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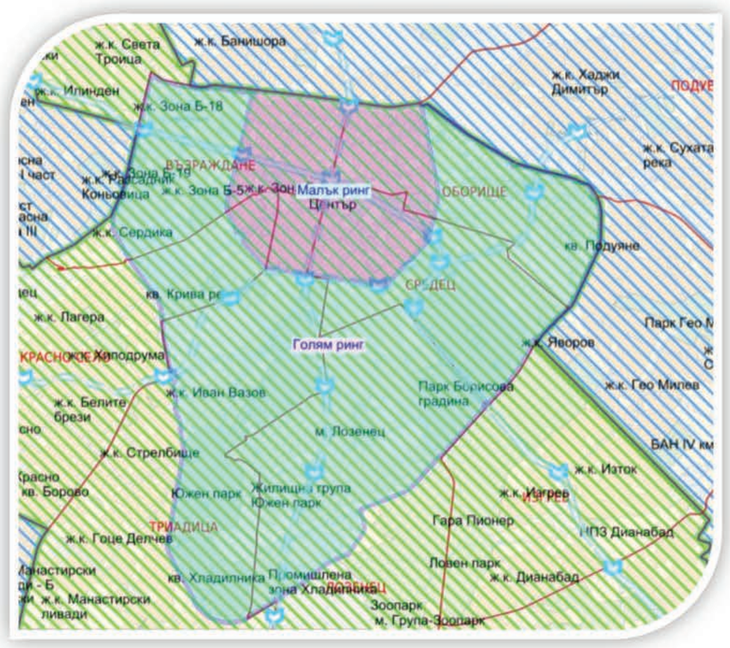
SOFIA UNIVERSITY -
MARKING MOMENTUM
FOR INNOVATION AND TECHNOLOGICAL TRANSFER

National Recovery and Resilience Plan
OF THE REPUBLIC OF BULGARIA

RESEARCH GROUP
MODERN TECHNOLOGIES

RESEARCH AREA
SOCIAL SCIENCES (POLITICAL SCIENCES, LAW, EDUCATIONAL SCIENCES)

Investigating the effect of urban mobility innovation using mode-switching time series methods



INTRODUCTION

A number of current scientific publications use various modifications of the Markov regime-switching model proposed by (Hamilton, 1989). In this approach, multiple sub-models are used that characterize the behavior of time series in their different regimes (states). A unique aspect of these models is their control mechanism: switching is determined by unobservable variables forming a first-order Markov chain. One state of behavior may dominate for some random period of time before being replaced by another when a sudden change occurs.

PROJECT GUIDELINES

Over 70% of EU citizens live in urban areas, which generate 23% of all greenhouse gas emissions from transport. The European Green Deal aims to make Europe the first climate-neutral continent by reducing greenhouse gas emissions (at least 55% by 2030 compared to 1990 and by 90% by 2050). The New EU Urban Mobility Framework (Strasburg, 14.12.2021 COM (2021)811final) proposes measures to encourage EU Member States to develop urban transport systems that help address urban mobility challenges, such as air pollution and increase the share of sustainable modes of transport (in particular public transport and active mobility).

METHODOLOGY

The daily and hourly time series used for examining passenger flows of the three zones exhibit two substantially distinct regimes with different intensities, thus characterizing the regular and vacation time mobility of citizens.

Consequently, we have two regimes (states) to which we apply Markov Regime-Switching Models. Following (Hamilton, 1994) the time series belonging to dissimilar states are modeled by the ARX process with specific structure and variability. We consider univariate ARX(0) and ARX(1) models of daily and hourly data.

The exogenous variable x_t for the daily data is the average number of passengers for a day of the week. In the case of hourly data, we have two exogenous variables: average number of passengers for a specific hour in the day of the week and “feellike” temperature for the respective hour.

RESULTS

Urban travel dynamics usually demonstrate a mix of sustainable and changing behavioral patterns that reflect local specifics, such as habits of residents, public holidays, traffic density, seasonality, and weather.

Our studies present an original approach for modeling the passenger flow to and from subway stops in suburban areas of cities based on an anonymized and statistically aggregated telecom operator dataset.

The primary data source analyzed is obtained through a collaboration agreement with one of the three main mobile network operators in Bulgaria and contains information about trips from "Manastirski Livadi" residential complex, located in the suburbs of the city of Sofia, to several different destinations in the capital city.

The data are grouped into three independent clusters of travelers:

(1) within "Manastirski Livadi" residential complex,

(2) to destinations that are accessible by subway or urban rail, and

(3) to destinations to which there is no convenient "green" public transport.

More precisely the results include:

- ✓ Markov regime-switching models suitable for analyzing passenger flow behavior are developed.
- ✓ The models for different clusters of travelers, specifically in the city of Sofia are tested.
- ✓ Data for air pollution in Sofia is collected.
- ✓ Two scientific papers, partially supported by SUMMIT BG-RRP-2.004-0008-C01 were published.

CONCLUSION

Many economic time series exhibit instabilities, often multiple times over their process history. Such is the case with the time series depicting transportation habits among Sofia residents. Under these conditions, the Markov regime-switching approach enables to deal with shifting behavioral patterns during both high-traffic periods and low-traffic ones. This allows conducting a statistical evaluation and forecasting of passenger flows at different periods with differing dynamics within a time series describing Sofia citizens' transportation habits. Public transportation routes and timetables created using data could make public transportation more appealing and favored by citizens, while decreasing car trips would improve air quality, noise pollution, and CO2 emissions within our cities.

The suggested frameworkx works well with a time series of statistically aggregated and anonymized geospatial records of mobile devices that have different frequencies and changing behavior patterns. Although the research framework provides an in-depth view of passenger flow, factors influencing the dynamics of urban mobility may not be completely generalizable from this dataset. Modeling the share of daily trips taken by each mode of travel can improve the planning of public transport routes and timetables. In Lee, Lee, Mastrigt, and Kim (2022), city-level modal splitting (the share of daily trips taken by each mode of travel) is explored in terms of city characteristics. Understanding how city features affect modal splitting is crucial to achieving a shift towards low-emission modes of travel and sustainable mobility. The authors note that socio-demographic factors have the greatest impact on the modal splits of cities. High population density and high employment rates are also positively associated with low-emission travel modes. People often reconsider owning a private vehicle because of high gasoline taxes, low fares for public transportation and taxis, and low fares on public transport. The cost of transportation from point A to point B depends on the type of fuel or energy and its price (diesel, gasoline LPG, NLG, hydrogen, electricity) in comparison to the expenses associated with using public transport. Convenience should also be taken into account.

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CONTRACT BG-RRP-2.004-0008 FOR THE FINANCING OF PROJECT "SOFIA UNIVERSITY - MARKING MOMENTUM FOR INNOVATION AND TECHNOLOGICAL TRANSFER" UNDER PILLAR 2 "ESTABLISHING A NETWORK OF RESEARCH HIGHER EDUCATION INSTITUTIONS IN BULGARIA", COMPONENT "INNOVATIVE BULGARIA" FROM NATIONAL RECOVERY AND RESILIENCE PLAN PART OF THE PROGRAM TO ACCELERATE ECONOMIC RECOVERY AND TRANSFORMATION THROUGH SCIENCE AND INNOVATION