# Economic Assessment of Free Public Transport in Athens

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**Abstract.** The introduction of Free Public Transport (FPT) is in many cities a potential path to control and reduce the environmental, social and economic problems. FPT can take several forms from the more widely used partial FPT, which includes limitations in its application, to full FPT. This paper aims to investigate the socio-economic feasibility of introducing FPT in Athens. For this purpose, a socio-economic analysis was conducted to assess the economic advantages and disadvantages of the FPT, up to the year 2030. Four Scenarios were examined considering 0% (S0), 50% (S1), 75% (S2) and 100% (S3) fare discount, respectively, on PT tickets. Consequently, a multinomial logistic model was developed to investigate for each of the three discounts the level preferring Athenians the FPT over private car, using data from a stated preference questionnaire survey. For S1-S3 the investment and the operational costs along with the impact on travel time, fuel consumption, road safety and air pollution were estimated and monetized. The socio-economic analysis illustrated that the introduction of FPT in Athens can contribute to social welfare in the medium-term future, mainly due to the modal shift from private cars to PT. More precisely, the examined scheme shows a positive NPV and high IRR in all the Scenarios, indicating its feasibility over time. To be noted that even in extreme price changes of significant input variables, NPV remains positive, ensuring a positive impact on society.

**Keywords:** Free Public Transport, Socio-economic Analysis, Logistic Model, Net Present Value, Sensitivity.

## 1 Introduction

The introduction of Free Public Transport (FTP) is being explored by many cities as a potential path for the control and reduction of environmental, social and economic problems. FPT can take several forms, from partial FPT, which includes limitations in its application but more widely used, to full FPT. Currently, more than 100 cities around the world offer a form of FPT to their citizens, such as Taihung in Taiwan, Miami in USA and Verenje in Slovenia [16]. The three main benefits of such schemes are to encourage a modal shift from private cars to Public Transport (PT), improve social inclusion, and enhance the urban and economic development of cities. However, a detailed economic assessment has to be made prior to the implementation of FPT schemes to determine whether they are worth undertaking or not from the social welfare point of view. While FPT is expected to boost ridership [19], it also raises costs for maintenance and financial strain on PT organizations, making it potentially unsustainable.

The most important impact of FPT on society is the mitigation of social inequalities. The main value of reducing or completely abolishing ticket fares lies in establishing simplified use of PT [9], since with FPT everyone can be transported, whenever they want [2]. Abolishing fares has been praised for directly addressing the issue of social exclusion, inequality, and poverty in transport by increasing its accessibility for lower income residents [12].

In this context, the objective of this paper is to investigate the socio-economic feasibility of introducing FPT in Athens. For this purpose, a socio-economic analysis was conducted to assess the economic advantages and disadvantages of the FPT, up to the year 2030. In the framework of the socio-economic analysis, four Scenarios were examined considering 0% (S0), 50% (S1), 75% (S2) and 100% (S3) fare discount, respectively, on PT tickets.

## 2 Methodology

### 2.1 Socioeconomic Analysis

Cost Benefit Analysis (CBA) is an analytical tool used to facilitate a more efficient allocation of resources by demonstrating the benefits to society of an intervention [18]. In the framework of the CBA, the socio-economic analysis is developed to evaluate the social value of a project by quantifying the social impacts of the project, with the costs and benefits being comparable in monetary terms considering distortions and limitations in markets [13]. The costs and benefits of the investment scenarios are compared to the do-nothing scenario to determine if the project is worth undertaking from a societal welfare perspective [17]. The costs and benefits arising at different times should be discounted using the Social Discount Rate (SDR).

### 2.2 Data

The main source of data, for the present study, was the annual report of the activities of the Athens Urban Transport Organization (OASA) [15], which is responsible of the operation and maintenance of all Athens PT, except for the Suburban Railway. These reports include the financial data of the organization, as well as the size of the fleet in use per year for each means of PT, the vehicle-kilometers, the trips, etc. To obtain the necessary traffic data, the OASA traffic simulation model and its results for the year 2018 were used. It is worth mentioning, that the assumption was made that the figures for 2018 are similar to the year 2023, since traffic data of the years 2020-2022 are not considered representative, due to Covid-19 virus. In addition, an annual increase of 1.2% in car and bus trips was considered, due to population growth and increasingly intense urbanization.

