The Cagliari Airport impact on Sardinia tourism: a Logit-based analysis

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The Cagliari Airport impact on Sardinia tourism: a Logit-based analysis

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Abstract

In the field of air transportation management, traditionally, airlines have been the main actors in the process for deciding which new flights 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 consequent reduction of the airports' fares, as well as the increment of the density of regional airports in several European countries are modifying the mutual roles of airlines and airports. The final decision on new flight to be opened, in fact, is nowadays the result of a negotiation between airlines and airports. 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 along two axes. From the pure transportation literature point of view, we introduce a Logit model able to predict the passengers flow in an airport when the management introduces a change in the flight schedule. The model is also able to predict the impact of this change on the airports in the surrounding areas. The second contribution is a case study on the tourist market of the Sardinia region, where we show how to use the results of the model to deduce the economic impact of the decisions of the management of the Cagliari airport on its catchment area in terms of tourists and economic growth.

Keywords: Logit models; Air Flow Forecasts; Economic Impact Extimation

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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 implies to study the demand, supply and the economic and spatial relationship between the different involved actors (airlines, airport management, passengers, public stakeholders). Traditionally, airlines have been the main

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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 the airports' fares, as well as the increment of the density of regional airports in several European countries are modifying the mutual roles of airlines and airports. The final decision on the new flight to be opened, in fact, is nowadays the result of a negotiation between airlines and airports.

On the one hand, airports must ensure the new routes sustainability and satisfy the primary needs of the passengers in the catchment area. On the other hand, public stakeholders (regional councils and municipalities) ask airports management to measure the economic impact of opened flights in order to grant a financial support (Perboli et al., 2011b). Hence, passengers have a double nature: users of airport services and investors through the public stakeholders. Analogously, evaluating the airport efficiency can be seen from two different perspectives: on one side the airports aim to evaluate the passenger flows, the market share, and the passenger satisfaction; on the other side public stakeholders are interested in evaluating the return of investments in terms of benefit for the territory (e.g., tourism impact). Then, from the point of view of airports management, they become an active actor in the process contacting the airlines that are more suitable with their stakeholders or, due to their lack of financial resources, they have to choose in a set of possible destinations provided by the airlines. To facilitate this process, specific workshops as Routes Europe have been recently introduced. In these meetings airlines, airports, public stakeholders and tourism authorities meet each other, in order to share common growth strategies, to negotiate and to build relationships (Routes, 2012).

In order to understand this important phenomenon, it is necessary to model the competition in the system and measure the impact of the transformations, as well as to develop new methods for dealing with decisions inherent the potential profit and traffic increase due to changes in their offers (IATA, 2008, 2010). This issue is interesting not only from a practical point of view, due to its relevant economic impact, but also for its research impact. In fact, the complexity of the systems and the strong relationship between the different actors make the problem challenging also from the point of view of the transportation systems research.

This paper contributes to advance the current state-of-the-art along two axes. First, it introduces a Logit model able to forecast passengers' flows generated by a change in the airport schedules, dealing with the uncertainty due to passengers' choice. Second, the method is applied to study the economic impact of air flows in terms of tourism revenues. In order to deal with this goal, we will present how the data coming from public database can be crosschecked in order to build the dataset necessary for tuning the model, as well as to evaluate the economic impact of the tourist flows. The overall methodology is applied to a real case study: the Cagliari airport and its surrounding area.

The paper is organized as follows. Section 2 presents the problem in details and give a quick review of the main literature. Section 3 is devoted to present the two-echelon Logit model used to predict the impact and a schedule change in Cagliari airport. Section 4 gives a detailed description of the procedure used to build the economic impact assessment using the Sardinia case study as an example of application. Finally Section 5presents the results of a critical analysis of the results.

