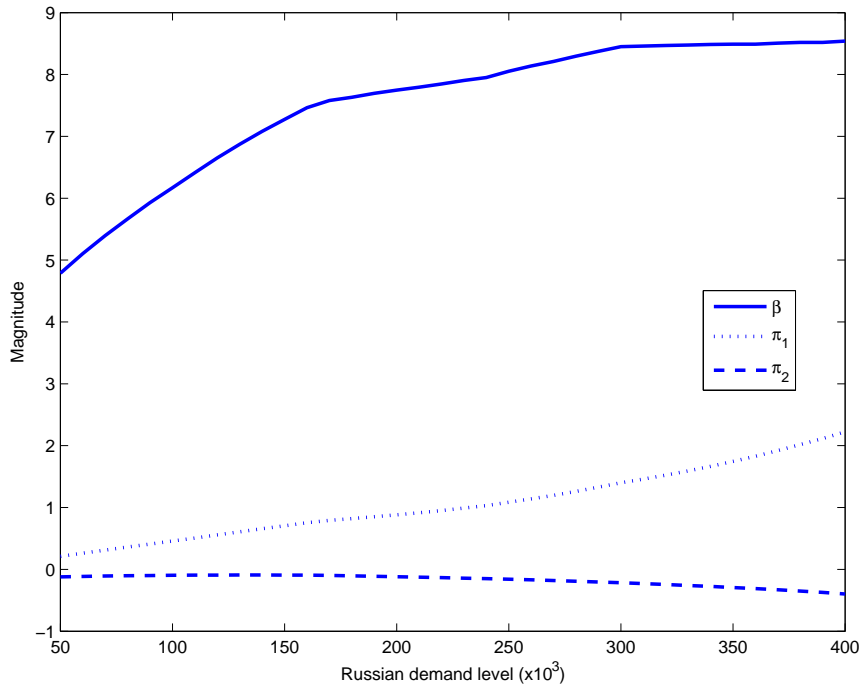


Figure 4: Value of the weights of choice criteria in the summer tourism market when the potential demand varies

considered in this analysis, but both gave poor results. In the sensitivity analysis, the Russian demand levels are drawn from the range [50.000, 400.000].

The summer tourism market shows a high sensibility to the cost of stay plus travel and, for a large value of the Russian demand, to airport efficiency. Both these parameters increase according to the demand level, but  $\beta$  tends to become constant when the demand reaches 300.000 units. In particular, this demand value corresponds to the ISTAT estimations for the number of Russians in the Italian seaside areas.

Conversely, the attractiveness factor shows a negative trend. This is due to the increase of the demand level and to the difficulty of satisfying the needs of the new catchment area. Moreover, the resulting substitution of HP tourism with MP tourist brings to a negative net return and to the increase of the cost driver.

Figure 5 shows changes of the flows according to levels of demand. Each figure represents a different total cost level ( $C_{tot}$ ) of stay and travel in the Cagliari area. More in detail, we consider 4 scenarios : the current weekly price in high

season (2400 Euros), the introduction of a direct Cagliari-Russia flight (2100 Euros), the weekly cost in low season with a direct flight (1900 Euros) and the limit scenario (1700 Euros) in which the weekly costs in Sardinia equal those in Emilia Romagna (Rimini). The last scenario is not realistic, but corresponds to the upper bound of the tourists flows yield by means of the Russia flight.

The four cases show different but consistent results. Cagliari considerably increases the flow of tourists and also has the ability to attract new clients in the HP segment. This flow component saturates at a level of demand of about 300.000, where the curve starts to decrease. This means that the system is sensitive to the attractiveness driver of the destinations.

Considering the limit scenario ( $C_{tot} = 1700$ ), the flow has the biggest variations and increases until a level of about 200.000, where flows reach saturation. The case with  $C_{tot} = 2100$ , that describes a more realistic scenario for the CAG Airport is more interesting. Here the numbers are one order of magnitude smaller and the Russian flow to the Cagliari area increases to a level of about 40.000.

The results of this scenario show a potential increase Russian tourists in Cagliari of about 3 times the present level, and a decrease of about 16% in the Rimini area. The simulation results are not intended to be an exact measure, but rather they reveal an area for further investigation. Furthermore, no constraints on the tourist capacity of destinations are considered.