### 2.3 FPT Acceptance survey

To estimate the modal shift to FPT, data from a stated preference questionnaire survey, were used to investigate the acceptance of commuters in Attica towards FPT [7]. To collect the required data, the method of stated preference in hypothetical scenarios of cost, time and comfort route, were included in a specially designed questionnaire with 234 participants. A multinomial logistic regression statistical model was developed to calculate the probability of shifting from private cars to FPT. Time, cost and convenience were the independent variables. The outcomes of the statistical model showed that the faster and more comfortable the commute, regardless of cost reduction, the more likely respondents are to choose FPT over remaining in their current mode of transportation. For Scenario 1 (50% fare reduction), modal shift from private cars to FPT is approximately 40.1%, for Scenario 2 (72.5% fare reduction) 43.8%, while for Scenario 3 (100% fare reduction), the modal shift percentage reaches 48.5%.

## 3 Socio-economic Analysis

The socio-economic analysis carried out for the introduction and operation of FPT in Athens is presented for a time horizon until 2030. The analysis was based on finding the costs and benefits that will result from the implementation of FPT in Athens in 4 Scenarios; i.e. 0% (S0), 50% (S1), 75% (S2) and 100% (S3) fare discount, respectively, on PT tickets. It should be noted that scenario S0 represents the do-nothing situation where the ticket fare remains unchanged. For each Scenario the investment and operating costs, and the socio-economic benefits have been calculated in monetary terms.

For the calculation of the impact of FPT on travel time, the annual passenger-hours spent on private cars and PT were taken into account in all the scenarios, as well as the value of the travel time (VOT). In Greece, VOT for work-related car travel is €9.00, for other purposes, it's €4.10 [8]. With 56% other and 44% work trips [5], the average VOT is €6.26/hour. The ratio of this price to the corresponding cost for PT is estimated to be approximately equal to 1.2 [6], i.e. €5.21.

To assess the impact on fuel consumption, the composition of the vehicles by fuel type, the average consumption of vehicles, as well as the price of fuels per year, were identified [20]. According to OASA, 10% of city buses run on compressed natural gas while the rest are diesel-powered, and 3.2% of buses are electric [15]. For passenger cars, the assumption that the entire fleet is gasoline-powered was made, even though approximately 8% use diesel and 1% of these are electric/hybrid in Greece [1]. Every year cars are becoming eco-friendlier and more economical, so a reduction of the average fuel consumption every year, was also considered [20]. On the contrary, the fuel consumption of PT was considered constant until 2030.

To assess the impact of FPT on road safety, the number of road fatalities and injuries in each Scenario, as well as the social cost per fatality and injury were considered. The latest available data from the Hellenic Statistical Authority (EL.STAT) [3] were used to record the road safety indicators. In particular, the minor and serious injuries and deaths in crashes involving private vehicles and PT were collected for the year 2019 as recorded in the Municipality of Athens. To calculate the cost of road safety, the social cost per death (€2,148,034), serious (€273,574) and minor injury (€51,372) in a road crash were used, as calculated for Greece [11]. Finally, it is assumed that road safety improves annually by 2.5%, a percentage that has been derived from the evaluation of road safety data per year for the countries of the European Union.

For the environmental impact assessment, a similar process was followed to calculate the costs of emissions. The cost per ton of $CO_2$ emissions is 42€/tn in the year 2021 with an annual increase of approximately 2.3%. For nitrogen compounds ($NO_x$) a fixed cost of 1,900€/tn per vehicle km is considered. The emissions per vehicle type are calculated based on literature for both private cars [10] and PT [14].

The investment cost of each scenario S1-S3 was formed considering two components, the cost of the required study and the purchase of new or used buses. It is worth noting that these two cost categories refer to year 0 (2023), i.e. before the operation of FPT in Athens begins. The cost of the study was considered in all scenarios to be equal to €500,000, which is disbursed once in 2023. The investment of the new bus purchase was found after identifying the number of buses that will be needed to accommodate the new needs for PT travel and achieved by correlating PT trips with PT vehicles [15].

