Access mode choice to Low-Cost Airports: Evaluation of new direct rail services at Milan-Bergamo Airport

Abstract

The purpose of this study is to investigate air passengers' choice of the access mode at low-cost airports, with the aim of supporting policy makers in evaluating improvements to the current ground access transport system. We assess the impact of the introduction of a new direct rail service on the airport's accessibility by passengers, relying on revealed preference data collected at the Milan-Bergamo airport in the period 2013-2016. We first implement a mixed logit model to examine the behavior of outgoing passengers and evaluate their sensitivity to various access time components and cost incurred. Second, based on the estimated coefficients, the introduction of direct rail services from/to Milan is assessed by means of a sensitivity analysis. Results show that low-cost airports should be aware of customers' priorities and not simply aim to deliver the solution with the lowest possible cost. The estimated value of time measures—equal to €40/h, €24/h, and €19/h for traffic, out-of-vehicle travel time, and in-vehicle travel time, respectively—reveal that low-cost airline passengers are not exclusively *cost-driven* when confronted with the access mode choice but do place considerable value on access time savings. This finding is corroborated by the assessment of different rail services, showing how the introduction of an airport express train has the potential to increase train usage much more (+7%) than the extension of the existing regional commuter service (+1%).

Keywords: Value of Time, Mixed Logit, Low-Cost Airports, Airport Accessibility

1. Introduction

In recent years, airport surface accessibility has been growing in importance, not only at major airports, but also at secondary ones. Airport accessibility is widely recognized as being both an enabling and boosting factor for airport development. Given the fast-growing air passenger market and increase in competition, ensuring proper airport access facilities is key not only to sustaining airport growth, but also gaining a competitive advantage over neighboring airports. According to Belobaba (2009), ground access and egress transportation are integral parts of a passenger's overall air trip. As such, good access systems have the potential to positively contribute to the passenger experience, whereas poor ground transportation negatively affects an airport's ability to provide quality service and attract air traffic.

As pointed out in the Transport Committee's surface transport to airports report (2016)[1], the strategic planning of surface access to airports is a major priority for governments as it addresses the twofold objective of accommodating aviation growth while minimizing the related environmental impact. The increase in the number of road trips from and to airports generates negative externalities, such as road congestion and greater pollution from vehicle emissions, which need to be mitigated. The main response of governments to this issue has been the introduction of policies aimed at encouraging modal shift from private to public transportation. In this respect, an interesting example is the Italian National Airport Plan (2017), which set the improvement of rail connections at strategic airports[2] as a primary intervention to achieve sustainable growth.

This study focuses on surface accessibility at low-cost airports, namely main low-cost bases resulting from the reconversion of secondary airports[3]. The impressive growth of the low-cost carrier (LCC) business model, involving the use of secondary airports connected through a point-to-point network as opposed to traditional hub-and-spoke systems, has afforded suburban airports with a great opportunity to grow their volumes and business (Francis, Humphreys and Ison, 2004), while at the same time posing a challenge for the airport infrastructure to keep pace with the growth, both at the airside and landside level. In most cases, secondary airports were not initially designed to handle thousands of passengers per day; as a consequence, the rapid increase in traffic volumes has led to considerable pressure not only on the airport facilities, but also on the urban transport system surrounding them. London-Stansted, London-Luton, and Milan-Bergamo are well-known examples of secondary airports, whose growing difficulty in meeting passenger demand has led to the design of direct air-rail links. The exceptional growth record is not the only reason why ground access at LCAs deserves particular attention. Another aspect that is worth examining is whether low-cost airline passengers' higher sensitivity to airfares translates into different preferences about their choice of the

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[1] Transport Committee's surface transport to airports report (2016) [*https://publications.parliament.uk*]

[2] The Italian National Airport Plan (2017) [http://www.mit.gov.it] identifies 16 strategic airports, which also belong to the TEN-T core network.

[3] A secondary airport can be defined as an under-utilized and reliever airport that complements the main or primary airport of a city (Rohafiz, 2009). Hereafter, Low-cost airports (LCAs) are referred to as low-cost bases resulting from the reconversion of secondary airports, whereas low-cost carrier terminals (LCCTs) are specialized facilities constructed by major airports in an effort to accommodate growing traffic from LCCs (Hanaoka and Saraswati, 2011).

transport mode to the airport. Factors such as their higher willingness to travel on public transport, as well as the lower value they put on their time, may indeed stress the importance for policy makers to develop surface access strategies that best fit their customers' needs.

In the last few decades, several academics in the field of air transportation have investigated the topic of mode choice behaviors from different perspectives (e.g., Pels, Nijkamp and Rietveld, 2003; Gupta, Vovsha and Donnelly, 2008; Tam, Lam and Lo, 2011), with most them focusing on large airports. While there is evidence in the literature of the so-called airlines' hybridization process (Klophaus, Conrady and Fichert, 2012; Morandi *et al.*, 2015), with passengers choosing the LCCs and full-service carriers becoming more and more like each other, the understanding of these passengers' preferences and behaviors with respect to the access mode choice has remained an unexplored topic. Indeed, preferences of these two categories of passengers with respect to air travel attributes do not automatically reflect those associated with access mode choice.

The purpose of this study is to investigate air passengers' access mode choice to low-cost airports by means of econometric modelling and provide a framework to assist policy makers in evaluating modifications to the current ground access transport system. We investigate the accessibility at one of the fastest growing airports in Europe—the Milan-Bergamo airport (BGY). This airport has been taken as a reference case because it fits with Hanaoka and Saraswati's (2011) definition of LCAs. First, it is a secondary airport serving the Milan area and it is almost entirely dominated by LCCs, which accounted for 96.7% of overall scheduled capacity in 2017. Second, it is currently facing growing surface access-related issues to keep up with the steady growth in passenger volumes. Indeed, the BGY's development plan has recently included the construction of a railway link between the main terminal and Bergamo station aimed at boosting accessibility from Milan while limiting the environmental burden.

We adopt a mixed logit model, where outgoing passengers are split into business and non-business categories, and focus on assessing their sensitivity to various access time components and cost. The introduction of direct railway services is then assessed by means of a sensitivity analysis. Data used for model calibration come from a revealed preference (RP) survey conducted at the BGY in the period 2013-2016. Although the assessment of a new transport mode might be supported by stated preference methods, this study attempts to develop a framework to analyze passengers' modal switching based on common profiling of customer data.

The remainder of this paper is organized as follows. Section 2 gives an overview of earlier studies on airport access mode choice. Section 3 describes the Milan-Bergamo accessibility system and the direct rail service alternative. Section 4 presents the data used for model estimation. Section 5 discusses the main methodological aspects, whereas Section 6 goes into the details of model development issues. Section 7 reports the results of the statistical analyses. Section 8 sums up the main findings and identifies possible future developments.

2. Literature Review: Ground Access Mode Choice Modelling

With the fast growth of air travel demand, modelling accessibility to airports has grown in importance amongst practitioners as a powerful tool to improve airport landside planning. Ground accessibility has also been largely investigated through the lens of airport competition. In particular, many contributions to the literature proved that ground accessibility is one of the key determinants of air travelers' airport choice (Skinner, 1976; Windle and Dresner, 1995; Pels, Nijkamp and Rietveld, 2003; Hess and Polak, 2005; Gupta, Vovsha and Donnelly, 2008); therefore, it can be leveraged to improve an airport's attractiveness over rival airports. Besides integrated airport-mode choice models, many contributions have focused exclusively on the ground access dimension. Although this approach may allow for a greater focus on the choice of the transport mode to the airport, it has the downside of overlooking important factors of airport and airline competition. Stand-alone access mode choice models have served a variety of purposes, ranging from the prediction of modal splits for relocated airports based on current modal shares (Psaraki and Abacoumkin, 2002) to the assessment of the introduction of a new mode (Jou, Hensher and Hsu, 2011). They have also been used to develop a better understanding of consumers' preferences, so as to support airport management companies in devising more effective and sustainable ground access strategies (Tam, Lam and Lo, 2011; Akar, 2013).

For mirroring as closely as possible the behavior of air travelers in their choice of access mode, practitioners over time have employed different methodologies and explored the effect of a variety of factors. An important role in modeling airport ground access is played by market segmentation. In one of the most relevant studies on airport choice, Harvey (1986) adopted a two-way segmentation into business and non-business travelers of the residents in the San Francisco Bay Area. The study revealed that business travelers are more sensitive to access time than non-business ones. The value of time for the business and non-business travelers are 41.4/h and $19.8/h, respectively. Business travelers are also more likely to use their own car to drive to the airport and park it there. These findings have been corroborated by subsequent research and can be explained by the fact that the travel expenses of business passengers are generally reimbursed by their company. In addition to the trip purpose segmentation, most studies considered a further distinction into residents and visitors (Psaraki and Abacoumkin, 2002; Gupta, Vovsha and Donnelly, 2008). The rationale behind such segmentation is clear: although residents are more likely to have their own car, or to know someone who can take them to the airport, visitors would rather rent a car or take a taxi to meet their transportation needs.