2. Problem description and state of the art

Given a set of origins of the tourist flows, a set of possible destinations, and a set of intermediate transit points, the airports, we aim to determine a model representing the flows while considering the airport schedule, the accessibility of the tourist destination from the airport area, the cost of the flight and the attractiveness of the destination region for the tourists. Given that model, we introduce a change in a target airport schedule (Cagliari, in our case), and we forecast the new tourist flows, as well as their expected economic impact.

While several applications of Logit Models can be found in other research field, as location and transportation (Tadei et al., 2009; Baik et al., 2008), the literature on airport-choice modeling mostly focused on two geographical areas: the San Francisco Bay area and the United Kingdom one (Pels et al., 2003; Hess and Polak, 2006). Moreover, even when considering the overall literature, it is mainly focused on large or hub airports, whose catchment areas are not shared between several airports. In addition, these studies are more focused on the pure transportation issues, marginally considering the economic impact of the changes in the airport schedules on the surrounding area and without giving a detailed description of how the economic data have been gathered (Perboli et al., 2011a).

3. Logit model

The mostly part of the modeling and optimization methods in the literature focuses on one of the actors involved in the airport system (users, airport managers, government agencies and airlines), usually simplifying the complex cause-effect relationships between decision makers, in particular the choice behavior of passengers, and the uncertainties on demand or offer forecasts. Indeed, in air transportation one of the most frequent source of errors are due to passengers flows and their profiling according to given sub-categories, as well as the uncertainty about the demand in terms of passengers for each airport flight.

The base of our forecasting method is a specialization of the economic and spatial interaction Logit model presented in Perboli et al. (2011a). In this work, we focus on the two-level Logit model that can represent intermodal or transshipment transportation networks. Throughout this section, subscript ^ and ~ will stand for the observed and estimated values, i.e. the values given to the Logit as input by simulator and the flows obtained after a parameter calibration, respectively.

Given a set of n tourist origins, a set of m intermediate airports and a set of r destinations, we define:

- identifier of origins $i \in \{1, ..., n\}$;
- identifier of intermediate points $j \in \{1, ..., m\}$;
- identifier of destination $k \in \{1, ..., r\}$;
- observed flows $\hat{\mathbf{T}} \in \Re^{n \times m \times l}$, i.e. elements $\hat{T}_{ij}^{k}$ give the number of passengers depart between i and k using the intermediate airport j;
- generalized flight cost matrix $\hat{\mathbf{C}}_{\mathbf{f}} \in \Re^{n \times m}$, i.e. elements $\hat{C}_{f\,ij}$ give the travel cost of the flight arriving in j and departing from the origin i;
- generalized travel cost matrix $\hat{\mathbf{C}}_{\mathbf{t}} \in \Re^{m \times l}$, i.e. elements $\hat{C}_{t\,j}^{\,k}$ give a possible travel cost between an intermediate point j and the destination k;
- average total cost $\bar{c}$, obtained as the weighted sum of the costs and the tourist flows.

Let us also define the destination-dependent supply vector $\mathbf{o}^{k} \in \Re^{n}$ of the origins, the total number of passengers at the intermediate points $\mathbf{d} \in \Re^{m}$ and the total demand of the destinations $\mathbf{r} \in \Re^{l}$ as follows:

$$\mathbf{o}^{k} = \sum_{j} \hat{T}_{ij}^{k}, \forall i, k$$

$$\mathbf{d} = \sum_{i,k} \hat{T}_{ij}^{k}, \forall j$$

$$\mathbf{r} = \sum_{i,j} \hat{T}_{ij}^{k}, \forall k .$$

The aim is to define a proper model for the estimated flows matrix $\tilde{\mathbf{T}}$ considering both the airport and flight characteristics, as well as the peculiar features of the destination. This model must be able to reproduce the matrix of the observed flows $\hat{\mathbf{T}}$.

