Bicycle traffic analysis before and after mobility interventions using crowdsourced data

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Abstract.

This paper aims to investigate the impact of a new cycleway on Panepistimiou st., implementing in the framework of Athens Great Walk (AGW), to bike and e-bike trips using crowdsourcing open data, which are paired with the original data of the Horizon Europe project PHOEBE. For this purpose, daily cycling trips recorded on the examined street before and after the operation of the new cycleway, were collected through "Strava Metro" platform. An interrupted time series analysis was developed to assess the effectiveness of the new cycleway on Panepistimiou st. on daily changes in number of bike trips from June 2019 to 2023. The Covid-19 pandemic lockdowns are regarded as supplementary interruptions due to their documented impact on inducing temporary and significant shifts in cycling patterns. Evaluation of the post-intervention period show an increase in cycling subsequent to the introduction of exclusive lanes for cyclists and widened sidewalks under AGW.

Keywords: PHOEBE; Interrupted Time-Series; STRAVA; Cycling; Athens Great Walk; COVID-19.

1 Introduction

Urban centres worldwide are grappling with mounting issues caused by motorized road transport. In light of this reality, cities face the challenge to enhance the quality of urban environment promoting sustainable transport modes such as bicycles [1]. Creating bicycle paths and expanding sidewalks to allocate road space for active travel modes emerge as fundamental measures for promoting sustainable mobility and addressing the external costs associated with transportation [2]. In line with these efforts, numerous cities have implemented sustainable urban transport policies, resulting in notable shifts toward active mobility and enhanced road safety.

Following the lead of numerous cities globally, Athens implemented several impactful mobility interventions in June 2020 formed a major urban regeneration plan titled the Athens Great Walk (AGW). The objective of these interventions was to create a

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new quality environment of urban mobility, promoting public transport and active travel modes, to achieve safe, green and efficient transport for all. Noteworthy interventions included expanding sidewalks on streets with high pedestrian traffic and creating dedicated lanes exclusively for pedestrians and cyclists.

The PHOEBE project ("Predictive Approaches for Safer Urban Environment") was initiated to enhance road safety for vulnerable road users, particularly those utilizing active mobility options. The project, which includes three pilot city use-cases—Athens, Valencia, and West Midlands-focuses on investigating the impact of the AGW on bicycle trips in the central area of Athens.

Prior literature has extensively explored sustainable urban transport policies and their impact on enhancing road safety and active mobility. However, a detailed analysis of the specific impact of interventions like AGW on bicycle trips in highly busy metropolitan areas was lacking. This study bridged this gap by utilizing interrupted time series analysis, to investigate the cycling before and after the implementation of exclusive lanes for cyclists and widened sidewalks on Panepistimiou st. under AGW.

2 Methodology

2.1 The Athens Great Walk

Since Autumn of 2019, a series of novel traffic and parking interventions for the center of Athens were examined, part of the new mobility policy of the City of Athens and harmonized both with the Athens Sustainable Urban Mobility Plan. The new mobility interventions formed a major urban regeneration plan called the AGW.

In June 2020 a pilot implementation of a subset of the new mobility interventions was decided, following the example of several cities worldwide during the pandemic, to support active travel modes, assess the mobility interventions in practice, initiate a live public dialogue. On June 18, 2020, Panepistimiou St. saw the expansion of its sidewalks and the establishment of a new cycleway, enhancing the width of the active infrastructure to 9 meters. This transformation reduced the number of traffic lanes to three. However, on August 3, 2020, an extra traffic lane was allocated to motor vehicles, resulting in the road operating with four lanes.

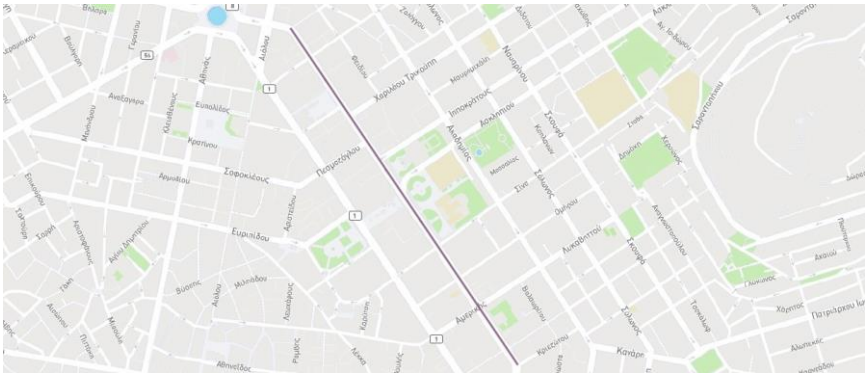

Fig.1. The Panepistimiou St.