Air travelers' access mode choice has been modeled mainly as a function of a variety of individual characteristics and alternative-specific attributes. Gender, age, car ownership, and income are among the most common individual parameters taken into consideration. In addition, some researchers found other variables to be significant in understanding airport accessibility, including the number of pieces of luggage and the size of the travel party (Gupta, Vovsha and Donnelly, 2008; Akar, 2013).

Regarding alternative-specific attributes, access cost and time are the two most significant parameters that negatively affect access mode choice. Although all existing studies include some measures of travel time and cost, they differ widely in the way such attributes are entered into the model and the extent to which travel time is broken down into its components. Harvey (1988) separated travel time into in-vehicle travel time (IVTT), waiting time and walk distance, whereas other approaches involved combining of walking and transfer time into out-of-vehicle travel time (OVTT) (Jou, Hensher and Hsu, 2011). The estimation of separate coefficients is intended to better reflect any difference in perceived (dis)utility associated with each travel time component and especially account for the extra burden associated with OVTT, compared to IVTT. Tam, Lam and Lo (2011) advanced the assessment of travel time impacts even further by investigating the role of time reliability on air passenger airport ground access mode choice decisions. The importance of reliable access to airports is also highlighted in Koster, Kroes and Verhoef (2011), who found that the impact of travel time variability for business travelers during rush hour was as high as 36% of the total access travel cost.

As was the case with travel time, the total travel cost can be split into various components, such as parking cost (Jou, Hensher and Hsu, 2011), toll charges, gasoline cost, public transport ticket cost. Nevertheless, the common practice is to combine monetary values into a unique coefficient. On the one hand, it does not make much sense to assume different implied values for different trip outlays; on the other hand, estimating a unique coefficient makes the calculation of passengers' value of time easier by taking the ratio of travel time and cost coefficients. An interesting output of mode choice studies is indeed the estimation of willingness to pay for savings in access travel time, or simply the value of access time. Very different values have been estimated in the literature, with a lower range of $16.2/h and $6.6/h (Tam, Lam and Lo, 2011), and a higher range of $174/h and $118/h (Pels, Nijkamp and Rietveld, 2003) for business and non-business passengers, respectively[4]. A common finding is that value of time for accessing airport is higher than conventional commuters' value of time. The reason why air travelers have a higher willingness to pay for reducing access time can be explained by the strong penalty they risk incurring for being late and eventually missing their flight (Hess and Polak, 2005).

Although airport accessibility has been widely researched over time, there are still areas of interest to be investigated. A particular one is access to an airport dominated by a low-cost carrier. This study aims to address this topic, thus contributing to previous literature by shedding light on low-cost passengers' mode choice behavior when they are confronted with airport ground access. In addition, we extend the current literature on access mode choice in two ways. As opposed to the analysis of safety margins approach proposed by Tam, Lam and Lo (2011) and Koster, Kroes and Verhoef (2011), wherein the difference between the preferred arrival time and the expected arrival, as provided by passengers, is taken, we account for the effect of travel time variability on mode choice decisions by incorporating the average additional travel time owing to traffic congestion on each route to the airport. Eventually, we address the need for more reliable access times and costs (Pels, Nijkamp and Rietveld, 2003) by collecting extremely detailed

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[4] See Table 6 for a more explicit comparison of values of access travel time savings reported in the literature.

information about IVTT, OVTT, and trip outlays from well-known transport search engines, thus avoiding any level of zonal aggregation by the estimation of precise transportation service data for every possible travel combination.

3. The BGY Accessibility System

3.1 Current scenario

The BGY is strategically located in the heart of Lombardy, one of the most industrialized and populated regions of Italy. It is 3.7 kilometers southeast of Bergamo and 45 kilometers northeast of Milan. The BGY has been growing at an impressive rate over the last fifteen years, showing a CAGR of 19.65% and an upsurge in the number of passengers from 1,252,878 to 11,159,631 in the period 2002-2016[5]. The fast growth was triggered by the establishment of Ryanair in 2003, which eventually resulted in the BGY becoming the third busiest airport in Italy and the largest European continental base of the Irish airline.

At present, the BGY is not directly connected by rail to Bergamo city. Passengers coming by train or other means to Bergamo station must switch to a public bus service to travel from the railway station to the departure terminal. As in many other low-cost airports, a key role is played by express coaches running from the terminal to the nearby main cities, including Milan, Brescia, and Turin. However, the dominant access modes are private car and drop-off, even though the ease in accessing the airport is dampened by the condition of the surrounding access road system, where traffic flows for the purpose of air travel and conventional commuter trips overlap to a considerable extent, leading to heavy congestion[6].

The BGY's location is found to have a dual effect. Although the high population density and economic activity is beneficial in terms of the catchment area and air travel demand, the widespread road congestion compromises the airport's ability to attract passengers by making trips to the airport unpleasant and travel times uncertain. Given the expected growth in traffic volume in the coming years, its future prospects are likely to become much worse if adequate ground access interventions are not made.

3.2 Developmental scenarios: direct rail services

In an effort to reduce car dependency for ground access trips and best accommodate the increasing passenger demand, the BGY's development plan has included the construction of a 5-km railway link between the main terminal and Bergamo station. Given the strategic importance of the project, the development of preliminary feasibility studies received funding by the EU commission through the TEN-T program. This intervention will make rail connections from/to the Milan region seamless and more attractive.

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[5] Data source: Assaeroporti [www. assaeroporti.com]
[6] According to the BGY Intermodal development Plan - Sacbo/Oneworks (2011), road trips to the Milan-Bergamo airport accounted for 18%-35% of overall traffic flows on the intercity axles to the airport, reporting an average volume to road capacity ratio of 80%-120% during the morning peak hour (8.00-9.00 a.m.).

Specifically, two different types of service are considered: the extension of the existing regional service and the introduction of a dedicated airport train. Figure 1 shows the travel cost and travel time for both services with respect to the current scenario. The regional service (blue line) goes through many stops; on the contrary, the express service (red line) is a non-stop train service from Milan to Bergamo central station. While the extension of regional trains is aimed to offer passengers a cheap and reliable service, the introduction of a brand-new express train targets customers who are instead willing to pay a higher price to lower their travel time, as well as enjoy a more comfortable and seamless trip to the airport.

[FIGURE 1 ABOUT HERE]

4 Data sample and sources

4.1 Survey

In this paper, data related to individual choices and personal characteristics come from an on-site survey conducted at Milan-Bergamo airport in the period 2013-2016. The interviews were carried out on an ongoing basis over the study period, with three 7-day sessions each year, using the Computer Aided Personal Interviews (CAPI) technique. Although the survey involved measurements over time, we gather multiple year observations within a pooled sample. This choice is justified by the fact that no major changes have affected the BGY accessibility network in the 2013-2016 period. Neither was the choice set available to passengers substantially altered nor were there changes in the features of transport modes[7].

The questionnaire had two main parts: the first one contained a set of general questions aimed to collect socioeconomic features of respondents (sex, age, origin, trip purpose, etc.), whereas the second was more focused on capturing information about the chosen access mode (party size, transport mode, car parking, etc.), as well as details on the air travel (trip destination, air trip duration, etc.). The resulting sample consists of 2,445 observations (see Table 1). Figure 2 shows the spatial distribution of respondents from all over Lombardy. More specifically, outgoing respondents come from 239 different municipalities in the north of Italy.

[TABLE 1 ABOUT HERE]

[FIGURE 2 ABOUT HERE]

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[7] As pointed out in Section 2.1, airport-generated traffic on the existing roadways has seen remarkable growth over the past few years and is one of the main reasons behind the railway project's introduction. Therefore, considering that the purpose of the study is the analysis of modal switching with respect to the introduction of direct rail connections, minor variations in travel cost and time throughout the 2013-2016 period appear negligible when compared with the better statistical significance of the pooled sample.

4.2 Transport Data

Our empirical analyses consider five main transportation means to access the BGY departure terminal: private car, drop-off, taxi, bus, and train. The following table (Table 2) provides the relative frequency of each alternative for the two market segments.

[TABLE 2 ABOUT HERE]

As previously described in Section 2, since the BGY is not directly linked to the regional railway network, the train alternative refers to people who reach Bergamo station by train and then take the public bus service to the airport. As regards alternative-specific attributes, they have been collected from well-known transport search engines[8] and assembled through a data integration process[9].