The analytical expression for the flows is given by

$$\tilde{T}_{ij}'^{k} = o_i^k \frac{w_j \psi^k e^{-\beta\left(\hat{C}_{f_{ij}} + \hat{C}_{t_j}^k\right)}}{\sum_{j,k} w_j \psi^k e^{-\beta\left(\hat{C}_{f_{ij}} + \hat{C}_{t_j}^k\right)}},$$

where $\mathbf{w} \in \Re^m$ is an attraction factor of the intermediate points, $\boldsymbol{\psi} \in \Re^l$ is an attraction factor of the destinations and β is a distance decay parameter.

In order to predict a change in the system due to a new flight or a schedule change, the system parameters $\mathbf{w}$, $\boldsymbol{\psi}$ and β must be calibrated and such that they reproduce the observed flows $\hat{\mathbf{T}}$. This is done by means of the following parameter estimation calibration phase (see Perboli et al., (2011a) for further details on the models and the parameter estimation).

- Initialization. Set $\beta_0 = \frac{2}{\bar{c}}$ and $\boldsymbol{\psi}_0 = \mathbf{1}$
- While the values of $\mathbf{w}$, $\boldsymbol{\psi}$ and β changes over a given threshold or a maximum number of iterations is not reached
  - Given $\beta_{\tau-1}$ and $\boldsymbol{\psi}_{\tau-1}$, find the values of $\mathbf{w}_\tau$ which are the roots of the system

$$d_j - \sum_{i,k} \tilde{T}_{ij}'^{k} = 0, \forall j$$

  - Given $\beta_{\tau-1}$ and $\mathbf{w}_\tau$, find the values of $\boldsymbol{\psi}_\tau$ which are the roots of the system

$$r^k - \sum_{i,j} \tilde{T}_{ij}'^{k} = 0, \forall k$$

  - Given $\boldsymbol{\psi}_\tau$ and $\mathbf{w}_\tau$, find the values of β_τ which are the roots of the system

$$\sum_{i,j}\left(\hat{C}_{f_{ij}} + \hat{C}_{t_j}^{k} - \bar{c}\right)\tilde{T}_{ij}'^{k} = 0$$

- Find a correlation between $\mathbf{w}$ and the economic and structural features of the corresponding intermediate points $\hat{\mathbf{\Pi}}$. Every row of the matrix $\hat{\mathbf{\Pi}}$ represents a different operative lever. This is done by a logarithmic transformation of the attraction factors estimated through linear regression. The correlation between $\mathbf{w}$ and two regression coefficients $\boldsymbol{\alpha}_w$ and δ_w is $\ln(\mathbf{w}) = \boldsymbol{\alpha}_w \hat{\mathbf{\Pi}} + \delta_w$.
- Find a correlation between $\boldsymbol{\psi}$ and the economic and structural features of the destination, indicated in the matrix $\hat{\mathbf{\Omega}}$. The correlation between $\boldsymbol{\psi}$ and two regression coefficients $\boldsymbol{\alpha}_\psi$ and δ_ψ is $\ln(\boldsymbol{\psi}) = \boldsymbol{\alpha}_\psi \hat{\Omega} + \delta_\psi$.

The calibration of $\mathbf{w}$, $\boldsymbol{\psi}$ and β is implemented by means of a fixed point algorithm, while the values of $\boldsymbol{\alpha}_w$, $\boldsymbol{\alpha}_\psi$, δ_w and δ_ψ are obtained by a linear regression. Even if the parameters have been accurately calibrated, it is not possible to take into account all the economic and structural features of the system. Thus, these factors are considered by a perturbation matrix $\mathbf{\Theta} \in \Re^{n\times m\times l}$. This matrix is defined by the ratio of observed flow in passenger ($\hat{\mathbf{T}}$) to computed flow with Logit model ($\tilde{\mathbf{T}}'$). Thus, each Θ_{ij}^{k} of $\mathbf{\Theta} \in \Re^{n\times m\times l}$ measures in percentage the impact of these unknown factors on the flow (i, j, k).Thus, the expression of the estimated flows becomes