2.2 Data Collection

To accomplish the paper's objective, the study utilizes crowdsourcing open data to analyze daily bike and e-bike trips recorded in the center of Athens before and after the implementation of AGW. The data were collected through the "Strava Metro" platform.

Strava is a crowdsourced fitness app [3], which utilizes anonymized, aggregated GPS data from its users to analyze activity over space and time (e.g. hour, year etc.) at fine spatial resolution three geometric units-street segments (edges), intersections, and polygons of trip origin and destination. They share this data via Strava Metro Service, offering a web-based platform to download activity information. This data is generated by users' mobile phones, which record their location using the built-in GPS device which are then matched to the nearest recreational or transport line from Open-StreetMap (OSM).

We restricted our analysis to the bikes and e-bikes trips recorded between June 2019 and June 2023 for 89 edges corresponding to 27 OSM street ids on Panepistimiou st., where the examined mobility intervention was implemented. To aggregate the trip data effectively, we elevated our analysis from the edge level to the street level, with Panepistimiou St. as our focal point. Throughout this process, we meticulously considered the minimum daily trip counts among the examined edges, considering that these trips encompassed the entire length of the street. The figure below presents the cycling trips on the street under consideration, including the examined interruptions.

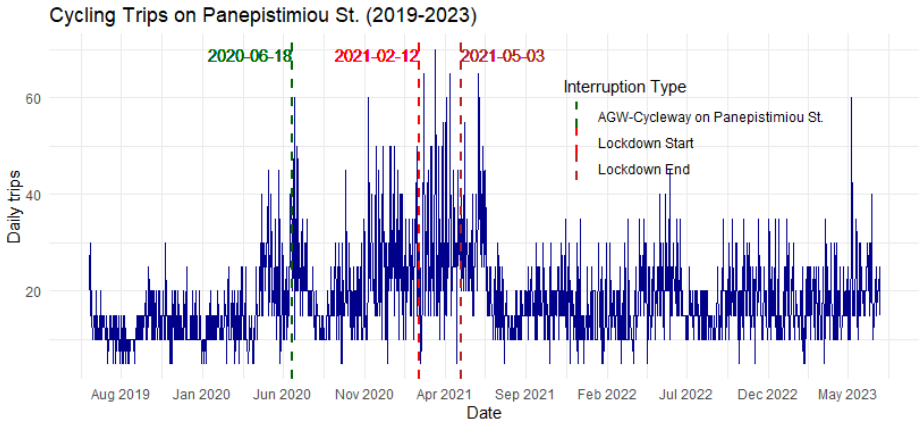

Fig. 2. Cycling trips on Panepistimiou st. and the examined interventions.

2.3 Interrupted Time Series

An interrupted time series (ITS) design involves regularly gathering observations at consistent time intervals from a group of entities both before and after an intervention. The data path may be disrupted by the intervention, leading to potential changes. An interrupted time series model assesses the difference between post-intervention predictions in a scenario where no intervention occurred, and post-intervention estimates when the intervention has been implemented.

In the current analysis, the primary intervention under examination is the implementation of the new cycleway and sidewalk expansion on Panepistimiou St. during AGW's pilot phase. Nevertheless, considering the data presented in Fig. 2, the end of the Covid-19 lockdown, which entailed the closure of educational institutions and retail establishments, should also be considered as an additional interruption.

For the examined interruptions, a linear regression model using generalised least squares was developed to estimate the effect of the intervention on the level change (change in level between time points immediately before and after the intervention accounting for the pre-intervention trend) and the change in trend (difference between pre-intervention and post-intervention slopes) for cycling counts. Autocorrelation between residuals was assessed using an autoregressive moving average (ARMA) model with the nlme package in R.

