Train vs. airplane: investigating the potential modal share shift and the environmental impact for a reduced train travel time from Thessaloniki to Athens

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Abstract. This paper investigates the impact of routing a train between Athens and Thessaloniki, completing the journey in 2.5 hours, on modal share. With high expectations for the modernization of the Greek railway system, particularly the Athens-Thessaloniki route, and recent tragic events involving the railway, this study aims to shed light on the potential effects of such an improvement. A questionnaire survey was conducted at Thessaloniki Airport "Makedonia" to gather data on travel time, ticket prices, and other factors influencing travelers' mode choices for the Athens-Thessaloniki route. The survey included 181 participants, most of whom had an income equal to or below the average monthly income. Results revealed that if the new rail system was implemented at equal cost, 63% of respondents would choose the train over the airplane, citing long transit times, waiting time, extra costs, and luggage restrictions as primary factors favoring the train. However, 8% expressed concerns about the reliability and adherence to estimated travel times. Overall, the research concludes that, despite the recent tragedy, the modernized train system could significantly increase its modal share and offer positive environmental benefits by reducing the journey time to 2.5 hours.

1 Introduction

Rail transport is perhaps the only technology which, during its evolution, has experienced a significant boom, then was quite controversial and in the last decades has not only recovered but has become a cutting-edge technology for many countries. The railway, as a means of land transport, fully prevailed between 1830 and 1950, performing at the same time great work both in terms of transport and culture. The development of the hinterland of all continents during the above period was mainly due to the railway. Without its existence, only the coastal regions would have developed, as they had the exclusive privilege of maritime transport.

Over the last 30 years, substantial environmental problems have arisen, due to several factors, such as urbanization, the increase in air pollution and noise, the ongoing energy crisis, and the dramatic increase in traffic congestion on roads and airports. All these factors have led and continue to lead to the development of rail transport, both for suburban and urban transport and for long-distance services to cover the needs of the population, as rail transport is more environmentally friendly compared to private cars and heavy trucks [1].

This is the reason why rail transport is promoted by the European Union in the general frame of promoting green transportation, according also to the new European Green Deal [2-3].

The importance of rail passenger transport, however, also lies in the advantages that a journey by train offers. Firstly, the transport capacity is greater than any other means. The development of high speeds and the safety offered in rail transport make the railways highly competitive. Also, the possibility of traveling regardless of weather conditions and the freedom of movement in the train, which is not the case with any other means of transportation, is a great attraction for the traveler. Finally, it satisfies the philosophy of many people regarding environmental awareness [1].

The subject of this paper is to investigate the redistribution of traffic (modal shift) on the route between Athens and Thessaloniki and vice versa after the launch of a suitable train that will cover the distance between the two cities in 2 hours and 30 minutes. The investigation is between air and rail transportation, as it was considered that passenger traffic with cars and buses would not be significantly affected. The main justification for this consideration is that the bus is a mode that serves several intermediate areas of the route and still offers travel at low fares. As regards cars, it was considered that they are used for personal purposes at the destination, so their ridership is not affected [4]. On the contrary, the airplane and the train compete for, more or less, the same target group of travelers on this specific route, as they have common characteristics in terms of cost and time.

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The aim of this paper is to present results on possible future changes in the modal split as well as to make proposals resulting from the investigation of travelers' preferences.

The methodology followed is to conduct a literature review and then an in-person questionnaire survey to investigate the wishes and intentions of travelers.

As regards the structure of the rest of the paper, the criteria that lead to the choice of transport mode are first defined (Chapter 2), then the current transportation mode options and the prospect of rapid transport between the two cities are presented (Chapter 3), afterward, the methodology (Chapters 4) of the research is analyzed, and the results are presented (Chapters 5), to reach to the discussion (Chapter 6), conclusions and recommendations resulting from the research.

2 Criteria for the choice of means of transport

The allocation of trips by means of passenger transport has the share of passenger trips to the respective means of transportation as its main objective. The allocation of movements of people takes place according to several key factors influencing the traveler's modal choice. Below, some of these criteria are mentioned for freight and passenger transportation. Nevertheless, this is a comparative study between airplane and train for a modified train travel time, and, therefore, for this paper, this is the most important factor.

2.1 Criteria based on the type and purpose of the journey

Transport is mainly divided into two (2) categories, passenger transport and freight transport.