Again we should take into account other costs such as advertising and promotion that would be necessary to sustain the new flow. For the new Cagliari-Moscow route to become sustainable a financial return for both the local agencies and the air company is required.

Finally in peak season, at least in the short term, there is no extra space for new tourists. This implies that the Russian flow will substitute other flows. This may not seem an advantage, but it should be taken into account that Russian tourists have a propensity to high spending.

In monetary terms, the estimated revenues are about 40 million Euros, not taking into account other extra expenditures, such as restaurants, museums, etc. The resulting estimated flow of tourists from Russia to the Cagliari area is of 25.000 arrivals per year. A direct daily flight is not sustainable with this flow. A seasonal/charter flight could suit both tourists needs and have an adequate load factor.

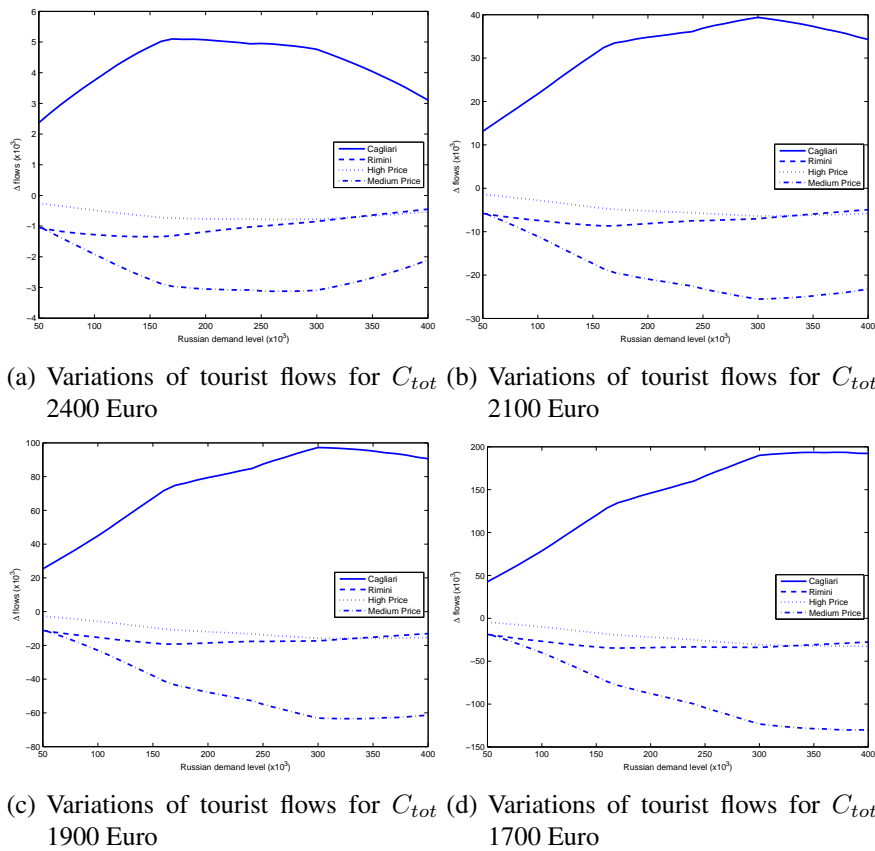


Figure 5: Flows for Cagliari and Rimini when MP and HP are in proportion of 80/20 demand levels for different total cost levels

## 5 Economic impact of Torino Caselle airport routes : the summer tourism market in Piedmont

In this section, we apply the same methodology used for the Sardinia case to a completely different market: the winter tourism. The winter tourism in Italy involves the 11.6% of foreign tourists. There are over 25.000 accommodation facilities for a total capacity that exceeds 615.000 tourists. The regions of Northern Italy cover most of this tourism.