We gathered relevant data about travel time, number of transfers, and monetary costs faced by each travel party in using the different airport ground transportation means. The total travel time (TT) is split into in-vehicle travel time (IVTT), which measures the time actually spent traveling, and out-of-vehicle travel time (OVTT). The OVTT is the sum of two components: the walking time and the transfer time. For all private automobile alternatives—car, drop-off, and taxi—this value is set to zero, given the absence of modal shifts and walking distance to the airport[10]. The OVTT measures some of the factors, including lower flexibility and higher waiting time, which characterize fixed-route public transport alternatives but not private ones and tend to make the latter preferable. In other words, passengers perceive OVTT as more burdensome than IVTT. As a result, being able to decompose the total travel time into OVTT and IVTT appears to be significant when modeling mode choice behaviors.

To capture the effect of traffic congestion on the choice of access mode, we collected average travel data from Google Maps under both normal (best guess scenario) and traffic conditions (pessimistic scenario)[11]. Despite other approaches used in the literature (Tam, Lam and Lo, 2011), we do not rely on stated preferences but set up a quantitative traffic index, computed as the difference between average travel time under congestion and normal conditions. Figures 3a and 3b depict the BGY catchment area by car travel time in the best guess scenario and pessimistic scenario, respectively. The blue area shrinks considerably under

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[8] Google Maps [www.google.com/maps] and ViaMichelin [www.viamichelin.com] are the main data sources for car travel, and Rome2Rio [www.rome2rio.com] for taxi and public transport alternatives. Alternative-specific attributes refer to the best itinerary suggested by transport search engines from each originating zone to the airport.

[9] The implementation of an ad-hoc automatic procedure for collecting transportation service information allowed us to avoid any level of aggregation and estimate detailed values for each originating zone. On the flip side, this approach necessitated the formulation of a simplistic assumption about the departing point of PT travels, which we set to be the main station within the municipality, if any. Otherwise, the additional time needed to reach the main station in the nearest municipality is also considered.

[10] We assume the walking time from parking slots to the airport terminal to be equal to zero.

[11] The pessimistic scenario is built by taking the weekly average travel time under congestion (Google Maps pessimistic estimates) at morning peak hour (8.00-9.00 a.m.), while the best guess scenario refers to normal traffic conditions; the related values are estimated by the weekly average travel time at noon considering Google Maps best-guess estimates. Google maps pessimistic and best-guess travel time estimates are predicted travel time values based on historical averages and real-time traffic conditions.

congestion, thus highlighting the remarkable impact of traffic on airport landside accessibility. The overall number of potential passengers that can reach the airport in less than 60 minutes is approximately 6.8 m in normal road conditions; under congestion, this figure drops by 47% to around 3.63 m.

[FIGURE 3a ABOUT HERE]
[FIGURE 3b ABOUT HERE]

As for travel times, the total amount spent for the access trip is estimated for each municipality and each available mode. Total cost (TC) by car is given by the sum of three components: gasoline cost, highway toll charges, and parking rates. The cost of parking was collected from the BGY management company website, taking into account quantity discounts for longer-term parking. Information about the number of companions in the ground access party, as well as the air trip duration, was then used to translate total expenses into the travel cost for each respondent. Starting from these values, drop-off attributes are computed by multiplying by two the car travel related expenses, net of parking costs. Table 3 reports the descriptive statistics for the alternative-specific variables included in the model.

[TABLE 3 ABOUT HERE]

5 Methodology

This section describes the main methodological steps taken to investigate air travelers' access mode switching response when different rail services are implemented. First, we run a mixed logit model and compute trade-off ratios to quantify air passengers' preferences with respect to access mode choice. Second, we simulate the introduction of direct rail services to the airport and use the estimated model coefficient to compute the potential rail market share.

The mixed multinomial logit model (MMNL) (McFadden and Train, 2000) is widely recognized to be a state-of-the-art discrete choice model (Hensher and Greene, 2003). MMNL is preferred over the more basic logit models owing to its higher flexibility; in particular, the MMNL formulation does not require the axiom of independence from irrelevant alternatives (IIA) to hold nor the definition of any nested structure a-priori. It also allows for taste heterogeneity across individuals, thus providing increased behavioral realism.

Let V_{qi} be the observable utility component of individual $q \in Q$ with respect to alternative $i \in J$, defined as a linear combination of both alternative-specific attributes and individual characteristics, plus a constant specific to alternative i (ASC_i):

$$V_{qi} = ASC_i + V(\delta_q, X_{qi}) + V(\gamma_{qi}, X_q) \tag{1}$$

Alternative specific constants (ASCs) can be interpreted as representing the intrinsic utility of alternatives, capturing the overall impact of unobserved factors, such as perceived quality and comfort, which are not made explicit in the deterministic utility component. Vectors X_{qi} and X_q represent the set of alternative-specific attributes and individual characteristics, respectively. The different sensitivity toward explanatory variables across individuals is modelled by estimating random "taste" coefficients δ and γ for individual q, whose distribution can be specified by the modeler based on prior knowledge on their sign or other considerations (Hess, Bierlaire and Polak, 2005). Consequently, MMNL does not provide a closed-form expression for choice probabilities and the use of simulation methods is needed to approximate MNNL model outcomes (for a detailed overview, see Train [2003])

Assuming that the estimation sample $Q_s \subset Q$ is representative of the whole population, the simulated probabilities can be used to predict the market share of each alternative $i \in J$ as follows:

$$\overline{MS}_i = \frac{1}{Q_S} \sum_{q \in Q_S} \overline{P}_{qi} \tag{2}$$

Notwithstanding the proven suitability of stated preference or hybrid methods to evaluate demand for brand-new transport modes or combinations of attribute levels that do not yet exist (Kroes and Sheldon, 1988; Hensher, 1994), the outcomes of revealed preference choice models may still be used to simulate incremental modifications to existing attributes.

To explain in more detail, let A_k be an existing transport alternative and let Δ_{qk} be a vector of length equal to that of X_k, which denotes the reduction of each alternative's attribute for each individual $q \in Q_S^*$; $Q_S^* \subseteq Q_S$ is the subset of respondents to whom the improvement of alternative A_k's service level applies. The deterministic utility component can be adjusted as follows:

$$\tilde{V}_{qk} = ASC_k + V(\delta_q, X_{qk} - \Delta_{qk}) + V(\gamma_{qk}, X_q), \ \forall \ q \in Q_S^* \tag{3}$$

Although it is possible to spell out explicitly the relationships between predicted improvements and the choice to be forecast for quantitative explanatory variables, this is not the case for more qualitative factors. To obtain insights about the extent to which variations in the set of unobserved parameters may affect the usage of a transport mode, a sensitivity analysis is carried out to determine how different values of alternative k-specific constant will impact choice probabilities. Since ASCs represent the intrinsic utility of alternatives, increasing ASC_k simulates the effect of improving alternative k's perceived level of service. Mathematically, this can be stated as follows:

$$\tilde{V}_{qk}(\alpha_k) = (1 - \alpha_k) \cdot ASC_k + V(\delta_q, X_{qk} - \Delta_{qk}) + V(\gamma_{qk}, X_q), \quad \forall\, q \in Q_S^*, \tag{4}$$

where α_k represents the relative change of ASC_k with respect to the baseline alternative. Accordingly, α_k should range between 0 and 1, where α_k equal to 0 refers to no change in alternative k's level of service and α_k equal to 1 implies the same level of service as the baseline alternative. Combining equations (2) and (4), choice probabilities and predicted market shares can be re-computed as a function of α_k:

$$\overline{MS}_k(\alpha_k) = \frac{1}{Q_S} \cdot \frac{1}{R} \cdot \left[\sum_{q \in Q_S^*} \sum_{r=1}^{R} \frac{e^{\tilde{V}_{qk}(\alpha_k)}}{e^{\tilde{V}_{qk}(\alpha_k)} + \sum_{j=1}^{J \setminus \{k\}} e^{V_{qj}}} + \sum_{q \in Q_S \setminus Q_S^*} \sum_{r=1}^{R} \frac{e^{V_{qk}}}{\sum_{j=1}^{J} e^{V_{qj}}} \right] \tag{5}$$

where R is the number random observations used in the simulation.

The potential impact of improving alternative k's service level can then be assessed by observing how the modal split is supposed to vary for different values of α_k.

6   Model Development

6.1 Utility specification

In this study, the portion of the utility function associated with alternative attributes is based on the following variables:

- *TC*: Total outlays per person for the trip, including gasoline cost, highway toll charges, parking rate, and public transport ticket cost (€)
- *IVTT*: In-vehicle travel time (min)
- *OVTT*: Out-of-vehicle travel time (min)
- *Traffic index*: Average traffic time on each route (min), computed as the difference between average travel time under congestion and normal conditions

The portion of the utility function associated with individual characteristics is the linear combination of three main variables:

- *Age (<35)*: dummy variable equal to 1 if the respondent is aged below 35 years, 0 otherwise
- *Gender (Male):* dummy variable equal to 1 if the respondent is male, 0 if female
- *Travel Party:* integer variable representing the size of the ground access travel party

6.2 Random utility coefficients

Parameters describing the direction and magnitude of the effect of attributes of the alternative are not allowed to vary across alternatives. A unique coefficient is estimated for each attribute, which implies that the marginal utility associated with any alternative-specific property—for example, travel cost or travel time—is identical across the available options. Coefficients related to a respondent's socioeconomic characteristics describe the effect of these variables on the propensity to use different modes. Based on this, a different parameter is estimated for each available travel option.