Regarding freight transport, the criteria which influence the choice of the means of transport are numerous and vary mainly according to the goods to be transported. In addition, the time taken to cover the journey and the conditions under which it is carried out are essential factors in the choice. Finally, particular importance is placed on safety and the possibilities offered by the terminals for further transporting and storing the goods. The purpose for which the transport is made plays a particular role in the selection of the means of transportation, as movements with different purposes have different characteristics, such as [5]:

- Route length.
- Time flexibility.
- Trip duration.

2.2 Criteria based on cost and quality

In addition to the criteria based on the type and purpose of the journey, the decision on the means of transport also depends on factors related to the quality and cost of the transport services. These criteria suggest that the characteristics of the transport services could influence the choice of means of transportation [5].

Quality and cost criteria are usually treated as a group, as most of the time, cost alone is not an essential factor in the choice of a transport means but is significantly influenced by the quality of the services provided. The quality criteria are defined by the following [5]:

- Flexibility.
- Reliability.
- Security.
- Journey duration.
- Preparation time.
- Waiting time.
- Status of installation sites and parking conditions.

Travel cost is defined as the amount paid to purchase transport services. Cost criteria are defined by the following [5]:

- Financial situation.
- Payment method.
- Possibility of paying a reduced fare.
- Variation of the ticket price based on the time of purchase.
- Possibility of cancellation or change of the selected route.

3 The case of travel between Thessaloniki to Athens and vice versa

Athens and Thessaloniki are the two largest and most important cities in Greece. The importance of Thessaloniki as a freight hub of the Balkans and Athens as the capital of Greece, combined with the existence of the largest port in Greece, that of Piraeus, make the connection between the two cities necessary. The same goes regarding the fact that these cities have the largest student population in Greece, meaning that many students who study in Thessaloniki are from Athens and vice versa [4]. Moreover, the development of the two cities as important industrial and economic poles further increase the need for the existence and continuous upgrading of the transport connection between the two cities.

3.1 Available modes of transport

For passenger transport between Athens-Thessaloniki the following modes are available [4]:

- Train.
- Bus.
- Airplane.
- Private vehicle.

The following information was valid during the period of the questionnaire survey, i.e., in 2017, and we present them here for the reader to understand what was compared with what [6-8].

3.1.1 Train

It started operating in 1904 and is one of the oldest means of transport connecting Athens with Thessaloniki and vice versa.

The length of the line was 508.6 km. The duration of the journey was 5 hours and 30 minutes. The evening train service performed the trip for an average time of 7 hours. The itineraries were as follows [6]:

• Itineraries from Athens: 07:18, 10:18, 12:18, 14:18, 16:18, 18:18, & 23:55.

• Itineraries from Thessaloniki: 05:13, 07:04, 10:04, 12:04, 15:04, 18:04, & 23:00.

The ticket cost at the counter ranged between €45 and €55, depending on the seat class. However, there were several ways to reduce the ticket price. Firstly, if the ticket was purchased online, there was a 10% discount, and if a return ticket was purchased, there was a 15% discount. If a return ticket was purchased online, the discount was 20%. Also, there were discount groups of passengers (children, elderly, students, soldiers, large families, people with disability, etc.) Finally, if the purchase was made with one of the Youth Cards up to two (2) days before departure, the ticket price was 12 euros, one way [6].

3.1.2 Bus

In the past, there were two different companies that operated the Athens to Thessaloniki route and vice versa, the KTEL THESSALONIKI and the KTEL ATTIKIS. These two companies have merged this route, and it is common.

The journey duration was six (6) hours, which varied depending on the traffic load and stops. The itineraries were as follows [7]:

• Itineraries from Athens: 06:30, 07:30, 09:30, 09:30, 11:30, 13:00, 14:30, 16:00, 17:30, 19:00, 22:30, & 23:30. The routes from Athens were starting from "Pedio tou Areos" and were making one stop at the "Kifissos" Intercity Bus Station. The 07:30 and 22:30 routes also stopped at the port of Piraeus.

• Itineraries from Thessaloniki: 07:15, 08:30, 10:00, 12:00, 13:30, 15:00, 16:30, 18:00, 21:00, 23:00, & 24:00. The routes from Thessaloniki were starting from the "New Railway Station" of Thessaloniki and were making one stop at the "Makedonia" Intercity Bus Station. The first and the last route ended in Piraeus.