The operating costs of FPT include the operating and maintenance costs of the system, mechanical equipment, as well as costs related to the additional human resources and fuel consumption of the new buses. To find the cost of employing additional human resources, the relationship between the new buses and the required new driver shifts was calculated. For each bus that operates every day, 2.4 drivers [15] were calculated.

# 4 Summary

## 4.1 Evaluation of Economic Feasibility

Specific criteria have been used to identify whether a scenario is beneficial [4]. The Net Present Value (NPV) of the investment must be positive, i.e. NPV>0, the Internal Rate of Return (IRR) should be greater than the SDR, the ratio of benefits to costs should be greater than unity, B/C>1. Table 1 summarizes the costs and benefits, as well as the economic performance until the year 2030 for Scenario 1.

**Table 1.** Socio-economic analysis for Scenario 1

| Costs and Benefits | Present Value (0.8%) | Implementation 2023 | Operation 2024 | 2025 | .. 2030 |
|---|---|---|---|---|---|
| C1 Investment Cost (mil.€) | -11.43 | -11.52 | 0 | 0 | 0 |
| C2 Operating Costs (mil.€) | -83.13 | 0 | -19.48 | -18.08 | -7.09 |
| **Total Costs (mil.€)** | **-94.56** | **-11.52** | **-19.48** | **-18.08** | **-7.09** |
| B1 Travel time (mil.€) | - 237.31 | 0 | -53.35 | -54.44 | -18.08 |
| B2 Fuel consumption (mil.€) | 655.30 | 0 | 178.58 | 164.71 | 38.28 |
| B3 Road Safety (mil.€) | 82.37 | 0 | 22.17 | 21.62 | 4.49 |
| B4 Emissions (mil.€) | 110.11 | 0 | 26.29 | 26.27 | 7.36 |

| Costs and Benefits | Present Value (0.8%) | Implemen-tation 2023 | Operation 2024 | 2025 | .. 2030 |
|---|---|---|---|---|---|
| **Total Benefits (mil.€)** | **610.47** | **0** | **173.69** | **158.16** | **32.05** |
| **NPV** (0.8%) | **515.92** | -11.52 | 154.21 | 140.08 | 24.96 |
| **IRR** | **1,327.6%** | | | | |

It was observed that the implementation of FPT in Athens has a significant positive influence on road safety, the environment and society in general. In particular, the considered system presents a positive NPV in all scenarios, from 515 million to 592 million €, IRR>100% and B/C from 4.5 to 6.4, indicating its economic viability over time. The summarized results of CBA analysis for each scenario are presented in Table 2.

**Table 2.** Summary results of CBA analysis by scenario.

| Scenario | NPV (€) | IRR (%) | B/C |
|---|---|---|---|
| S1 50% fare reduction | 515,919,563 | >100% | 6.46 |
| S2 72.5% fare reduction | 540,500,076 | >100% | 5.24 |
| S3 100% fare reduction | 592,985,724 | >100% | 4.52 |

## 5 Discussion

In conclusion, with the introduction and operation of partially and fully FPT in the urban network of Athens, a significant improvement in road safety, the environment and in general the quality of life is expected. Specifically, by the year 2030, a major reduction in road fatalities (by 20 for S1 - 25 for S3), severe (by 38 for S1 - 46 S3) and light injury (by 622 for S1 -733 for S3), as well as improvement in fuel consumption (reduction by 1.3 (S1) – 1.4 (S3) billion liters of gasoline-equivalent fuel), and air pollution (reduction of $CO_2$ pollutants by 2.5 (S1) – 3.1 (S3) mil. tons) is expected. The suggested intervention in the network of Athens is a socio-economically sustainable investment.

To ensure the successful introduction and operation of FPT in Athens, a pilot operation is proposed as trailhead. This will allow the effectiveness and efficiency of the system to be fully assessed, before being implemented across the whole city. Furthermore, it is proposed to upgrade the existing infrastructure and PT fleet, as well as the level of service of PT, by increasing itineraries, purchasing new environmentally friendly buses and other similar actions to attract more commuters to PT and ensure a smoother transition to the FPT.

## 6 Acknowledgements

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