The effect of travel cost, OVTT, and IVTT are modeled by means of normally distributed random coefficients. Two different coefficients— the mean and the standard deviation of the relative distribution— are estimated for each parameter. Although the sign and magnitude of the mean coefficient gives an indication of the average impact, the standard deviation expresses by how much the respondents differ from the mean in terms of sensitivity to the corresponding parameter. For these three attributes, we found enough variation in the sensitivity to cost and travel time to justify the use of random coefficients. This was not true for the traffic index, which was, therefore, entered into the model in a deterministic fashion.

6.3 Computation of value of time savings

Although the randomization of parameters better reflects the inner stochasticity in human behavior, it complicates the estimation of the value of time measures and trade-offs between parameters. If either cost or time sensitivity is found to differ across the population, the ratio of the means of coefficients is a biased estimator of the value of time as it ignores the taste heterogeneity of individuals' willingness to pay for travel time-savings (VTTS). As suggested by Hess, Bierlaire and Polak (2005) a better approach consists of approximating the population of the ratios of time and cost coefficients by simulation and using inferential statistics to deduce properties of the underlying distribution.

Following this procedure, we run a Monte Carlo simulation generating 1,000 samples, each of size 1,000. Since estimated coefficients are not correlated by construction, we produced independent draws from each population and derived VTTS observations by taking the ratio of each pair of coefficients, with the random cost coefficient forming the denominator. Eventually, for each population, the central tendency was estimated by the sample median.[12]

6.4 Model specification and estimation issues

As pointed out in the previous section, the IIA property is one of the main limitations of the basic multinomial logit models (MNL). Assuming that the odds ratios are independent of the other alternatives is

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[12] The median was preferred over the mean as a proxy of central location for two main reasons. First, the population distribution of the ratio of two independent Gaussian random variables does not have a convergent mean or other moments of higher order. Second, the median is a more robust statistic in the presence of outliers or extreme values far from the mean, which is likely to be the case for the denominator, β_{TC}, in all models that often take values close to zero.

rather restrictive in realistic choice situations because it provides unrealistic substitution patterns and implies that preferences between the two alternatives are not affected by modifications to the choice set. This problem is exacerbated when model coefficients are used to simulate the addition of another option or, as in our case, change the characteristics of a third option. We tested the independence assumption through the Hausman-McFadden test (1984) when the car alternative is dropped. Based on the results (Table A1 in appendix), the independence of irrelevant alternatives is rejected for two of the three models estimated; therefore, a more complex mixed logit model allowing for less restrictive competitiveness patterns is preferred.

The model is estimated using Halton sequences. According to Bhat (2001, 2003) and Train (1999), these sequences are superior to pseudo-random ones, yielding significant reductions in computation time and improved accuracy in Monte Carlo integration. One crucial issue of mixed logit model is to determine the proper number of draws that ensure the stability of estimated coefficients, especially for complex formulations with many random parameters. As suggested by Hensher and Greene (2003), we estimated the model over a range of draws (25, 50, 100, 250, 500 and 1000). The results (Table A2 and Figure A1 in appendix) stabilize after a rather small number of draws (50-100), especially for the reduced models, and their number does not seem to significantly affect the accuracy of the estimates. Ultimately, we used 100 Halton draws because this provides sufficiently accurate (and stable) estimates while reducing the computation time.

7 Results

7.1 Econometric results

Table 4 presents the model estimation results for both business and non-business passengers. Driving a car is taken as the baseline alternative, which means that all coefficients for individual characteristics and the alternative specific constants have to be interpreted in relative terms[13]. The ASCs all have a negative value and are all statistically significant, except for the taxi alternative in the business passengers' sub-model[14]. Model coefficients reveal that both business and non-business passengers favor driving to the airport over all other transportation means (ceteris paribus), while the second most preferred alternative is drop-off. Although we consider the operating cost of the vehicle for the return trip, the utility function for drop-off

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[13] The need for setting a reference alternative follows directly from the constant difference property of logit models. As suggested by Ortuzar (1982), we arbitrarily chose private car as a reference since it is the alternative more universally available.

[14] Using taxicab is not a very common transport means to BGY and to locations in the Bergamo region in general. The taxi industry is a heavily regulated sector in Italy with high entry barriers. The frequent fare revision, which makes the price uncertain to users and the inflexible supply even in the face of growing demand trends (e.g., airports) are both factors that have negatively affected the propensity to use this transport mode (Bentivogli and Roversi, 2009). The number of taxi licenses per 10,000 inhabitants in Bergamo is equal to 3.0, far below the Italian average of 12.4 and the maximum value of 36.5 in Milan [*Source: ISTAT 2014*].

alternative ignores the disutility incurred by the driver (e.g., it does not assign any disutility to the time spent by the driver). While drop-off may reasonably be expected to be the preferred choice for most of the passengers, the actual availability of this option varies widely across individuals and so does its related cost, thus resulting in a lower preference. As expected, non-business passengers are more prone to use public transport that business travelers, although both categories of passengers exhibit a strong aversion to the train-bus alternative. The latter is found to have the lowest ASC, meaning that it is perceived by the average outgoing passenger as the worst ground access alternative, net of factors made explicit in the deterministic utility component.

[TABLE 4 ABOUT HERE]

In the non-business passengers' sub-model (see Table 4), the standard deviation coefficient for IVTT is not statistically significant, which means the null hypothesis that no significant taste heterogeneity exists across the population cannot be rejected. In the case of the business passengers' sub-model, the failure in the estimation of the OVTT coefficients is rather traceable to the low data availability on businessmen using public transport. In all three models, the use of the MNNL model yields a better fit than the MNL specification, as shown by the log-likelihood values at convergence.

Table 5 reports the results of the VTTS estimation. Business passengers, in general, tend to be more time-sensitive but less cost-sensitive than non-business ones. Nevertheless, the difference in the estimated average value of IVTT for the two passenger types, that is, €19.38/h and €23.95/h for business and non-business travelers, respectively, is not as large as in the other studies (see Table 6). Researchers investigating the propensity of business passengers to use low-cost airlines have shown how the growing pressure to reduce travel expenditure is making business air passengers increasingly price sensitive to airfares (Mason, 2001). Our result seems to corroborate these findings concerning access travel expenses.

As regards the disutility associated with OVTT, the aggregated model shows how even low-cost passengers consider OVTT as more burdensome than IVTT. The average value of OVTT for non-business passengers is equal to €37.48/h, which is 1.94 times the standard IVTT value of €19.38/h. Non-business passengers are willing to pay almost double the price for reduction in time spent outside the chosen transportation means—for example, waiting for connections or walking to the next station—than for a similar reduction in IVTT. Planning at low-cost airports should, thus, focus on designing effective surface access solutions that do not simply optimize the cost-time trade-off but also minimize the number of modal shifts. This result is consistent with international standard practices for transport project appraisal, which recommend, in the absence of specific data, to approximate the OVTT value by weighting IVTT value by a factor of 2 for walking time and a factor of 2.5 for waiting and interchange (or transfer) time[15]. In the case of road congestion, that is, if the volume to capacity ratio for a link is in excess of 1.0, HEATCO guidelines

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[15] Developing Harmonised European Approaches for Transport Costing and Project Assessment [http://heatco.ier.uni-stuttgart.de]

suggest that traffic time be valued at 1.5 times the standard IVTT. Consistent with previous studies (Hess and Polak, 2005; Koster, Kroes and Verhoef, 2011), we found that travelers to BGY are much more sensitive to time reliability than normal commuters. Non-business passengers exhibit a value of traffic time-savings of €38.16/h, which is similar amount to that of OVTT, whereas business passengers are willing to pay up to €74.27/h, namely €1.23 for a one minute reduction in time spent in a traffic jam. Besides all the burdens and stress associated with driving during rush hour, the main explanation for such a high value probably lies in the fact that time reliability is crucial for air travelers owing to the consequences of missing their flight. Another reason is BGY's location. As reported in Section 2.1, the surrounding road system suffers from heavy congestion, making the impact of travel time uncertainty very important.

[TABLE 5 ABOUT HERE]

Although the estimated time values are smaller than many estimated in the literature (Table 6) it is not possible to state with certainty whether LCA passengers value their time less than their peers traveling from major airports. Indeed, the different model specification, quality of data, survey-based techniques, or even regional differences in attitudes toward mobility, are all factors that limit the comparability and generalization of outcomes from different access mode choice models.