3. Results and Discussion

To provide a comprehensive overview, a detailed snapshot of daily cycling trips on Panepistimiou St. across multiple years, with colors used to facilitate comparisons of trip numbers for the same months across different years, is provided via the following table. In 2019, cycling activity remained relatively modest. However, in 2020, the landscape altered significantly, primarily due to the introduction of the new cycleway in June. The positive impact persisted into 2021, potentially influenced by concurrent lockdowns, promoting active mobility. Although 2022 and 2023 recorded a slight decline in cycling traffic, levels remained notably higher than those observed prior to the AGW intervention in 2019.

Table 1. Monthly summaries of daily cycling activity on Panepistimiou St.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	n/a	n/a	n/a	n/a	n/a	15	11	9	15	14	13	13
2020	13	14	13	19	24	**26**	21	13	19	18	24	27
2021	26	28	29	31	27	30	16	14	18	18	18	14
2022	16	15	14	20	22	20	15	14	18	20	19	18
2023	18	17	18	17	21	21	n/a	n/a	n/a	n/a	n/a	n/a

In the following model, “Time” variable represents the study days, tracking the progression of time from 0 to 1477 day. “AGW_new_Cycleway” and “Covid19_Lockdown_end” are binary variables indicating whether the specific intervention occurred at a given time. “AGW_new_Cycleway_time_since” and “Covid19_Lockdown_end_time_since” are variables measuring the time that has elapsed since the intervention took place, providing insight into the post-intervention period. It must be noted that the correlation structure of the following model is specified as an ARMA(0,1) process.

Table 2. Uncontrolled ITS analysis

	Value	t-value	p-value	
(Intercept)	9.789	9.318	0.000	**
Time	0.026	5.359	0.000	**
AGW_new_Cycleway	-2.180	-1.408	0.159	.
AGW_new_Cycleway_time_since	0.015	1.975	0.049	**
Covid19_Lockdown_end	-11.190	-8.274	0.000	**
Covid19_end_time_since	-0.043	-6.779	0.000	**

The positive coefficient for “Time” suggests a slight upward trend in daily cycling trips over time. For each 100 days, we can expect additional 3 cycling trips. Notably, the introduction of the new cycleway and sidewalk expansion had a marginally adverse but not statistically significant effect on daily cycling trips, potentially attributed to ongoing construction during the first days. However, the time elapsed since this intervention showed a positive effect, contributing to increased cycling trips.

The large negative coefficient of “Covid19_Lockdown_end” indicates a substantial decrease in daily cycling trips associated with the end of the Covid-19 lockdown, implying that the lockdown had a significant negative impact on cycling activity. Additionally, the time elapsed since the lockdown demonstrated a further small but statistically significant reduction in cycling trips.

4. Conclusion

This paper endeavors to explore the impact of the newly implemented cycling infrastructure along Panepistimiou St. within the AGW framework. To this end, an ucontrolled ITS analysis is conducted harnessing crowdsourced open data on bike and e-bike trips collected through the "Strava Metro" platform.

The analysis results highlight the dynamic nature of urban cycling patterns and the intricate relationship between infrastructure enhancements, external disruptions, and time trends. While interruptions such as the Covid-19 pandemic can lead to temporary extreme changes in cycling, well-executed active mobility infrastructure projects, like the AGW, can ultimately promote and sustain cycling as a viable mode of urban transport contributing to the increase of the overall volume of cycling trips over time.

It's imperative to acknowledge that, akin to other forms of crowdsourced data, Strava constitutes a relatively small sub-sample of the overall population. As a result, the data may require calibration against fixed-point counter stations to facilitate population-level estimations of total activity volume [4,5]. Addressing this limitation could further enhance the robustness and representativeness of the findings of the current analysis.

Understanding these dynamics is crucial for urban planners and policymakers as they work to create cyclist-friendly environments offering valuable lessons for transforming densely populated urban spaces into safer, greener, and more efficient environments. Overall, this research contributes to the growing body of knowledge on sustainable urban transportation, fills a novel gap on how highly busy, metropolitan areas can be

transformed and offers practical particular insights into promoting cycling as a viable mode of transport in Athens.

5. Acknowledgements

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