Advancing Sustainable Urban Mobility: A Model-Based Analysis of a Proposed Mobility Card System in Athens and User Acceptance

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Introduction

- Rapid increase in private vehicle ownership has led to severe traffic congestion, air pollution, and noise in major urban centres such as Athens.
- Urban mobility accounts for 23% of greenhouse gas emissions from the European transport sector.
- Economic impact: congestion costs EU societies around €270 billion annually.
- Athens ranks 16th in Europe for congestion, with an average of 112 lost hours per driver per year.
- Many European cities have introduced measures like congestion charging and integrated travel cards to promote public transport use.
- This research proposes an integrated "Mobility Card" system for Athens: a tool designed to encourage sustainable urban mobility through benefits, incentives, and rewards.

Data Overview

- The data for this research were collected through an online structured questionnaire designed to investigate citizens' travel behaviour, perceptions of mobility services, and willingness to adopt a new integrated "Mobility Card" system.
- A total of 115 valid responses were obtained. Participants were required to be residents of the Attica region, **regularly commuting to the centre of Athens**, and **using public transportation daily**.
- All responses were analysed using descriptive statistics to identify patterns and trends in user behaviour.
- Subsequently, binary and multinomial logistic regression models were developed to explore the determinants of:
  - **Citizens' willingness** to use the proposed Mobility Card system.
  - The **preference** between the Basic and Premium card options.

Methodology

- To evaluate citizens' willingness to adopt the proposed "Mobility Card" system, a quantitative research approach was employed, combining descriptive statistics with statistical modelling techniques.
- The analysis sought to determine which factors significantly influence both the decision to use the integrated card system and the preference for one of its two variants: Basic or Premium.
- Modelling Framework:

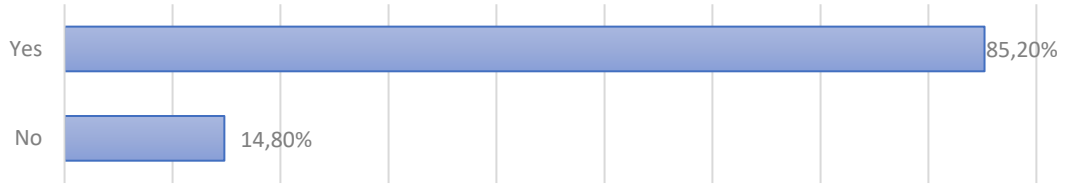
Two models were developed under the Generalised Linear Model (GLM) framework:

1. Binary Logistic Regression Model:
   - Used to estimate the probability of a **participant's willingness to use** the proposed Mobility Card system.
   - Dependent variable: Willingness to use the card (Yes = 1, No = 0).
2. Multinomial Logistic Regression Model:
   - Used to analyse participants' preference among the three options: the **existing transport card**, the **Basic Mobility Card**, and the **Premium Mobility Card.**
   - Dependent variable: Card preference (Existing = 0, Basic = 1, Premium = 2).

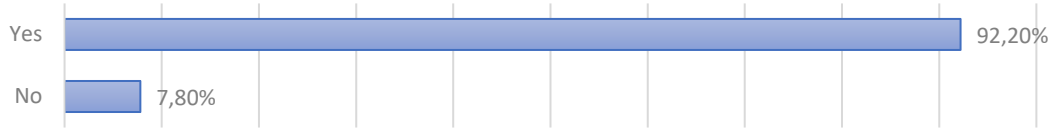
Key Descriptive Findings

- **Gender Distribution:** Approximately **52% female** and **48% male** participants.
- **Willingness to Adopt the Mobility Card:** A strong **positive** response, with **85.2%** expressing willingness to use it.
- **Trip Frequency:** Most respondents make **more than 10 weekly trips** for work or study purposes, but fewer than 5 trips for leisure activities.
- High levels of interest in discounts for **public transport**, **shared mobility services**, and **controlled on-street parking**.
- Lower but still notable interest in **off-street parking discounts**, suggesting that convenience outweighs price when choosing where to park.

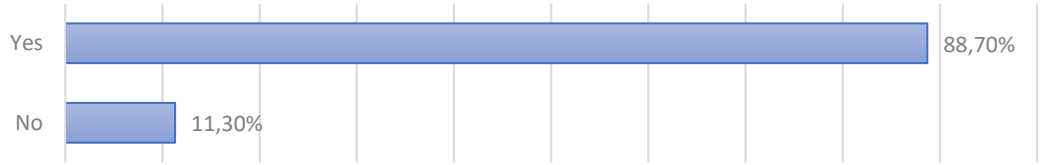
Distribution based on the willingness to adopt a the integrated system titled “Mobility Card.”