[TABLE 6 ABOUT HERE]

What is worth noting is that low-cost passengers, in general, are not as indifferent to access travel time as one might expect. Results suggest that while price may be still the most important factor, the level of service also matters. Landside planning at low cost airports should therefore be aware of customers' priorities in accessing the airport and consider the changing customer mix underpinned by the growing relevance of business passengers.

7.2 Results from the simulation analysis

To assess the impact of the two different types of rail services, transport data for the train-bus alternative are adjusted according to the relative improvements expected. Special attention has been paid to changing values only for those individuals who might actually benefit from the new connections, that is, people for whom the Milan-Bergamo regional line features as part of their train-bus alternative to the airport (Figure 4). For instance, customers coming from eastern Lombardy will not benefit from direct connections along the Milan-Bergamo axis. More precisely, the number of origin-destination pairs subject to changes is 78 out of 239 originating locations in the dataset, for a total of 849 records out of the 2,445 forming our "restricted sample."

[FIGURE 4 ABOUT HERE]

The extension of the regional service will lead to incremental savings in both IVTT and OVTT, without raising the service price. Therefore, it is reasonable to expect that the number of people who will use the train alternative will increase if this solution is put into practice. However, extending regional trains will offer passengers a transport alternative comparable to the current one in terms of overall quality and journey comfort. The fact that most of the utility gains associated with avoided modal shift and reduced travel time are already captured by the OVTT and IVTT coefficients, allows the approximation of the regional train's ASC by the current train-bus ASC (equation 3). On the other hand, the greatest advantage of the express service does not lie in travel time or cost savings, but rather in the better performance and quality of service. Using equation (5), ground access modal split is estimated as a function of train ASC, ranging from its current value up to the car ASC.

The simulation was done using the "all passengers" model and setting the number of repetitions to 100. In the case of the regional service, it turns out that the overall expected increase in the train alternative's market share is about 0.97% (full sample). If one restricts the analysis to only those passengers who might actually use the service (restricted sample), the percentage increase rises to +2.77%. Although the regional service surely improves rail connectivity to the airport and makes this transport alternative more attractive, the degree of improvement is substantially limited to a 10 minutes saving of IVTT and OVTT. Extending regional trains does not overcome the major problems of the regional service, such as poor level of service, overcrowding, and uncomfortable spaces, which make this mode very unattractive to outgoing passengers.

[FIGURE 5 ABOUT HERE]

Figure 5 depicts the sensitivity analysis for the express service, showing how the modal split is supposed to vary with the increase in rail service level (for details on the simulation approach, see section 5). Being an abstract measure, the ASC only makes sense when comparing alternative solutions. As a reasonable benchmark, it is worth observing how rail market share is supposed to change when ASC_{train} becomes equal to ASC_{bus} (dotted line in Figure 5), meaning that people are indifferent between riding the express train and coaches, other things being equal (i.e., same price, same in-vehicle and out-of-vehicle travel time, and same traffic index). If that is the case, the aggregate rail probability rises to 27% (+20.2%) within the restricted sample and to 13.5% (+7%) within the full sample.

According to this analysis, the express line will be a real competitive alternative, able to capture a substantial share of passengers. Despite the higher cost—which matches similar airport-dedicated trains in Europe—it can provide a faster, seamless, and more reliable service than express coaches do. Relying on new and airport-dedicated rolling stocks, it will also be able to better address peculiar air passengers' needs and provide additional services, such as space for luggage, Wi-Fi connection, and comfortable seats.

8 Conclusions

This paper aims to expand the current literature on airport access mode choice models by examining a market segment that has not been fully investigated yet —i.e., passengers flying via LCAs— by focusing on the Milan-Bergamo airport. This topic deserves in-depth research owing to the increasing importance of LCAs in the world aviation network and the remarkable differences between them and primary airports. In addition, low-cost airline passengers are commonly known to be extremely sensitive toward airfares, although it is unclear whether they also tend to favor no frills low-cost options when choosing the transport mode to the airport. Addressing this issue today is key to helping decision makers prioritize surface access interventions.

By running a mixed logit model, we extrapolate a set of coefficients—either random or deterministic—describing the impact of various factors on the propensity to use different transport modes. Next, we show how to make use of this information to make decisions about the ground access projects that are worth pursuing.

We found that low-cost passengers are not exactly low-cost consumers when it comes to the access mode choice. With an average value of IVTT of €19/h, our analysis suggests that despite price still being the most important factor, the level of service also matters. This finding is corroborated by the sensitivity analysis reporting how significant improvement in the quality of service by the introduction of a dedicated express train is supposed to increase rail usage far more than the extension of the existing regional service.

Further, some insights emerge from the analysis of the effects of different travel time components. We found that each additional minute of OVTT leads to a higher disutility than a unit increase in IVTT, although it is the time wasted due to congestion that is perceived as the most unpleasant and burdensome. Consistent with earlier studies (see Section 2), we find that business passengers are willing to pay more than non-business ones for a reduction in travel time. Nonetheless, their estimated value for IVTT savings is not as high as one might expect for this category of travelers, thus contradicting the conventional perception of passengers on business trips being totally unconcerned about travel expenses.

Generally speaking, our analysis highlights the importance for policy makers and practitioners at low-cost airports to address the access time-cost trade-off by carefully accounting for passengers' preferences and not simply delivering a service with the lowest possible cost. The framework proposed is based on easy-to-gather and commonly available customer profiling data. Although the evaluation of the new transport modes can be improved by means of stated preference experiments, this approach has the advantage of providing airports with an easy-to-implement and practical tool for systematically assessing modifications to the current scenario and selecting from the different alternatives.

However, this study is not without limitations. A major one is that it focuses exclusively on outgoing passengers, for whom data is readily available. Analyzing the behavior of foreign incoming passengers would be fruitful as they represent a significant portion of the airport population and may potentially have different preferences toward access modes. Another improvement to the current model is the development of

a joint airport and ground access mode choice model. Indeed, the Milan-Bergamo airport is in strategic interaction with the two other major airports serving the Milan Area—Linate (LIN) and Malpensa (MXP). This makes ground accessibility an even more important factor affecting the ability to attract air traffic.

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Tables

	Levels	Sample size		Levels	Sample size
Gender	Male	1,300 (53%)	*Travel party size*	1	989 (40%)
	Female	1,155 (47%)		2	915 (37%)
Age	<35	1,025 (42%)		3	276 (11%)
	≥35	1,430 (58%)		4	143 (6%)
Trip purpose	Business	509 (21%)		5	33 (1%)
	Non-business	1,946 (89%)		6	99 (4%)

Table 1. Sample composition

Market segment	Current mode choice (sample size - %)				
	Car	Drop-off	Taxi	Bus	Train
Outgoing Business	239 (47%)	153 (30%)	15 (3%)	61 (12%)	40 (8%)
Outgoing non-Business	662 (34%)	681 (35%)	39 (2%)	448 (23%)	117 (6%)

Table 2. Modal Split for the two market segments

Access Mode	Varible	Mean	Median	Std deviation
Car	*TC (€)*	40.19	36.84	21.28
	Traffic Index (min)	14.96	14.49	9.52
	IVTT (min)	58.39	48.98	37.84
	OVTT (min)	-	-	-
Drop-off	*TC (€)*	16.94	10.16	17.95
	Traffic Index (min)	14.96	14.49	9.52
	IVTT (min)	58.39	48.98	37.84
	OVTT (min)	-	-	-
Taxi	*TC (€)*	56.35	50.00	40.67
	Traffic Index (min)	10.69	10.44	5.19
	IVTT (min)	43.79	46.38	21.37
	OVTT (min)	-	-	-
Bus	*TC (€)*	10.49	6.00	13.07
	Traffic Index (min)	9.93	9.66	6.55
	IVTT (min)	81.02	55.00	64.78
	OVTT (min)	10.66	1.00	20.85
Train	*TC (€)*	13.31	9.80	10.14
	Traffic Index (min)[16]	-	-	-
	IVTT (min)	92.51	74.00	42.65
	OVTT (min)	16.41	11.00	11.99

Table 3. Characteristics of Different Ground Access Modes

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[16] The Traffic index for the train alternative is set equal to zero. Rail transport to Bergamo station is not affected by congestion at all, owing to the use of segregated and private lanes. On the contrary, the transportation from Bergamo Station to the airport (see Figure 1) may be suffering from congestion but its average travel time variability can be safely ignored as it represents a small portion of the overall trip to the airport.