Considering the strong homogeneity of mountain ski locations of Northern Italy and their geographical proximity, we have analyzed about 150 locations of 12 provinces. Figure 6 shows a map divided by provinces, where both locations

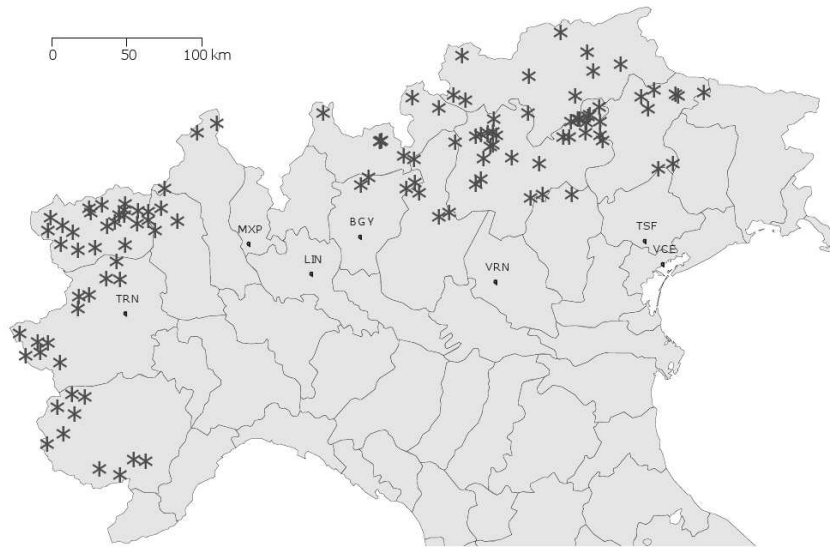


Figure 6: Mountain locations of ski resorts and airports in northern Italy

(asterisks) and airports (square) are represented. However, as the result of a first study on the relevance of foreign tourist flows, six provinces are considered in this analysis: Aosta, Torino, Sondrio, Belluno, Trento and Bolzano.

The number of tourists in the provinces is affected by a number of factors. In particular, the strongest is the number of ski resorts in each province. Trento and Bolzano have the highest number of ski resorts (about 40 each), followed by Aosta and Sondrio (about 25 each), Belluno (about 15), and finally Turin (about 10). This also gives us a measure of overall length of ski runs and number of hotels. We should also mention that the provinces of Trento, Bolzano and Belluno have made great efforts over time to promote the Dolomiti as a brand.

The provinces mentioned above have gained the reputation of pricey and charming. Aosta and Sondrio are well known in the Italian panorama and have good reputation for ski resorts, thus not as charming as the others. Turin had some boost from the 2006 Olympic games, but still does not promote enough its ski resorts. However, it is interesting to note that the prices of stay are similar in the various provinces.

Considering these provinces, we selected all major airports in Northern Italy and all the direct links. The airports in question are: Turin, Milan Linate, Milan Malpensa, Bergamo Orio al Serio, Verona, Venice and Treviso. Note that the list lacks some airports in Northern Italy as Cuneo, Genova or Bolzano and does not

considered foreign nearby airports. These airports are not included in the study because they show a minimal tourist traffic to Italian mountain provinces.

The airports cited above generate an overall traffic of around 55 million passengers and are connected with approximately 150 destinations around the world.

## 5.1 Analysis of the tourists flows

Recalling that only tourists that use air transport are considered, in the winter tourism case, more than 80% of the foreign tourist flow is given from European countries. UK tourists account for almost 20% of our total. In the dataset Poland, Belgium, Swedish and USA present always a strong flow in the winter period. The last one is particularly important in the surrounding area of Turin. Finally, Russian tourists is evenly spread (in absolute means) across all the provinces except Turin. Figure (7) summarizes the main flows in the Northern Italy [26, 27].

A good preliminary analysis of tourist flows must take into account both relative and absolute numbers. In facts, provinces have very different overall flows: Turin is the smallest and has about 30.000 foreign tourists per year, while Trento and Bolzano are the biggest with about 400.000 foreign tourists per year.

Focusing on the province of Turin, it easy to note the unexpected different composition of the tourist flow. On one hand Turin has a much lower percentage of Russian, Polish and Swedish tourists (all about 2%). Polish tourist in the specific account for less than 2% in the Turin and Aosta area, while are more than 10% in average. The numbers for these tourist are very low (close to zero in some cases) so we should consider these groups are almost completely new potential tourists flows. On the other hand Turin has a high percentage of UK, and USA tourists (respectively 25% and 8%), with respect to an average of 15% and 5%. Although the percentage looks high, the absolute numbers are significantly lower than in other provinces, thus looking as if an increase of this flow is possible. Between the two, USA looks even more interesting given the absence of a direct flight.