$$\tilde{T}_{ij}^{k} = o_i^k \frac{\Theta_{ij}^{k} e^{\alpha_w \hat{\Pi}_j + \delta_w} e^{\alpha_\psi \hat{\Omega}_k + \delta_\psi} e^{-\beta\left(\hat{C}_{f_{ij}} + \hat{C}_{t_j}^{k}\right)}}{\sum_{j,k} \Theta_{ij}^{k} e^{\alpha_w \hat{\Pi}_j + \delta_w} e^{\alpha_\psi \hat{\Omega}_k + \delta_\psi} e^{-\beta\left(\hat{C}_{f_{ij}} + \hat{C}_{t_j}^{k}\right)}}.$$

4. Economic impact assessment process

In order to calibrate the model and to simulate the changes due to the introduction of a new schedule, which is the basic information needed to estimate the economic impact of this schedule change, 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 and cost for the rental car; presence of the direct flight. In the following we present how the different quantities can be deduced from public database.

4.1. Sardinia tourist region description

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, gaining more than 13% with respect to the previous year.

The logic of airport development is based on the possibility to properly identify and profile its potential customers, in order to identify potential groups of users 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 customers, it is essential to consider the characteristics and attractiveness of the area, as these aspects may confer a particular specialization at the airport. The 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 potential routes to develop, the starting point is the analysis of Sardinia airports data to outline a general idea of the airport and the Sardinia region situation. Historical data (Enac, 2010; 2009) 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 an estimation of the loading factors of the airplanes given by the mean loading factors in the past three years (Enac, 2010; 2009; 2008). 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.

4.2. Analysis of the tourist 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 ISTAT (2011;

2010) demonstrates that in 2009 more than 60% of tourists from Finland, Sweden, Denmark and Ireland stayed in the macro area of Alghero, which operates almost exclusively the connections to and from these countries. 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 arrivals 2009 (ISTAT, 2011), 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.

4.3. 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 close 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 k 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 another, 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 control levers considered in the simulation are one for the airport operations and one related to the socioeconomic situation of the tourist region around each airport. The airport lever depends on the presence or absence of direct flights between the airport and the origins. The economic lever is a measure of customer satisfaction of the destination 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. The times considered were calculated thanks to the implementation of Google Maps. This study allows knowing the tourist competition between the three airports and to proceed with the cross-analysis of tourist and airport data. This analysis basically 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 k, are collapsed in a macro destination representing Sardinia and the eventual other tourist areas considered in this study, e.g. Rimini area (See Figure 1).

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 we have calculated an average cost of a typical holiday. The cost of accommodation has been estimated with a telephone and online survey to the several hotels to check the price during the high and the low season and then we have calculated the average cost.

The documents by ISTAT (2011; 2010) reveal that 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 the island 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.

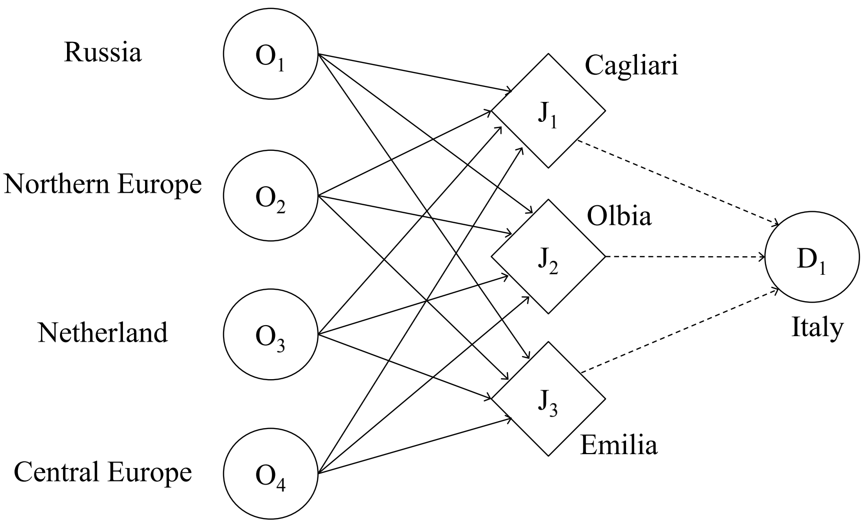

Figure 1: Representation of the system model used in this study

5. Analysis of the results

In the following we analyze the results obtained after the calibration of the model. The coherence calibration has been checked as in Perboli et al., (2011a). Moreover, all the results (flows after the calibration and what-if analyses) have been checked by trained staff of BDS Consulting s.r.l. and CAG airport members.