Parameters	All passengers			Business passengers			Non-business passengers		
	Estimate	*t-statistic*		*Estimate*	*t-statistic*		*Estimate*	*t-statistic*	
Alternative specific constants									
Bus	-2.1071	-8.776	***	-2.6897	-4.1871	***	-1.9468	-7.1792	***
Drop-off	-1.3686	-7.456	***	-1.1100	-2.401	**	-1.3959	-6.6583	***
Taxi	-2.9109	-6.699	***	-1.6841	-0.8264		-3.0282	-6.4922	***
Train	-3.7208	-10.090	***	-4.0277	-3.444	***	-3.6697	-8.8885	***
Alternative specific variables									
TC μ	-0.0407	-8.9790	***	-0.0367	-4.1007	***	-0.0432	-7.8004	***
TC σ	0.0391	7.4779	***	0.0445	4.1295	***	0.0334	4.3732	***
IVTT μ	-0.0200	-3.8703	***	-0.0301	-1.679	*	-0.0166	-3.3762	***
IVTT σ	0.0243	2.9556	***	0.0416	-1.8377	*	-0.0153	-1.471	
OVTT μ	-0.0255	-2.5373	**	-0.0460	-1.3226		-0.0351	-2.6423	***
OVTT σ	0.0282	1.9219	*	0.0515	-1.1959		0.0457	2.8273	***
Traffic Index	-0.0368	-3.629	***	-0.0750	-2.5207	**	-0.0327	-2.9073	**
Individual specific variables									
Bus: Age (<35)	0.8567	5.960	***	0.7865	1.8214	*	0.7180	4.7101	***
Drop-off: Age (<35)	0.6443	5.521	***	0.5099	1.6159		0.5571	4.404	***
Taxi: Age (<35)	-2.6152	-3.486	***	-10.809	-0.5465		-30.131	-2.7967	***
Train: Age (<35)	0.9866	4.711	***	11.072	1.8003	*	0.9229	3.9432	***
Bus: Gender (male)	-0.6242	-4.493	***	-0.9657	-2.217	**	-0.4299	-2.9199	***
Drop-off: Gender (male)	-0.3808	-3.394	***	-13.581	-4.3101	***	-0.1145	-0.9450	
Taxi: Gender (male)	-0.1525	-0.425		-0.1694	-0.1172		-0.2683	-0.6489	
Train: Gender (male)	-0.5448	-2.605	***	-0.7669	-1.1731		-0.4581	-1.9946	**
Bus: Travel party	0.4208	6.745	***	0.4729	2.4014	**	0.3780	5.5731	***
Drop-off: Travel party	0.2229	4.498	***	0.3502	2.4122	**	0.1930	3.4784	***
Taxi: Travel party	0.3160	2.711	***	-0.6398	-0.5688		0.3905	3.0602	***
Train: Travel party	0.4405	5.063	***	0.2902	0.5768		0.4488	4.8287	***
Obs	2455			509			1946		
LL (MNNL)	-2946.5			-578.91			-2333.5		
LL (MNL)	-2963.9			-587.27			-2340.6		
McFadden R^2	0.09			0.11			0.09		

*** 99% level of confidence, ** 95% level of confidence, * 90% level of confidence

Table 4. Estimation Results of the three MNNL models

Statisticstics	All passengers			Business passengers			Non-business passengers		
	IVTT	*OVTT*	*Traffic Index*	*IVTT*	*OVTT*	*Traffic Index*	*IVTT*[17]	*OVTT*	*Traffic Index*
Mean	18.76	24.02	39.76	23.95	37.30	74.27	19.38	37.48	38.16
Dev.std	1.37	1.69	1.21	2.34	2.95	2.38	0.52	2.62	1.02
Half length CI	0.09	0.10	0.07	0.15	0.18	0.15	0.03	0.16	0.06
Lower limit	18.67	23.92	39.69	23.80	37.12	74.12	19.35	37.32	38.10
Upper limit	18.85	24.12	39.83	24.10	37.48	74.42	19.41	37.64	38.22
Relative precision	0.45%	0.44%	0.19%	0.61%	0.49%	0.20%	0.17%	0.43%	0.17%
Significance Level				5%					
Sample Size				1000					
Number of samples				1000					

Table 5. Simulation Results for Value of time measures (€/h) – Central Tendency

Study	Case study	Models	Value of Time[18]		
			Business	**Non-Business**	**Δ%**
Harvey, G., 1986	San Francisco Bay Area	MNL	41.4 $/h (66.6 €/h)	19.8 $/h (31.9 €/h)	109%
Pels, et al., 2003	San Francisco Bay Area	NL	174 $/h (166.7 €/h)	118 $/h (113 €/h)	47%
Gupta, et al., 2008	NYC Metropolitan Region	NL and MNL	63 $/h (51.6 €/h)	42 $/h (34.4 €/h)	50%
Tam, et al., 2011	Hong Kong International Airport	Structural equation modelling and MNL	16.2 $/h (12.7 €/h)	6.6 $/h (5.2 €/h)	145%
Our estimate (IVTT)	Milan-Bergamo Airport	MMNL	*24 €/h*	*19 €/h*	26%

Table 6. Values of access travel time savings reported in the literature.

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[17] Since IVTT σ is not statistically significant in the non-business model - the null hypothesis that no significant taste heterogeneity exists across the population cannot be refused -VOT measures have been estimated by setting IVTT σ equal to 0.

[18] To facilitate the comparison among different currencies over time, values into brackets are expressed in equivalent terms (Euro 2017). The conversion is based on US government CPI data released by the U.S. Labor department's Bureau of Labor statistics [*www.bls.gov*] and the latest purchasing power parities (PPPs) provided by the OECD [*data.oecd.org*].
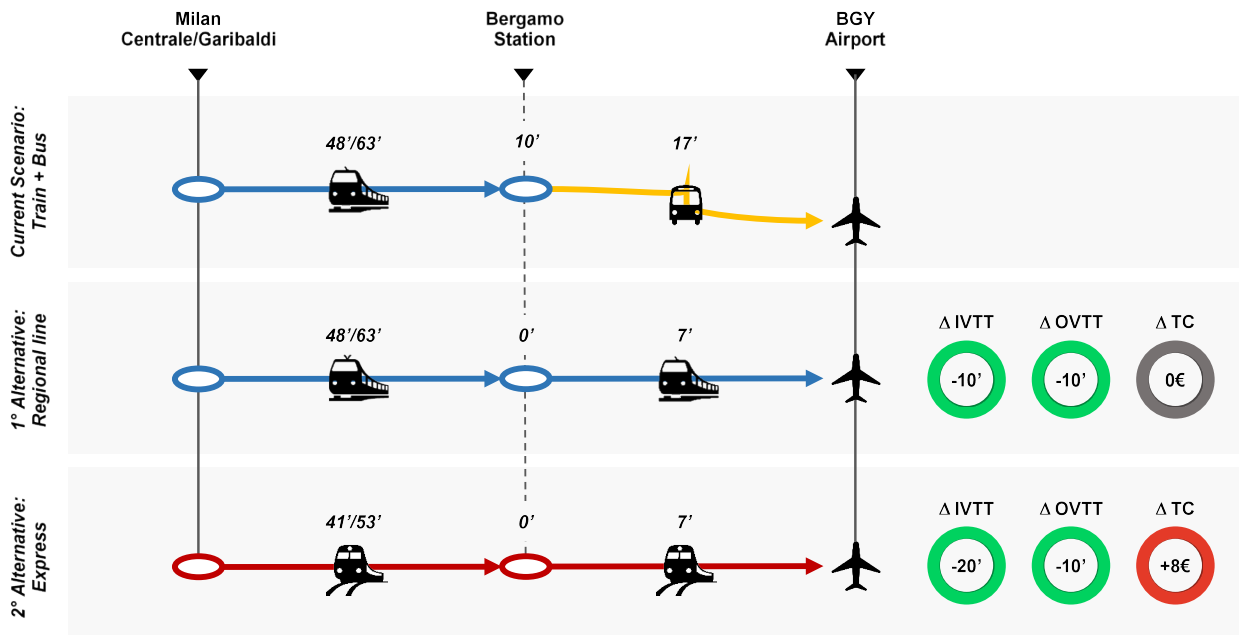
Figures

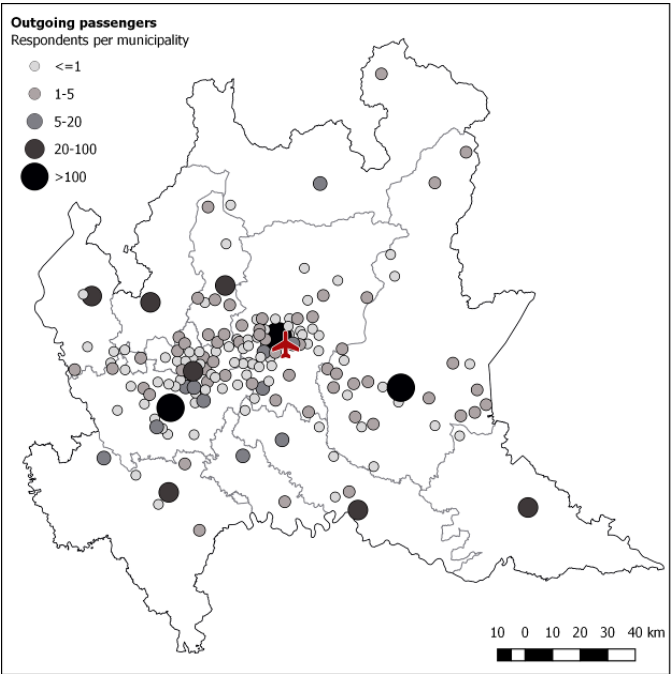**Figure 1.** Rail service alternatives [19],[20]

Figure 2. Number of outgoing passengers per municipality

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[19] The average transfer time at Bergamo station is computed as the arithmetic average of the service frequency.