## 5.2 Input data and their economic aspects

The link airport-province is done looking at ski stations web sites, where information about local airports can be found. One airport can serve more than one province and one province can be served by several airports as well. This implies the same airport could be in different clusters.

The Turin airport serves both the provinces of Turin and Aosta. The province of Sondrio has three airports in its cluster: Milan Malpensa, Milan Linate and

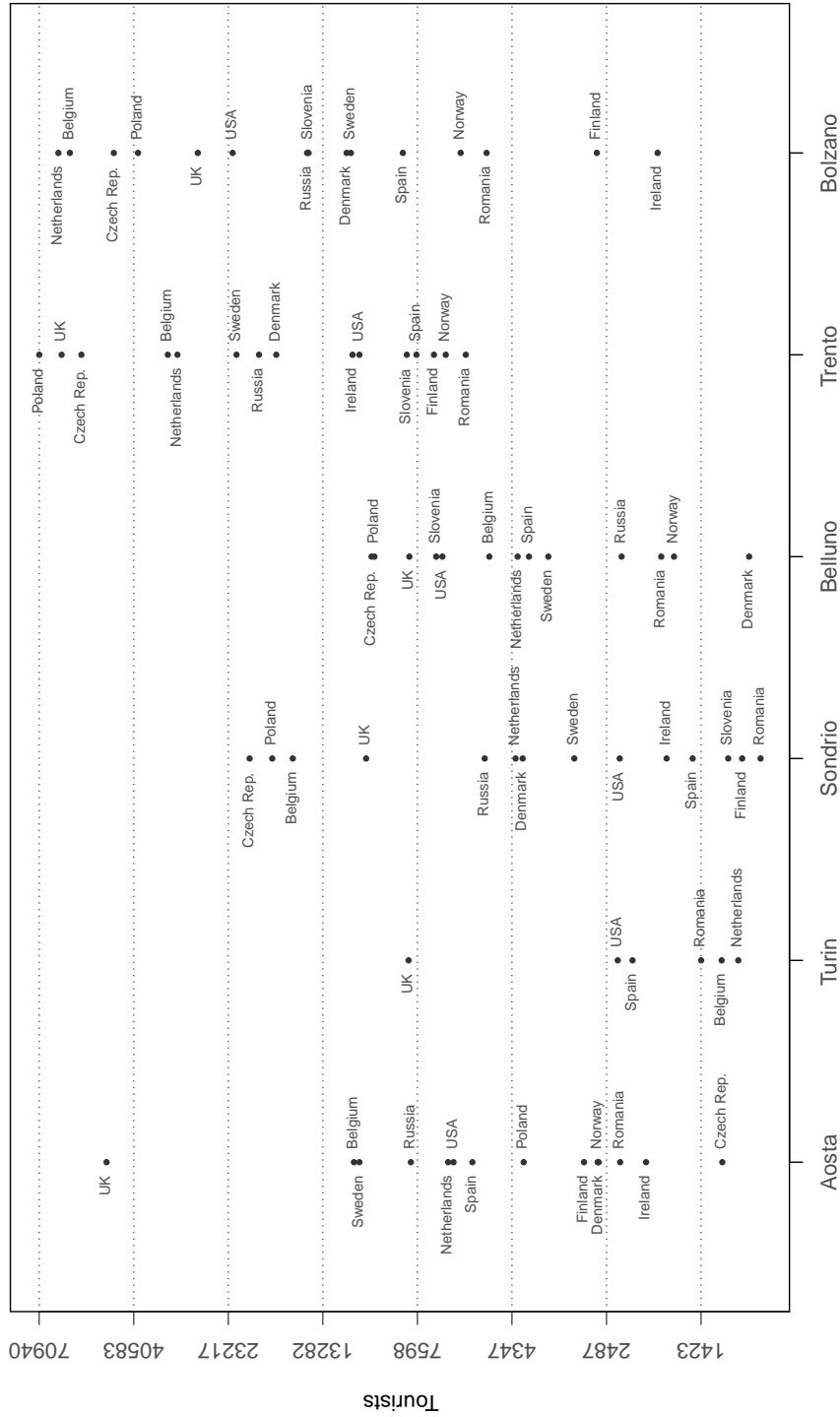


Figure 7: Main touristic flows in the Italian winter market

Bergamo Orio al Serio. Trento and Bolzano are both served by the Verona airport, and finally the Belluno province is served by the Venice and Treviso airports.