The ticket cost was €45 one way and €65 for a return ticket. There were, however, several ways to reduce the ticket price. First, the price was reduced by 10% for the online purchase of the ticket. In addition, for each route, a limited number of tickets were available for €9 and €15. Finally, discounts were offered to special groups (elderly, students, military, people with disability, large families, uniformed persons, etc.) [7].

3.1.3 Airplane

After the rise of low-cost airlines, the choice of airplane travel between Athens and Thessaloniki and vice versa has become dominant. The main reason is the sharp drop in prices due to competition, compared to the previous situation of no competition.

When the questionnaire survey took place, more than four (4) companies were operating daily on this route [7].

Almost always, the journey takes 50-60 minutes. Of course, at this time, the passenger must add another one (1) hour of waiting before departure and the trips between the cities and the airport. All in all, the duration of the journey is between two (2) hours and 30 minutes and four (4) hours [7].

There are many routes throughout the day and night. For example, the number of routes from Athens was several times 20, while the number of routes from Thessaloniki was usually 12 per day [7].

The ticket price for the Athens to Thessaloniki route depends mainly on the time of purchase. Usually, the earlier the ticket is purchased, the lower the price, but everything depends on the supply and demand factor. The lowest prices started at around €20-€30 one way and went up to €40-€60 for a round trip. The above prices were the prices of the most economical tickets. More generally, prices ranged from €20-€70 one way and €40-€120 for a round trip [7].

However, traveling by airplane has many parameters that need to be considered, such as luggage, seating comfort, airport location and access, airport taxes, security, the possibility of changing reservations, etc. [7].

3.1.4 Car / private vehicle

The kilometers between Athens and Thessaloniki were covered by car in five (5) hours, depending on the traffic and the speed of the driver. If there is no traffic to cover this distance in the above time, a driver might not need to develop high speeds, which means low fuel consumption. In this case, an average car would have consumed around €55.43 of fuel. Including tolls, which cost €30.65, the total journey cost would have been €86. This cost was relatively low for a family of four (4) people or a family. But it becomes higher if one travels at higher speeds to reach the destination in a shorter time, and as we all know, time is money. Nevertheless, even then, the cost was high enough if the driver traveled alone, without family members or friends.

3.2 The prospect of rapid transit by train

When the questionnaire survey took place, i.e., in 2017, the company with exclusive rights to rail transport operation in Greece was TRAINOSE.

After being included in various investment programs, projects are being carried out to complete the railway line between Athens and Thessaloniki and the electrification along the entire length of the line. Initially, the plan concerned the opening of the Othrios tunnel by 2018. The Othrios tunnel has a length of 6.5 km per branch, and its design could allow for speeds of 160 km/h so that the journey would be reduced by 2 km and the journey time by 30 minutes [9].

With the completion of the Tithorea-Lianokladi-Domokos project in 2017, the Athens-Lianokladi route would take up to 90 minutes; the Athens-Domokos would take up to 108 minutes, while the Athens-Thessaloniki route will not exceed 3.5 hours. The project budget, which would be completed in two years from 2017, was €52,753,400, and after the discount (22.35%) was €41,297,174.41. As part of the project [9]:

• The signaling and telecommand systems would be upgraded and restored so that they returned to their good working condition and upgraded by adding new functions.
• An optical fiber cable would be installed.
• The copper wiring would be protected against theft and sabotage.
• The stations between Oinoe-Dafleia and between Domokos-Larissa would be upgraded.
• The Thessaloniki-Kilkis line would be restored in the Nea Philadelphia and Galliko section.

However, with the inclusion of TRAINOSE in the Hellenic Republic Asset Development Fund, the acquisition of TRAINOSE by the Italian Ferrovie Dello Stato Italiane was foreseen at that time and realized later. As had been announced by the management of the Italian company, its main objective was the development of passenger rail transport, and according to the company, in 2020, the Athens-Thessaloniki route would be carried out in 2 hours and 30 minutes (!), with high-speed trains of more than 200 km/hour, with rolling stock coming, most likely, from Italy [9].

Today, in 2023, we know that this promise was never realized. On the contrary, the recent tragedy of the Tempi railway accident proved that the Greek railway system's running conditions were inadequate. Nevertheless, this tragedy raised the question of whether a high-speed, efficient, and safe train route from Athens to Thessaloniki and vice versa is worth developing and if it can compete with the respective air transport routes. In this light, our questionnaire survey became once again timely.