According to the results presented in Section 4, we focus our what-if analysis on the opening of a direct route between Russia and CAG airport. In more details, we test the following scenarios:

- CAG Airport opens a direct flight to Russia in the high season: months like July and August represent the high tourist season and as a consequence the period of strongest competition between Cagliari and Rimini. In terms of values, the price of the flight Cagliari – Russia is halved;
- Measure of the reaction of Olbia Airport, which opens a direct flight to Russia: it is easy to presume that in other to maintain its competitiveness on the market, Olbia Airport would open a new route with Russia. This reaction would lead to bring out an internal island competition.
- CAG Airport opens a direct flight to Russia in the low season: June, September, and October represent the low tourist season during which Sardinia continues to be attractive thanks to its favorable climate, while Rimini decreases significantly its attractiveness. To simulate this situation, we can presume that Cagliari matches the price of the tourist infrastructure of Rimini.

The first simulation consists in opening a direct flight between Cagliari and Russia in the high season (July and August) which includes the reduction of the cost of the ticket. Currently, the connection with Russia requires at least one stop at the airport of Rome. The new simulated tourist flow is showed in Table 1. The increase of Russian tourists in the Cagliari’s area is estimated to be about 90%. From an economic point of view, the analysis of ISTAT (2011), revenues on the territory from direct effects can be valued to about 12 million euros. Rimini airport, despite being the competitor that has contributed most to the flow of new avionics offer, cannot respond to reductions of tourists as already offers a direct flight from Russia.

Let us now assume that the new route between Russia and Cagliari has become a reality. Olbia could now open a direct flight from Russia to address the cascading effects of the new offer of CAG Airport. The simulation results in

Table 2 shows an increase of tourists in the Olbia area of 124% and a negligible variation in the close area of Cagliari. Consequently, the two open routes can coexist.

The last simulation consists in opening a direct route between Russia and Cagliari in low season (June, September and October) which involves, in addition to the reduction of the flight ticket, a decrease of the cost of subsistence in the territory. In fact, in this period the hotels offer some discounted fares. Table 3 shows an increase of Russian tourists by 225% which, in an economic point of view, corresponds to an income of about 20 million euros.

Table 1.New Russia-CAG Flight – high season. The table reports the observed flow (T), the flow after the opening of the direct flight Cagliari-Russia in high season (T_D) and its variation (ΔT_D).

	Cagliari	Olbia	Emilia
T	6908	4534	74705
$\mathbf{T}_D$	13125	4216	68728
$\Delta\mathbf{T}_D$	+ 90%	- 7%	- 8%

Table 2.Olbia reaction. The table reports the observed flow (T), the flow after both airports in Sardinia open the direct flight to Russia in high season (T_D) and its variation (ΔT_D).

	Cagliari	Olbia	Emilia
T	6908	4534	74705
$\mathbf{T}_D$	12158	10156	63499
$\Delta\mathbf{T}_D$	+ 76%	+ 124%	- 15%

Table 3.New Russia-CAG Flight – high and low season. The table reports the observed flow (T), the flow after the opening of the direct flight Cagliari-Russia in low season (T_D) and its variation (ΔT_D).

	Cagliari	Olbia	Emilia
T	6908	4534	74705
$\mathbf{T}_D$	22451	3627	59764
$\Delta\mathbf{T}_D$	+ 225%	- 20%	- 20%

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