In order to identify what groups of tourists to study, we need to discard all the meaningless groups, in terms of numbers (i.e., too few to be economically significant) and in terms of distance. For instance German tourists are discarded because they would rather choose the car rather than plane and therefore choose Bolzano or Trento as their destination. Keep in mind our analysis is targeted on flight transportation.

For these reasons the analysis is limited to a small group of origins: Belgium, Russia, Poland, Sweden, UK, and USA. The remaining groups are condensed in a group named World. Similarly to the Cagliari study, the touristic destinations are collapsed in a macro destination representing the North of Italy (see Figure 8).

The choice criteria considered in the simulations are one related to the social-economic situation of the mountain provinces and one for the airports accessibility. The accessibility concerns distances of airport from the surrounding locations. The economic criterion is the measure of the customer satisfaction of the destination. It depends on the number of hotels, the presence of prestigious shops, the kilometers of ski slopes and the total number of tourists (including national tourism). The airport criterion takes into account the distance between airports and mountain locations of the covered provinces, the cost of any tolls, the number of provinces that are served by the airports and the size of these airports (i.e. the total number of flights).

The financial impact on the territory has been estimated considering the cost of the flight plus the accommodation and extra costs (i.e. weekly ski pass), not present in the summer market. To determine the cost for each location, we consider a typical holiday.

By [26], the typical holiday has the following characteristics :

- People who go on holiday: 2 adults;
- Accommodation type: Hotel;
- Hotel stars: three stars or four stars hotel;
- Guest Rooms: double standard room, breakfast and dinner included;
- Duration: 7 nights (one week)
- Period: a week in December, January and February, high season.