4 Methodology

A relevant questionnaire survey took place based on travel time, ticket prices, and other factors that could affect the choice of transport mode for the Athens-Thessaloniki route. The questionnaire survey took place in person in the Thessaloniki Airport "Makedonia" where travelers who chose an airplane for their trip to Athens were interviewed about their modal choice in case there was an operational train route to Athens that would realize the journey in 2.5 hours, as were the expectations from relevant announcements and newspaper publications [9].

4.1 Methodology of analysis

The theoretical framework presented in the previous chapters provided the framework within which the process of transport mode selection usually takes place.

The methodology followed belongs to the "analytical" method of approach and aims to investigate the possible choice of the train as a means of transport, compared to the airplane, in case of reduction of travel time as well as the relationship of cost with this choice.

More specifically, the methodology followed is as follows:

• Formulation of questionnaires to obtain an analytical picture of the situation regarding the process and factors influencing the decision to choose a means of transport.
• Conducting a questionnaire survey for the completion of the above questionnaires. The survey involved people who had chosen the airplane as a means of transport.
• Evaluation and statistical analysis of the results of the questionnaire survey to get an overview of the selection process and the possible modal shift from airplane to train in case the new high-speed train will indeed be developed and realize the Athens-Thessaloniki route and vice versa in 2 hours and 30 minutes, as promised by the new railway operator.

4.2 Design of the questionnaire

The objectives pursued with the questionnaire can be summarized as follows:

• Collection of demographic data of travelers.
• Collection of data on the choice of the airplane as a means of transport (ticket cost, time of purchase).
• Investigate the likelihood of choosing a train over an airplane based on journey time and ticket price.
• Investigation of additional factors that played a role in the response.
• Investigation of the final choice of the means of transport.

The questionnaire consists of four main parts:

1. General demographic questions (1-3):
   In this first part, survey participants were asked to indicate the age group to which they belonged, their main occupation and the income group to which they belonged.
2. Questions regarding the chosen mode of transport (4-5):
   In the second part, participants were asked to answer questions regarding the price and the time of ticket purchase.
3. Questions regarding the possibility of choosing the train option (6-8):
   In this category, participants were first asked whether they would choose to travel by train at the price they bought the airplane ticket, which covers the distance of 2 hours and 30 minutes.
   They were then asked about the price at which they would choose such a trip compared to the price at which they bought the airplane ticket. This question was asked in parts, proposing twice the price as an option and concluding, by subtraction, with a price equal to the airplane ticket.

The questionnaire survey took place in person at the International Thessaloniki Airport "Makedonia." The fact that the survey was not an online survey adds to the credibility of the results.

5 Results

A total of one hundred and eighty-one (181) people aged between eighteen (18) and sixty-five (65) years old who were traveling or had recently traveled from the International Thessaloniki Airport "Makedonia" to the International Athens Airport "Eleftherios Venizelos" participated in the survey.

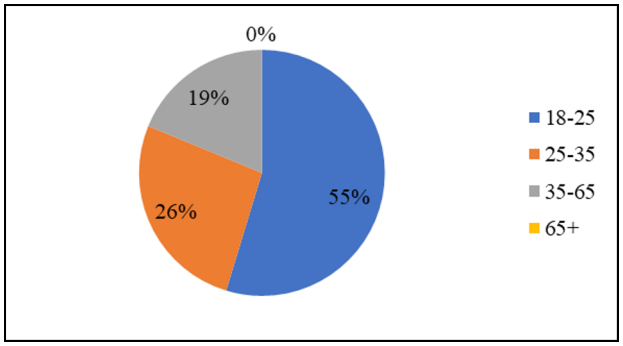

Fig. 1. Age distribution of the sample.

As shown in Fig. 1, the age distribution of the participants was as follows:
• 18-25 years old: 55%.
• 25-35 years old: 26%.
• 35-65 years old: 19%.
• 65+ years old: 0%.

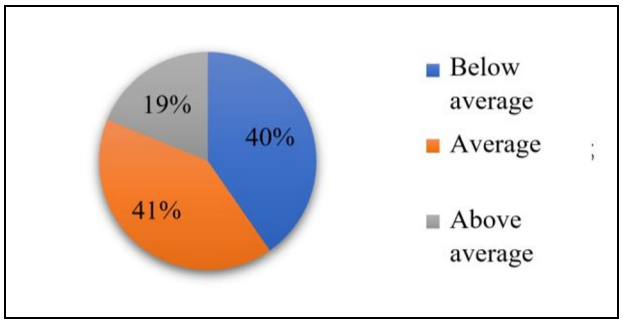

Fig. 2. Income distribution of the sample.