[20] Travel time and cost for the rail connections come from the BGY Intermodal development Plan - Sacbo/Oneworks (2011).
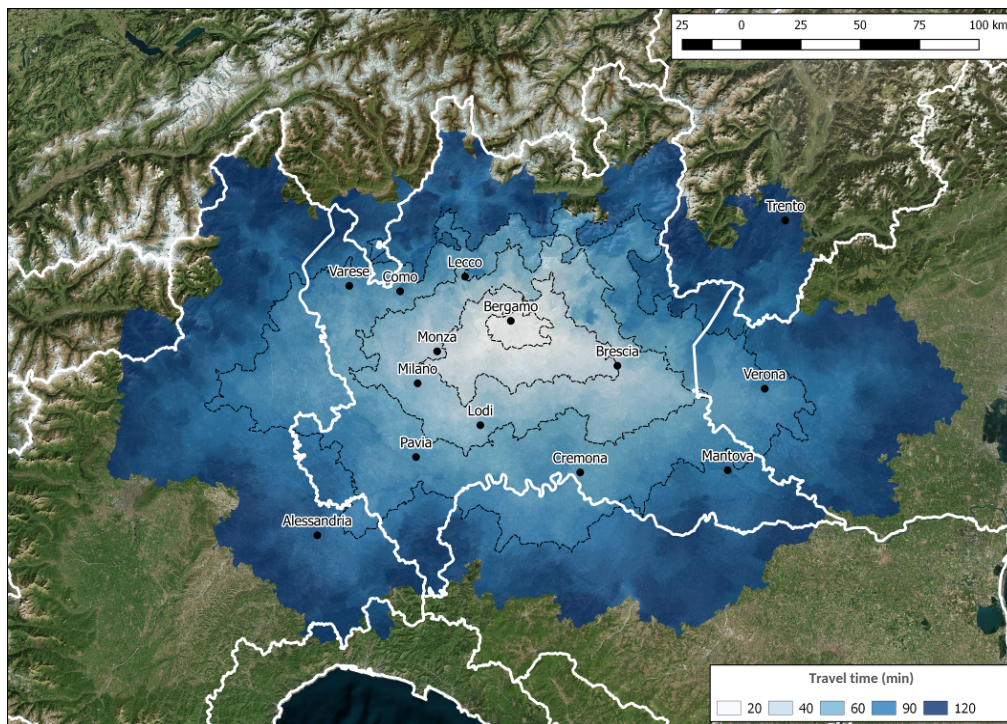
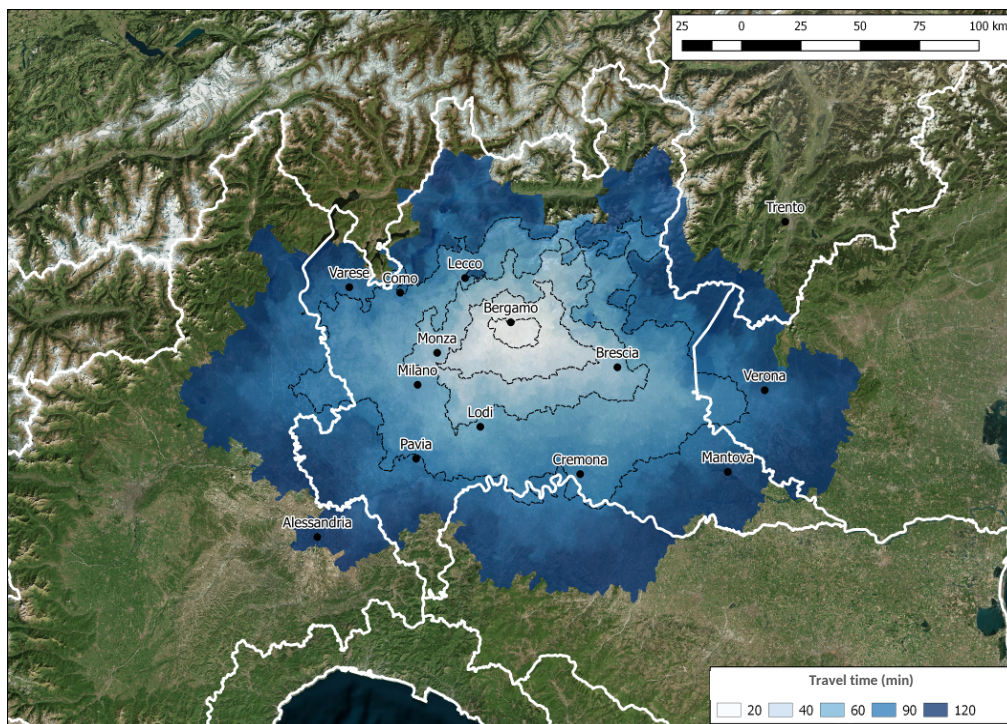**Figure 3a.** Travel time by car to BGY terminal (Best-guess scenario)

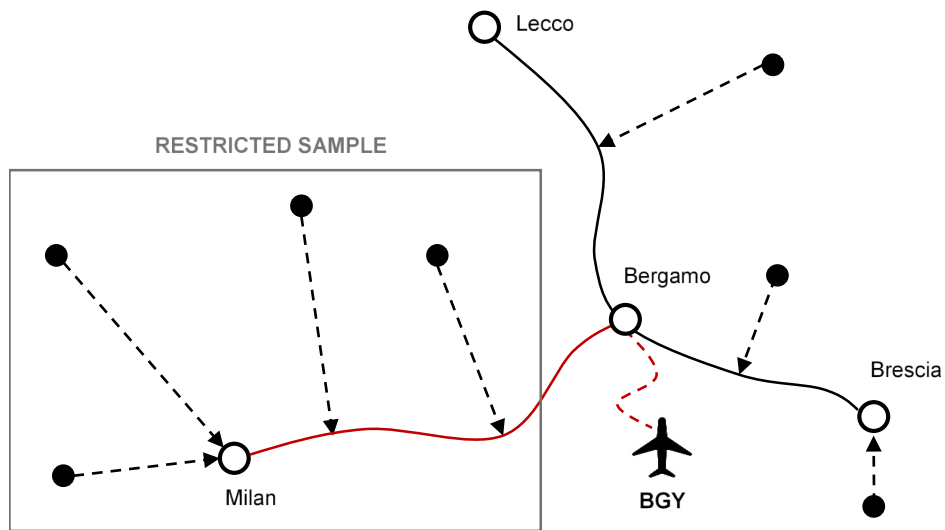**Figure 3b.** Travel time by car to BGY terminal (Pessimistic scenario)

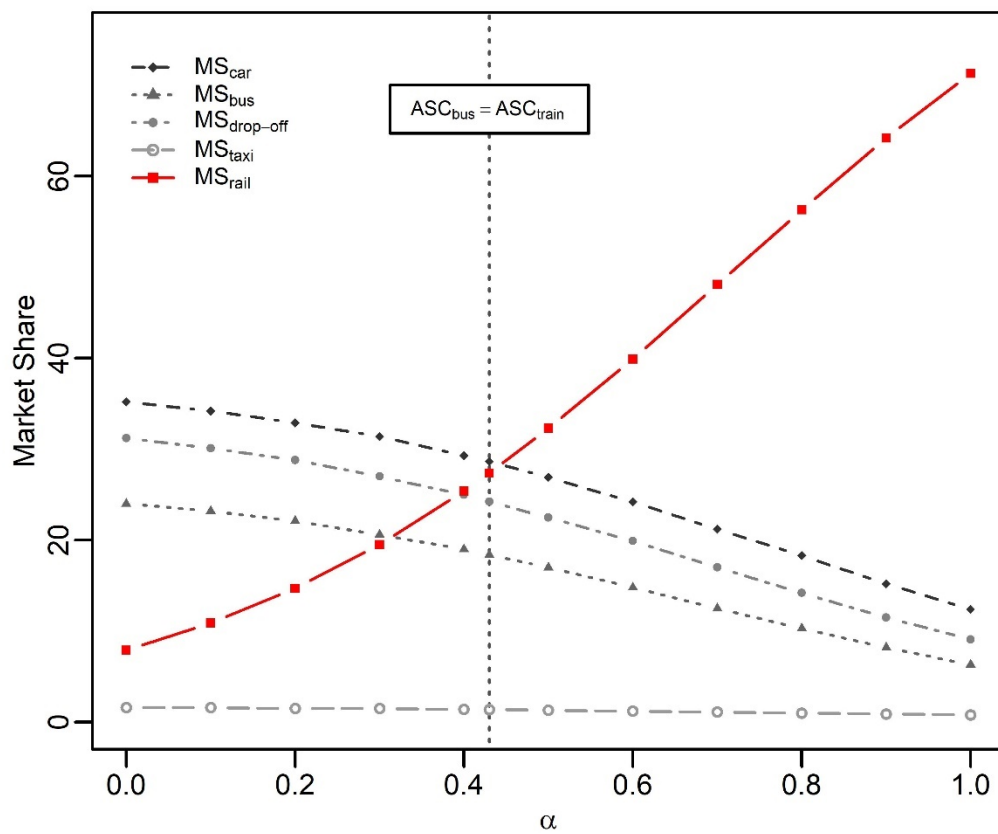**Figure 4.** Restricted sample definition