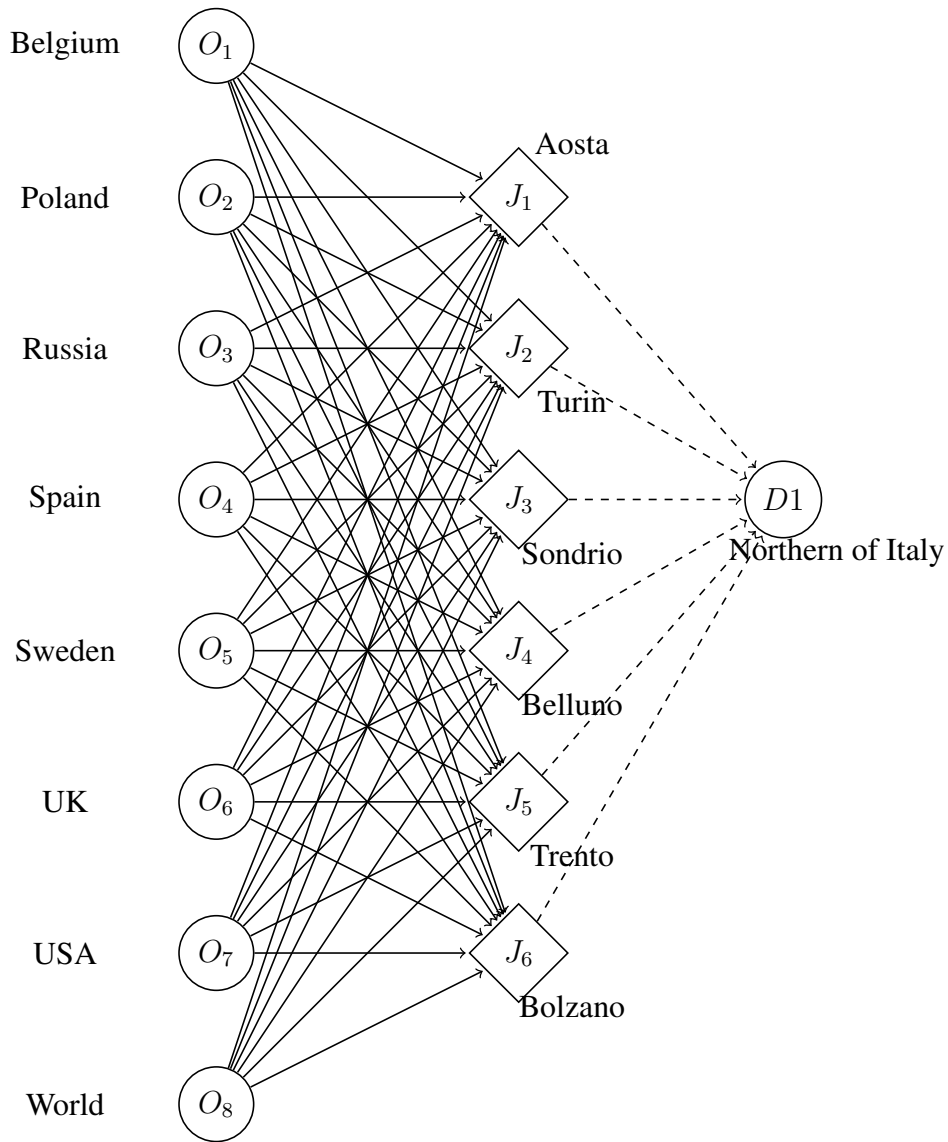


Figure 8: Representation of the system used to study the winter tourism market.

### 5.3 Analysis of the results

According to the deduced results, we considered six provinces served by seven airports for the winter tourism market in the North of Italy. We focus the analysis on two main aspects :

- The drivers of the Logit model in the winter market system. Recalling the choice criteria defined in Section 3.1, we denote with  $\pi_1$  the airport driver, with  $\pi_2$  the socio-economic attractiveness of the provinces and, finally, with  $\beta$  the cost driver of the winter holiday;
- The sensitivity of the system to the elasticity of the demand. More in detail, we consider a *Weakly Loyal* demand (WLD) in order to estimate the potential flows due to the introduction of changes in the system (i.e. new direct flight).

Figure 9 shows the importance of the driver of the winter market system when WLD is drawn from the range [10.000, 800.000]. Differently from what we observed in the summer tourism market, the cost factor is negligible due to the similarity of the price in the various provinces of the system. Conversely, the attractiveness of the destination ( $\pi_2$ ) becomes the main driver of touristic flows, followed by the accessibility of the airport ( $\pi_1$ ). Note that the decrease of the attractiveness factor due to the high WLD level cause the saturation of all drivers of the model.

Two important considerations arise : (1) the price elasticity of demand with respect to flight and stay costs is lower than in the summer tourism market and (2) customers in this market are more loyal and more work needs to be done to move tourist flows between destinations (i.e. expansion of the ski sloped and services for tourists).

Furthermore, several facts support this analysis:

- Extra costs (i.e., other than flight and stay) are much higher in the winter market. Take for instance the ski-pass and equipment rental costs, that could account for more than the whole stay plus flight costs.
- The type of tourists in this market is different than in the summer market. Usually just families with medium-high income spend winter holidays skiing, whether in the summer market the target is more heterogeneous.