As shown in Fig. 2, the income distribution of the participants was as follows:
• Below average: 40%.
• Average: 41%.
• Above average: 19%.

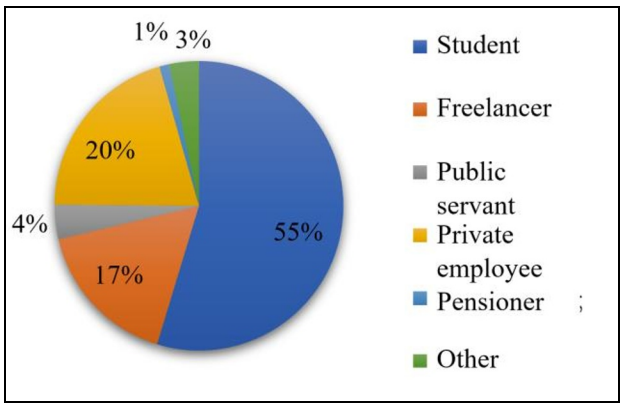

Fig. 3. Profession distribution of the sample.

As shown in Fig. 3, the sample consisted of the following professions:
• Student: 55%.
• Freelancer: 17%.
• Public servant: 4%.
• Private employee: 20%.
• Pensioner: 1%.
• Other: 3%.

From the above, it is seen that the majority were students, freelancers, and private employees, and 81% of the participants indicated that their monthly income was no more than the average.

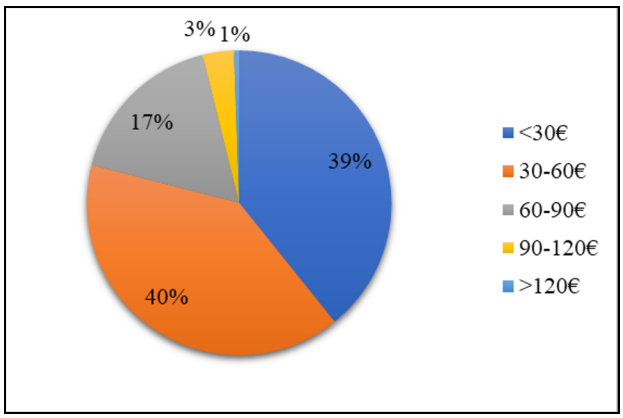

Fig. 4. Distribution of airfare prices.

As shown in Fig. 4, 39% of the respondents paid less than €30 for their air ticket for the Thessaloniki-Athens route, and 40% paid between €30 and €60. 17% paid between €60 and €90, 3% between €90 and €120, and 1% more than €120.

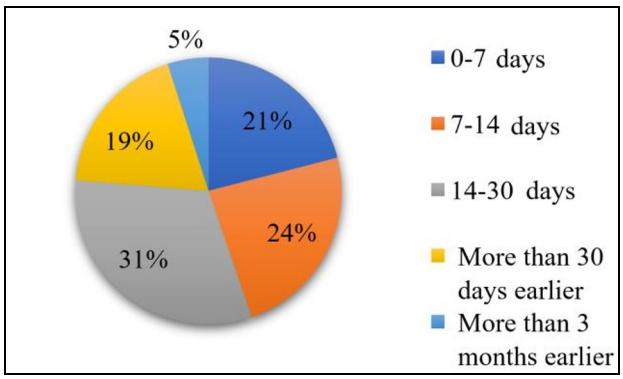

Fig. 5. Distribution of how many days earlier the ticket purchase took place.

As shown in Fig. 5, the time of purchase of tickets varies. Most passengers (31%) bought their ticket 14 to 30 earlier, 24% bought their ticket 7-14 days earlier, 21% bought their ticket 0-7 days before the trip, 19% bought their ticket more than 30 days earlier, and only 5% bought their ticket more than three months earlier.

It seems that more than half of the respondents bought their ticket between 7 to 30 before their trip, perhaps trying to find the best possible offer.

Following, questions regarding the possibility of choosing the train option were posed, and the results are presented below.

