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SUMMIT
SOFIA UNIVERSITY
MARKING MOMENTUM
FOR INNOVATION AND
TECHNOLOGICAL TRANSFER

SOFIA UNIVERSITY -
MARKING MOMENTUM
FOR INNOVATION AND TECHNOLOGICAL TRANSFER

National Recovery and Resilience Plan
OF THE REPUBLIC OF BULGARIA

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

Scientific topic of the project

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).

Traffic in Sofia has an impact on air pollution and is in third place in terms of pollution with fine dust particles. The number of vehicles registered in Sofia is increasing daily. There are 550-600 cars per 1000 inhabitants. In 2017, a quarter of all vehicles were over 20 years old and a further 60% between 10 and 20 years old. In 2020 Sofia becomes the first Bulgarian city to win funding under the "INNOAIR" project, supported by EC program Urban Innovative Actions that encourages local authorities to search for, test and implement innovative solutions. The Faculty of Economics and Business Administration, Sofia University "St. Kliment Ohridski" participates as a partner and a major part of the team that works according to the present scientific study. Through INNOAIR, "green public transport on demand" was introduced, which is one of a series of measures taken in Sofia to achieve sustainable urban mobility.

Sofia implements various measures to achieve sustainable urban transport, such as low-emission zones, whose effect on air quality in Sofia is precisely the object of research in the scientific study.

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.

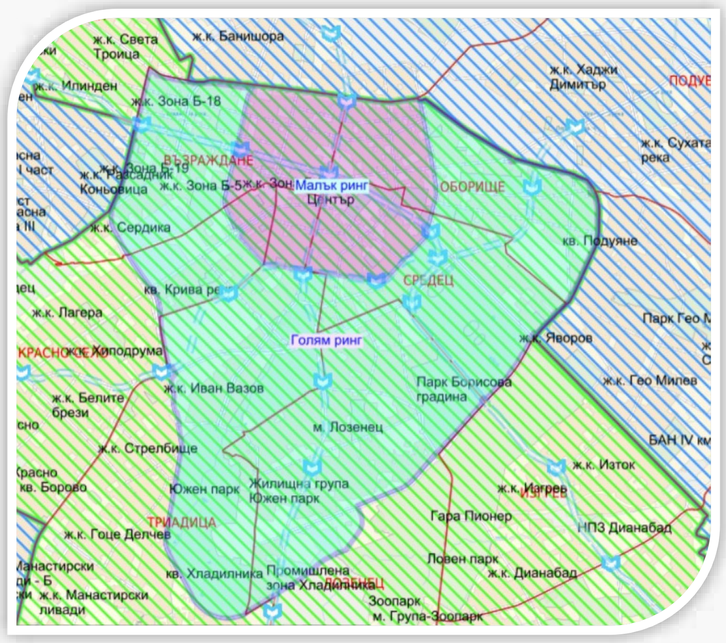
Most often, this approach is used in the analysis of financial data, e.g. (Dueker, 1997), (BenSaïda A., Litimi H., Abdallah O., 2018), (Ardia D., Bluteau K., Rüede M., 2019), (Baek S., Mohanty S.K., Glambosky M., 2020), (Egan P., McQuinn K., 2023). In (Le, C., David, D., 2014) investigate the transmission of volatility in financial markets in the US, Europe and East Asia for the period 2007-2011. Markov regime switching models prove useful during various crises . A recent study (Ghorbel, A., Jeribi, A., 2021) examines the correlations between energy index volatility, crude oil price movements, and gas price changes during the COVID-19 pandemic.

Another recent publication (Chkili, 2022) examines the relationship between Islamic stock markets and two major commodities - gold and crude oil - from January 1996 to December 2020. For the entire period analyzed, the authors used vector autoregressions to examine the relationships between the three markets studied.A regime-switching Markov model has also been applied to estimate the effect of the introduction of digitalization of public transport and urban mobility in Jacksonville, USA on carbon dioxide emissions (Netov,N., Lomev B., 2022).

Methodology

The research project builds on the experience gained by our team during the work on the "INNOAIR" project, building on scientific research and focusing it on the effect of introducing a series of measures to achieve sustainable urban mobility, such as low-emission zones, green corridors, use of electronic ticket only in public transport, etc., which are introduced after the completion of the project, incl. and the subsequent expansion of the "green public transport on demand" service in other neighborhoods of Sofia. In this context, we formulate the following research objectives:

1. Research contribution to the decision-making process at the local level for the implementation of innovative solutions leading to the achievement of sustainable urban transport.
2. Experimentation and modification of mode-switching time series theory methods for examining data that result from applied city-level measures.
3. Testing of hypotheses in two main directions: a) specific interdependence of an applied measure for sustainable urban transport and air quality and b) an applied measure/regulatory sanction and behavioral attitudes of citizens.
4. Modeling the future impact of a given measure (eg expansion and selection of an additional location of a low-emission zone).



Conclusion

1. Application of various modifications of a Markov model (autoregressive time series with vector Markov switching to adapt to changing behavioral patterns) to investigate the effect of implementing elements of sustainable urban transport.
2. The preparation of scientific reports and the publication of 3 studies in Web of Science on the topics formulated as scientific tasks.
3. Establishment of a mechanism through which the effect of implementing measures (low-emission zones) will be tested in other neighborhoods of Sofia, other Bulgarian or European cities.
4. Recommendations for city-level policies based on the effect of introducing elements of sustainable urban transport on air cleanliness.

Research field: statistics and econometrics

Results

- ✓ Development of a methodology for collecting empirical material for the needs of the project goals and creating an innovative experiment by modifying the Markov model to measure the effect of introducing measures for sustainable transport in an urban environment, based on current results from the field of transport and ecology.
- ✓ Conducting the experiment on a large enough database for a specific period in different seasons (including expansion of the low-emission zone Small - Big Ring) and deriving dependencies between key parameters in the study;
- ✓ Data analysis and modeling of possible future developments when certain key parameters change.
- ✓ Recommendations for urban policies based on scientific findings.

Head of the research group:

Assoc. Prof. Dr. Boyan Lomev

Members of the group:

Assoc. Prof. Dr. Marian Milev

Assoc. Prof. Dr. Diana Netova

Assist. Prof. Dr. Teodora Varbanova

Assist. Prof. Dr. Savina Mihaylova

Boyan Davidkov

Konstantin Georgiev

Slavena Dudrenova

Katya Nikolova

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