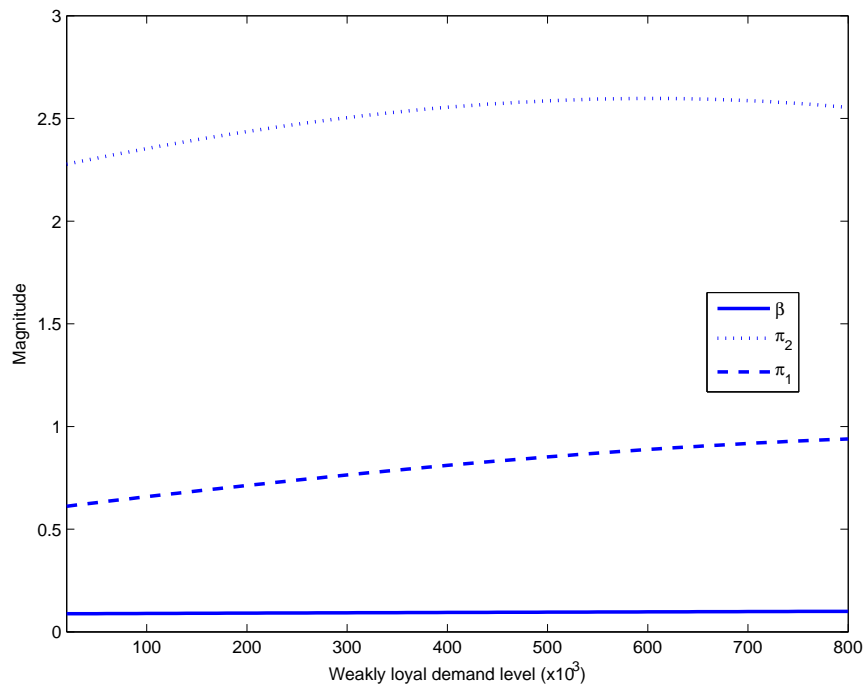


Figure 9: Magnitude of model parameters in the winter tourism market

- Finally tour operators are big players in this market. As stated before they package the entire holiday and also tend to make strong agreements with destinations.

All this points lead to a market that naturally has more barriers than the summer market. High extra costs, loyal customers and tour operators are obstacles if one wants to increase it's tourist flow.

From preliminary studies, we observed that the origin that only was worth to further investigate was USA. The changes we introduce during simulation are the increase of attractiveness for the Turin province and a direct flight on Turin Caselle as well. This implies a direct flight is also available for the Aosta province, since it is part of the catchment are of Caselle airport. It is also plausible to think to a reduction in flight ticket.

Summarizing, we consider four scenarios : ( $S_1$ ) a minor expansion of Turin province, ( $S_2$ ) a minor expansion of Turin province and the introduction of direct USA-Turin connection, ( $S_3$ ) a major expansion of Turin province, ( $S_4$ ) a major expansion of Turin province and the introduction of direct USA-Turin connection. Last two scenarios are not realistic because involves a huge investment for renewing the main mountain resorts in the Turin's area and the expansion of ski facilities.

The simulated results are shown in the Table 2. The increase of the US tourists in the Turin province is estimated to be about 2 times the actual flow and 3 times when the direct flight is introduced. From an economic point of view, revenues on the territory from direct effect can be valued to about 9 million euros. The reductions of tourists in the other destinations are negligible and, difficultly, a reaction of competitors will be performed.

Finally, scenarios  $S_3$  and  $S_4$  show a very promising results : the number of tourists from USA becomes about 4 and 7 times the actual presences.

More in detail, a tourist coming from USA does not perceive as very different going to ski in different locations in north Italy, while it does make a big difference for other tourists under study. Tour operators also have a major role. It is in fact very common to buy a package for winter holidays in Europe. This is especially true for European tourists. What the tour operator does is package the whole holiday, including flight, stay, ski pass, and equipment rental.

However there are very fewer tour operators that sell packaged winter holidays for such a long distance. This means that a tourist coming from USA will normally schedule his own trip, and this makes him more responsive to price changes and direct flight. We should also mention that tourist from USA are not

Table 2: US flows after the changes on Turin Caselle and province. The table reports the observed flow ( $T$ ), the estimated flow in the scenarios ( $T_D$ ) and its variation ( $\Delta T_D$ )

		<b>Aosta</b>	<b>Torino</b>	<b>Sodrio</b>	<b>Belluno</b>	<b>Trento</b>	<b>Bolzano</b>
	<b>T</b>	6140	2327	2300	6556	10704	22629
$S_1$	$T_D$	5761	5307	2158	6152	10044	21234
	$\Delta T_D$	-6%	+128%	-6%	-6%	-6%	-6%
$S_2$	$T_D$	5568	6826	2086	5946	9707	20522
	$\Delta T_D$	-9%	+193%	-9%	-9%	-9%	-9%
$S_3$	$T_D$	5011	11217	1877	5350	8735	18467
	$\Delta T_D$	-18%	+382%	-18%	-18%	-18%	-18%
$S_4$	$T_D$	4333	16550	1623	4627	7554	15969
	$\Delta T_D$	-29%	+611%	-29%	-29%	-29%	-29%

usually accustomed clients, and this also makes them less loyal customers.