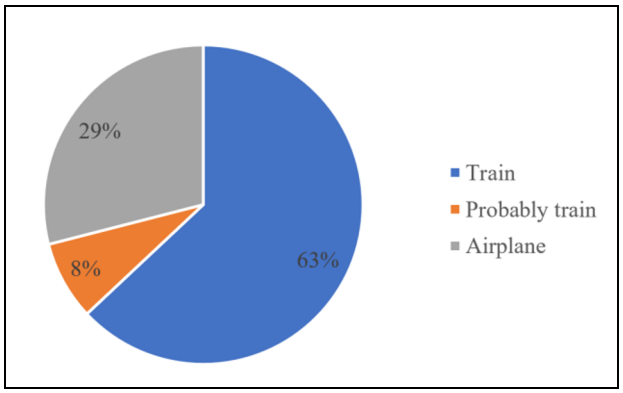

Fig. 6. Modal choice between a high-speed train and airplane for the same price.

As shown in Fig. 6, regarding perhaps the most important question of the survey, i.e., "In case there was a train that would cover the route from Thessaloniki to Athens in two (2) hours and 30 minutes and the cost was the same as that of the air ticket (as mentioned above)" the answers were as follows:

• 63% would choose the train to travel from Thessaloniki to Athens,
• 8% would probably choose the train, and only
• 29% would choose the airplane.

The above results suggest that there is an opportunity for passenger railway transport to attract approximately 2/3 of the passengers who currently use air transport. This is a very high percentage, which means the two transportation modes are very close, competing at the marginal cost.

According to an open question regarding their choice, the main reasons why 63% of travelers would choose to travel by train are the following:

• Considering the time it takes to get to the airport and the waiting time, the total time by airplane can exceed by far two (2) hours and 30 minutes, making the journey more stressful and tiring. In contrast, traveling by train is more relaxing. An additional 2.5 hours by train is fully usable as opposed to traveling by airplane.
• If one uses an airplane, there are extra costs that make the trip unprofitable. For example, tickets to and from airports are more expensive than regular public transport tickets, and taxis are not economically viable. On the contrary, train stations are located close to city centers so that short distances must be traveled to the destination. Consequently, commuters save time and money.
• The ticket price for train travel is fixed, and there is no need to buy the ticket well in advance of the journey (great flexibility in terms of purchase time).
• In the case of trains, there are no additional charges or restrictions for carrying luggage as there are for airplanes.
• The train is considered a friendlier and safer means of transport than the airplane and offers better conditions for passengers' comfort and enjoyment of the journey.

29% of respondents would continue to use the airplane mainly because the journey time is much shorter than by train. This percentage also includes those who commute to the two cities by car.

The remaining 8% of travelers expressed doubts about the reliability of the train in terms of delays and adherence to the journey time. However, they had a positive attitude towards the possibility of the journey taking 2.5 hours.

When the participants were asked to estimate the average cost of an air ticket for the return trip from Athens to Thessaloniki, 54% answered that it ranged from €40 to €80 (Fig. 7).

Following, they were asked what price in relation to the average cost they estimated they would choose to travel by train. This question was asked in parts, proposing as an option first "twice the price" and ending with the option "I would not choose the train." As shown in Fig. 8, 89% would prefer to travel by train to be the same or half the cost of traveling by airplane (Fig. 8).

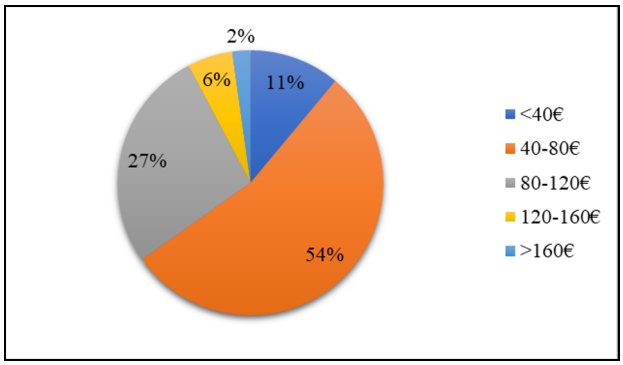

Fig. 7. Estimation of the cost of a return air ticket from Athens to Thessaloniki.