Figure 5. Sensitivity analysis – Express train modal share

Appendix

Hausman McFadden Test	All passengers	Business passengers	Non-Business passengers
chisq	49.351	82.683	22.009
p-value	2.91E-05 ***	5.445E-11 ***	0.1429

Table A1. Hausman McFadden Test
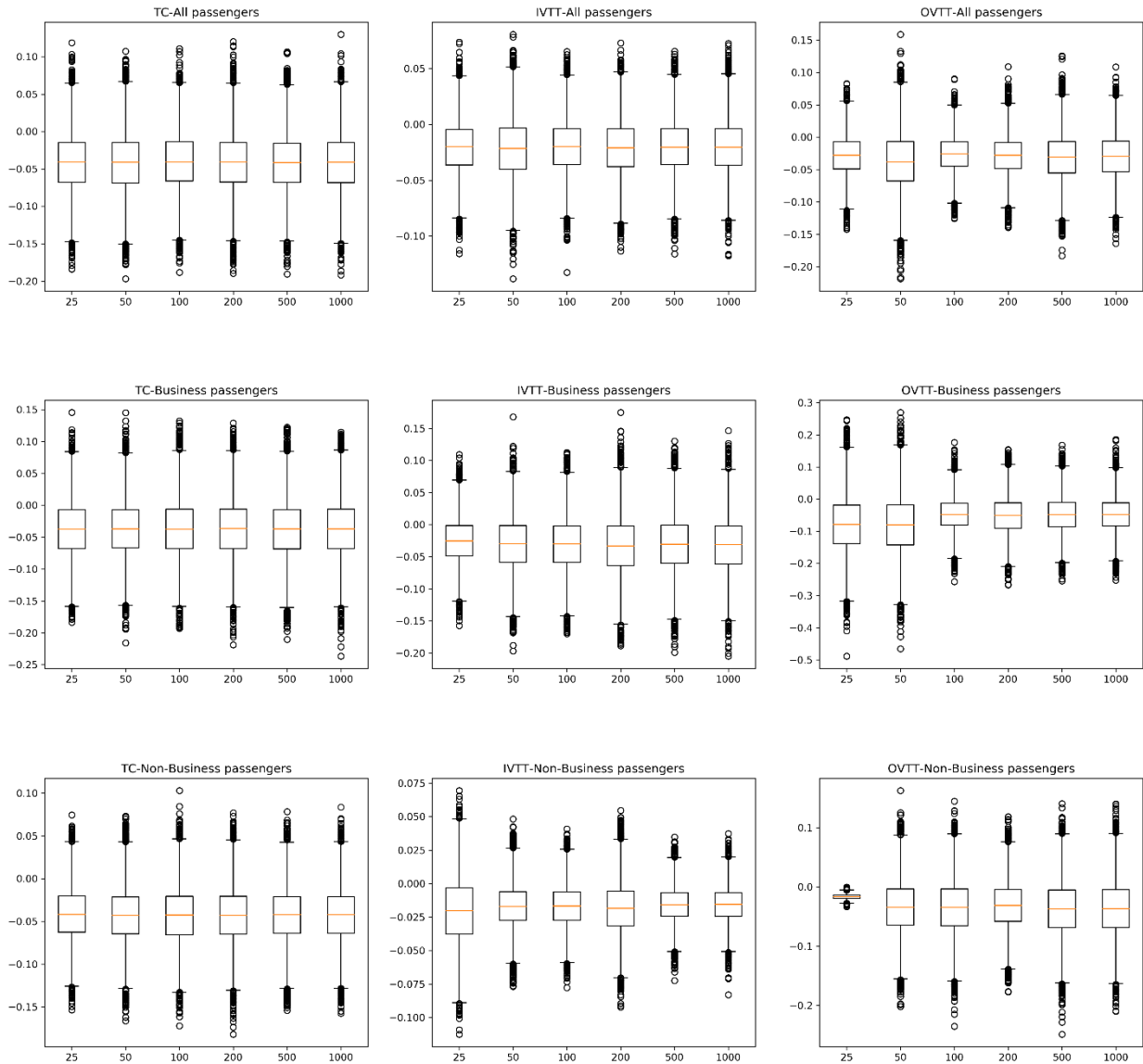
Figure A1. Random coefficients distributions

Number of Halton draws	25			50			100			200			500			1000		
	Estimate	t-statistic		Estimate	t-statistic		Estimate	t-statistic		Estimate	t-statistic		Estimate	t-statistic		Estimate	t-statistic	
All Passengers																		
TC μ	-0.04	-9.00	***	-0.04	-8.85	***	-0.04	-8.98	***	-0.04	-8.92	***	-0.04	-8.95	***	-0.04	-8.94	***
IVTT μ	-0.02	-3.99	***	-0.02	-3.88	***	-0.02	-3.87	***	-0.02	-3.87	***	-0.02	-3.80	***	-0.02	-3.82	***
OVTT μ	-0.03	-2.87	***	-0.04	-2.83	***	-0.03	-2.54	**	-0.03	-2.58	***	-0.03	-2.70	***	-0.03	-2.67	***
TC σ	0.04	7.58	***	0.04	7.53	***	0.04	7.48	***	0.04	7.39	***	0.04	7.53	***	0.04	7.54	***
IVTT σ	0.02	2.95	***	0.03	3.08	***	0.02	2.96	***	0.03	3.02	***	0.02	2.79	***	0.02	2.86	***
OVTT σ	0.03	2.42	**	0.05	2.78	***	0.03	1.92	*	0.03	1.97	**	0.04	2.39	**	0.03	2.30	**
Business passengers																		
TC μ	-0.04	-4.11	***	-0.04	-4.05	***	-0.04	-4.10	***	-0.04	-4.11	***	-0.04	-4.11	***	-0.04	-4.11	***
IVTT μ	-0.03	-1.67	*	-0.03	-1.53		-0.03	-1.68	*	-0.03	-1.68	*	-0.03	-1.66	*	-0.03	-1.66	*
OVTT μ	-0.08	-1.96	**	-0.08	-1.66	*	-0.05	-1.32		-0.05	-1.29		-0.05	-1.31		-0.05	-1.31	
TC σ	0.04	4.13	***	0.04	4.04	***	0.04	4.13	***	0.05	4.14	***	0.05	4.14	***	0.05	4.14	***
IVTT σ	0.04	1.78	*	0.04	1.69	*	0.04	1.84	*	0.05	1.91	*	0.04	1.85	*	0.04	1.85	*
OVTT σ	0.09	2.07	**	0.09	1.68	*	0.05	1.20		0.06	1.19		0.06	1.17		0.06	1.17	
Non-Business passengers																		
TC μ	-0.04	-7.93	***	-0.04	-7.67	***	-0.04	-7.80	***	-0.04	-7.73	***	-0.04	-7.73	***	-0.04	-7.73	***
IVTT μ	-0.02	-3.83	***	-0.02	-3.38	***	-0.02	-3.38	***	-0.02	-3.40	***	-0.02	-3.27	***	-0.02	-3.27	***
OVTT μ	-0.02	-2.51	**	-0.03	-2.65	***	-0.04	-2.64	***	-0.03	-2.46	**	-0.04	-2.68	***	-0.04	-2.68	***
TC σ	0.03	4.44	***	0.03	4.14	***	0.03	4.37	***	0.03	4.26	***	0.03	4.18	***	0.03	4.18	***
IVTT σ	0.02	3.18	***	0.02	1.64		0.02	1.47		0.02	1.34		0.01	1.19		0.01	1.19	
OVTT σ	0.00	0.15		0.05	2.92	***	0.05	2.83	***	0.04	2.43	**	0.05	2.96	***	0.05	2.96	***

Table A2. Random coefficient estimates with different number of (Halton) draws