From these considerations, the sensitivity analysis is performed varying the WLD from USA for the four scenarios specified above. Figure 10 reports the more significant flow changes of the system. Simulations show a potential flow increase if Turin decided to target tourists from USA. As stated before these customers are less loyal and can be easily attracted. They also have a high sensibility to a direct flight.

For obvious reasons a direct flight from Turin to USA cannot be hypothesized just on tourism analysis. Business men and many other targets (including inverse tourism) should be taken into account to prove the profitability of this route.

## 6 Conclusions

The present study provides a systematic methodology, based on the AirCAST simulator, to assess the financial impact of a air transportation system. The proposed approach offers a road-map specifically devoted to identifying the key enabling factors of the tourist markets.

The potential of our methodology has been verified on two real tests on Italian airports, one on airport of Cagliari and one on the airport of Torino. The framework shows the capability to forecast new flows and the financial impacts due to

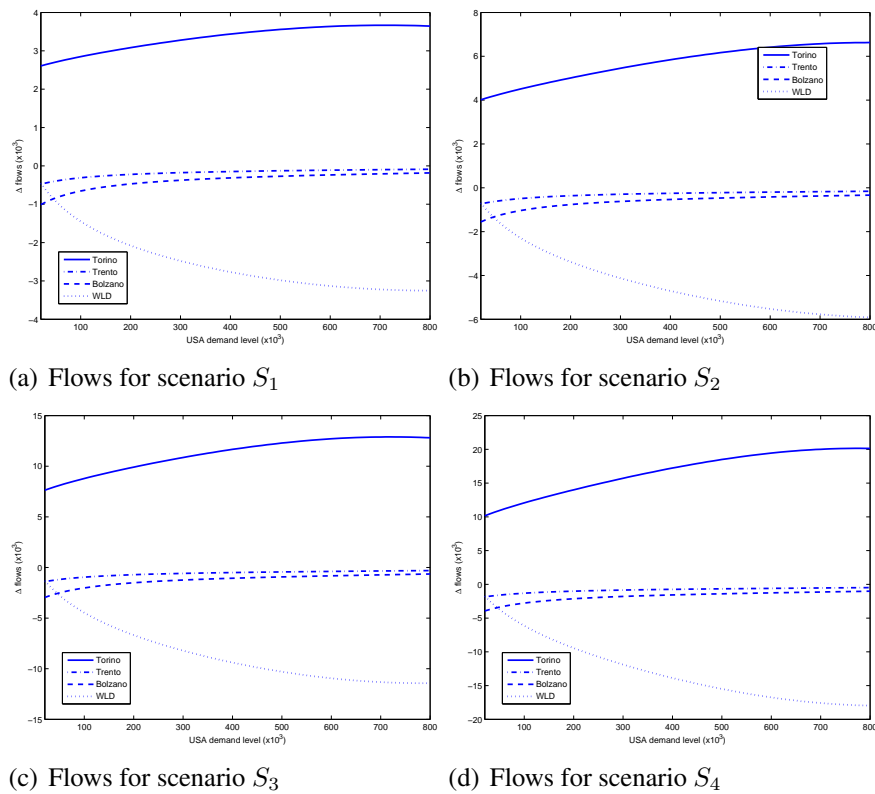


Figure 10: Flows in winter market with the variation of demand level from USA

the opening or the changing of the flight connections.

From a socio-economic point of view, the comparison between the summer and winter tourism market shows different behavior of customers and demand elasticity. The summer tourism market has a much higher price elasticity. Therefore, we should expect higher price competition in the summer market rather than in the winter market. However, it is difficult to isolate this effect from all the others. In fact, multiple factors interact in the system such as the attraction index, the direct flight and others that may have not been highlighted by the model. Indeed, the winter market is characterized by a strong loyalty of customer. In particular, the key lever of this market is the attractiveness of destinations.

Focusing on the air transportation field, we can clearly see that direct flights always have a strong weight in the choice. With the Cagliari case, where the model has been validated by the Cagliari airport, we have shown the power and effectiveness of simulation and modeling tools here used.

Further investigations and analysis could be done in various directions starting from this paper. First of all the integration in a System Dynamic framework aiming to assess the diffusion of the decisions taken with the proposed framework. The perspectives of airports, users and stakeholders could be considered and their enabling factors investigated.

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