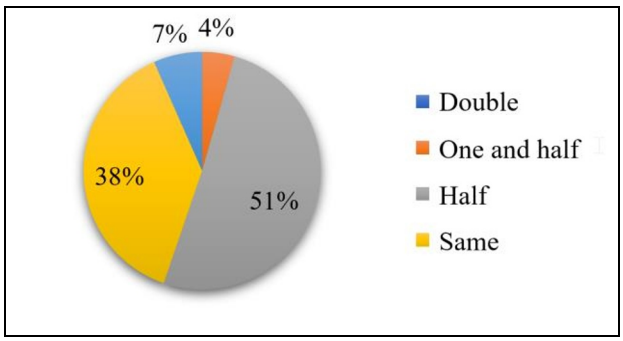

Fig. 8. Cost of travel by train, which the respondents would prefer compared to an airplane.

More specifically, as shown in Fig. 7, the results for the estimation of a return air ticket from Athens to Thessaloniki were as follows:

• <€40: 11%.
• €40-€80: 54%.
• €80-€120: 27%.
• €120-€160: 6%.
• >€120: 2%.

As shown in Fig. 8, regarding the cost of travel by train which the respondents would prefer it compared to the airplane, the results are as follows:

• Double price: 7%.
• One and a half price: 4%.
• Same price: 38%.
• Half price: 51%.

It should be noted that 66% (119 people) considered in their responses any additional costs, such as the cost of traveling by taxi or metro, while the remaining 34% (61 people) did not. 56% of those who had not taken other costs into account would not change their answers, while 33% would, and 11% would probably change their answers and choose to travel by train.

Those who would not change their answers said that they generally prefer to travel by air and the extra costs involved are very small. Moreover, they would not save time because they would have to travel the same distance to and from the airport and the railway station.

In case the answers were changed, the cost of traveling by train varies, as shown in Fig. 9.

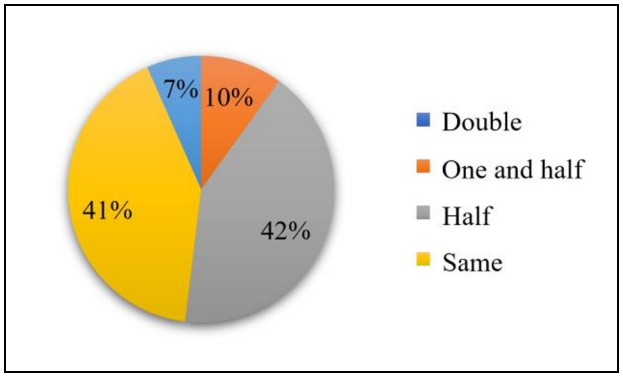

Fig. 9. The final cost of traveling by train compared to airplane among the respondents who changed their answers.

It can be observed that when the survey participants considered factors such as the cost of traveling by taxi or metro, waiting time at the airport, and travel time to and from the airport or railway station, the responses varied as follows (Fig. 9):

• The percentage that prefers the price of a train ticket to be half the price of an airline ticket decreases by 9% (from 51% to 42%).

• The percentage that prefers the price of the train ticket to be the same as the price of the air ticket has slightly increased (+3%) from 38% to 41%.

• The percentage willing to pay up to one and a half times the price of an air ticket to travel by train shows a higher increase, as it more than doubles from 4% to 10% (+6%).

6 Discussion

The launch of high-speed trains which will run between Athens and Thessaloniki in two (2) hours and thirty minutes, as promised, is desirable when the right conditions are created.

As can be seen from airline data and the factors presented above, passenger traffic between Athens and Thessaloniki and vice versa is high on a daily basis, which is an important factor in the creation of a new passenger transport line that will be competitive with air transport.

The price of the ticket is another very important factor. There is a high demand (42%) for a cost equal to half the price of an airline ticket.

A fairly large proportion of respondents prefer to choose the train over the airplane, paying the same fare or even a 50% higher fare. However, considering the high cost of setting up and operating such a line, at least until the breakeven time, the stakes are high for an increased ticket price. Nevertheless, a large percentage of travelers would choose the train due to the productive travel time, its comfort, and the less last-mile travel time.

Finally, other surveys regarding the transportation habits of railway users in Greece [10] and the impact of the economy [11] should be considered.

7 Conclusion

The survey shows that travelers are willing to change the way they travel between the two cities. However, some of the following suggestions could bring better results:

• Running trains that do not have the current problems.

• Cost of a ticket at the same price as the airplane.

• Offers and discounts for special groups (e.g., students).

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