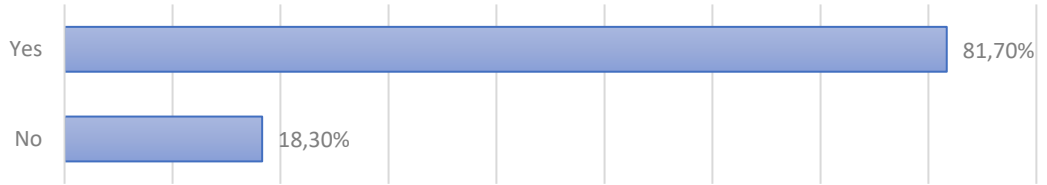
Distribution based on interest in receiving discounts and benefits for parking vehicles in on-street parking areas.



Distribution based on interest in receiving discounts and benefits for parking vehicles in off-street parking areas.



Distribution based on interest in receiving discounts and benefits for public transport services.



Key Variables Considered in the Models

1. Travel Characteristics:

•Percentage change in travel time, number of weekly trips, and weekly transport costs.

2. Perceived Quality and Safety:

•Level of satisfaction with public transport safety and technological services.

3. Economic and Environmental Factors:

•Financial benefits from mobility services, environmental improvement percentage, and cost of courier services.

4. Rewards and Discounts:

•Interest in gaining rewards for using public transport, parking in controlled areas, and shared bicycles/scooters.

5. Personal and Demographic Attributes:

•Gender, annual income level, and ownership of private vehicles or motorcycles.

Results

Model Type	Purpose / Dependent Variable	Key Positive Predictors	Key Negative Predictors	Interpretation / Insight
Binary Logistic Regression	To examine **willingness to use** the proposed "Mobility Card" (Yes / No)	• Gender (Female) • Income (higher) • Technological quality of public transport • Desire for financial savings • Environmental awareness • Vehicle ownership	• Off-street parking discounts	Citizens are **generally willing to use** the Mobility Card system. Adoption is mainly driven by **technology, financial benefits, and environmental values**, while off-street parking incentives are less appealing.
Multinomial Logistic Regression	To determine **preference between card types** — Existing, Basic, or Premium	• Environmental improvement • Technological services in public transport • Financial savings and discounts • Vehicle ownership	• Longer travel time • Off-street parking discounts • Courier service cost sensitivity	Users are more likely to prefer the **Basic or Premium Card** when they perceive **environmental and economic advantages**. However, **time efficiency** and **service costs** remain critical barriers.

Model 1: Binomial Model
Coefficients:

Variables	Estimate	Std. Error	z value	Odds Ratio	Pr(>|z|)	
(Intercept)	-8,636	1,338	-6,454	0,000	< 0,001	***
b5_discount1	10,484	1,334	7,857	35.739,078	< 0,001	***
b7_parkdisco1	-4,005	0,620	-6,462	0,018	< 0,001	***
b8_bikedisc1	4,116	1,056	3,898	61,295	< 0,001	***
b9_mmmuse1	4,296	0,543	7,908	73,369	< 0,001	***
genderΓυναίκα	6,345	0,940	6,747	569,808	< 0,001	***
income> 30000	5,996	1,309	4,581	401,818	< 0,001	***
income10000 - 20000	1,936	0,633	3,057	6,933	0,002	**
income20000 - 30000	3,613	0,879	4,112	37,077	< 0,001	***
incomeΔεν ξέρω/ Δεν απαντώ	4,897	0,989	4,950	133,914	< 0,001	***

Binomial Model Summary

Null deviance	Residual deviance:	AIC	McFadden
867.16 on 1034 deg of freedom	236.10 on 1025 deg of freedom	256.1	0.728

Model 2: Multinomial Model
choice 2: Κάρτα Κινητικότητας Premium
Coefficients:

Variables	Estimate	Std. Error	z value	Odds Ratio	Pr(>|z|)	
(Intercept):1	-5,734	0,731	-7,850	0,003	< 0,001	***
time	-2,305	0,631	-3,653	0,100	< 0,001	***
finbenefit	0,466	1,512	0,308	1,593	0,758	
environ	1,289	0,650	1,983	3,628	0,047	*
a2_employment2	0,846	0,312	2,708	2,329	0,007	**
a2_employment3	0,375	0,313	1,199	1,456	0,231	
a3_cost2	0,431	0,266	1,623	1,539	0,105	
a3_cost3	0,331	0,336	0,984	1,392	0,325	
a3_cost4	0,063	0,421	0,149	1,065	0,882	
a4_safety1	2,166	0,341	6,348	8,727	< 0,001	***
a4_safety2	0,896	0,334	2,680	2,450	0,007	**
a4_safety3	1,633	0,415	3,935	5,117	< 0,001	***
a4_safety4	-2,650	1,183	-2,240	0,071	0,025	*
b1_telematics1	2,329	0,444	5,247	10,270	< 0,001	***
b1_telematics2	2,283	0,449	5,087	9,804	< 0,001	***
b1_telematics3	2,364	0,486	4,867	10,635	< 0,001	***
b1_telematics4	5,273	0,673	7,840	195,000	< 0,001	***
b4_cost1	-0,454	0,450	-1,007	0,635	0,314	
b4_cost2	-0,584	0,463	-1,260	0,558	0,208	
b4_cost3	-1,345	0,510	-2,636	0,261	0,008	**
b4_cost4	-0,701	0,552	-1,270	0,496	0,204	
b5_discount1	-1,922	0,348	-5,519	0,146	< 0,001	***
b6_parkdisc1	2,292	0,400	5,727	9,891	< 0,001	***
b8_bikedisc1	1,778	0,275	6,471	5,920	< 0,001	***
b11_saving1	1,243	0,576	2,158	3,467	0,031	*
b11_saving2	0,013	0,515	0,025	1,013	0,980	
b11_saving3	0,763	0,592	1,290	2,146	0,197	
b11_saving4	1,730	0,635	2,722	5,638	0,006	**
d71	0,806	0,239	3,364	2,238	< 0,001	***

Model 2: Multinomial Model
choice 1: Κάρτα Κινητικότητας Basic
Coefficients:

Variables	Estimate	Std. Error	z value	Odds Ratio	Pr(>|z|)	
(Intercept):1	-3,774	0,647	-5,830	0,023	< 0,001	***
time	-2,305	0,631	-3,653	0,100	< 0,001	***
finbenefit	0,466	1,512	0,308	1,593	0,758	
environ	1,289	0,650	1,983	3,628	0,047	*
a2_employment2	-0,201	0,283	-0,709	0,818	0,478	
a2_employment3	-0,961	0,302	-3,176	0,383	0,001	**
a3_cost2	-0,520	0,263	-1,979	0,595	0,048	*
a3_cost3	-1,153	0,322	-3,584	0,316	< 0,001	***
a3_cost4	-0,064	0,368	-0,173	0,938	0,862	
a4_safety1	2,078	0,320	6,489	7,991	< 0,001	***
a4_safety2	0,255	0,304	0,840	1,291	0,401	
a4_safety3	-0,260	0,414	-0,628	0,771	0,530	
a4_safety4	-0,261	0,628	-0,415	0,771	0,678	
b1_telematics1	1,262	0,400	3,156	3,534	0,002	**
b1_telematics2	1,707	0,417	4,097	5,514	< 0,001	***
b1_telematics3	0,915	0,450	2,034	2,498	0,042	*
b1_telematics4	2,481	0,691	3,593	11,958	< 0,001	***
b4_cost1	-1,145	0,426	-2,687	0,318	0,007	**
b4_cost2	-1,600	0,437	-3,666	0,202	< 0,001	***
b4_cost3	-1,950	0,480	-4,061	0,142	< 0,001	***
b4_cost4	-2,635	0,526	-5,006	0,072	< 0,001	***
b5_discount1	-1,077	0,345	-3,120	0,340	0,002	**
b6_parkdisc1	2,509	0,430	5,837	12,294	< 0,001	***
b8_bikedisc1	1,020	0,262	3,890	2,774	< 0,001	***
b11_saving1	2,289	0,600	3,816	9,861	< 0,001	***
b11_saving2	1,989	0,527	3,770	7,306	< 0,001	***
b11_saving3	2,725	0,592	4,601	15,261	< 0,001	***
b11_saving4	2,773	0,641	4,324	16,005	< 0,001	***
d71	0,690	0,231	2,992	1,994	0,003	**

Conclusions (1/2)

- The research confirms a **high level of public acceptance** for an integrated Mobility Card system in Athens.
- **Technology, financial savings, and environmental improvement** are the main motivators for adoption.
- Citizens demonstrate a **strong willingness to shift** toward sustainable transport when reward mechanisms are in place.
- **Travel time, cost perception, and parking convenience** remain critical barriers influencing user choice.

Conclusions (2/2)

- Policymakers should promote incentive-based mobility programs, integrating discounts and benefits across multiple transport services (public transit, shared bikes, scooters, parking).
- Digital innovation (real-time updates, seamless payments) should be prioritised to enhance user trust and satisfaction.
- Environmental incentives, such as linking rewards to eco-friendly behaviour, can strengthen participation and align with sustainability goals.
- Collaboration between public authorities, operators, and private mobility providers is essential for the system's effective implementation.

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