International Journal of Innovative Technology and Interdisciplinary Sciences
https://journals.tultech.eu/index.php/ijitis
ISSN: 2613-7305
Volume 7, Issue 4
DOI: https://doi.org/10.15157/IJITIS.7.4.147-156
Received: 17.10.2024; Revised: 25.11.2024; Accepted: 11.12.2024

Research Article

On a Comparative Analysis of Research Performance Trends in Western Balkans through Peer Reviewed Indexing Databases

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Abstract

In order to be published in scientific journals and conferences, the results of every systematic study must be presented in the form of a research report or paper that satisfies the standards established by the scientific community during centuries of development. It is well acknowledged that the output of research is what defines its performance. Because there are millions of researchers in the world, there has been a significant increase in demand in recent years for boosting the visibility of research outcomes. Every research group aims to maintain its research efforts and obtain further funding by maximizing the impact and visibility of the research results it produces in the scientific community. This obviously holds true for the advancement of any researcher's career in universities and research canters. As a result, over time, the international scientific community has established commonly used standards and measurements to distinguish between different levels of quality in research. Ranking significant and unimportant outcomes is the constant aim of all such groups. In light of the aforementioned observations, indexing has become a crucial criterion for characterizing each research publication. All research groups want to expand their effect in their respective scientific societies and gain more funding by producing more indexed papers than other groups in the same field. Additionally, indexed articles describe the calibre and effectiveness of research conducted by both individuals and groups, but also that of universities and research canters. As a generalization of the aforementioned factors, it makes sense to take into account research performance at the national level if, on the other hand, every organized nation is evaluated in terms of its universities and research canters with reference to local research development. Therefore, comparing research performance and its evolution across nations with comparable organizational characteristics in relation to the global competitiveness is the goal of this study. Here, the Western Balkans are chosen as a collection of "similar" nations. Therefore, starting with the widely used SCOPUS indexed database, an attempt is made to measure their research performance in terms of absolute numbers of indexed papers. Finding patterns in these nations' scientific advancements, however, is the most crucial component of this study. Naturally, this is still a work in progress, and the quantification study that is being undertaken should take into account a lot more aspects. It is obvious that such work could be applied to any other group countries.

Keywords: Research Performance; Impact of Research; Research Indexing; Time Series Models; Statistical Trends; Western Balkans

INTRODUCTION - STATE OF THE ART AND CONTRIBUTION

The state of the art in research indexing is constantly evolving as new technologies and techniques emerge. However, some of the most popular and widely used research indexing methods include:

- Bibliographic databases: These are digital databases that contain bibliographic information about research publications, such as the author, title, abstract, and publication details. Examples of bibliographic databases include PubMed, Scopus, and Web of Science.
- Full-text indexing: This involves indexing the full text of research publications, including the body of the article as well as the abstract and other metadata. Examples of full-text indexing tools include Google Scholar and Microsoft Academic.
- Citation indexing: This involves tracking and analysing citations between research publications to identify relationships and patterns. This method can be used to identify influential research papers and to measure the impact of research. Examples of citation indexing tools include Web of Science and Scopus. Topic modelling: This involves using machine learning algorithms to analyse the content of research publications and identify key topics and themes. This method can be used to identify emerging trends and to group research publications by topic. Examples of topic modelling tools include LDA and Latent Dirichlet Allocation.
- Semantic indexing: This involves analysing the meaning of words and phrases in research publications to identify relationships and patterns. This method can be used to identify related research papers and to group research publications by topic. Examples of semantic indexing tools include Semantic Scholar and Mendeley.

Overall, research indexing is a critical component of the scholarly communication ecosystem, enabling researchers to discover, access, and build upon existing research. The state of the art in research indexing is constantly evolving as modern technologies and techniques emerge to support the evolving needs of the research community.

This paper attempts to address the issue on how to compare countries with respect to their overall research potential. Moreover, to investigate the future trends countries present with regards to such relevant research potentials. Comparing countries in research potential can be a complex process that involves multiple factors. However, here are some key indicators that can be used to compare countries in research potential:

- Research output: The number of research publications that a country produces are a common measure of research output. This can be assessed by looking at the number of research papers published in reputable journals or conference proceedings.
- Research impact: The impact of a country's research can be assessed by looking at the number of citations that its research papers receive. This can be measured using citation-based metrics such as the H-index or the number of highly cited papers.

- Research funding: The amount of funding that a country invests in research and development can be an indicator of its research potential. This can include both public and private sector funding.
- Research institutions: The quality and quantity of research institutions in a country can be an indicator of its research potential. This can include universities, research centres, and government research agencies.
- Human resources: The number of highly skilled researchers and scientists in a country can be an indicator of its research potential. This can include the number of individuals with advanced degrees in science, engineering, and other fields.
- Collaboration: The extent to which a country collaborates with other countries and institutions can be an indicator of its research potential. This can be assessed by looking at the number of international research collaborations, joint publications, and joint funding opportunities.

It is important to note that each of these indicators has its own strengths and limitations, and no single indicator can provide a complete picture of a country's research potential. Therefore, it is often necessary to use multiple indicators and to take a holistic approach when comparing countries in research potential. This research effort is preliminary regarding Western Balkans and attempts to build relevant comparison models based only on their Research outputs as they appear in reputed only research databases containing only peer reviewed journals and conference proceedings publications. Such a reputed Research Database is SCOPUS (www.scopus.com), managed by Elsevier Inc. Since Western Balkans were established during early 1990, the relevant data compared in this study are considered from 1990 till today. The Western Balkans region includes countries located in the Balkan Peninsula of southeastern Europe. The specific countries that are considered to be part of the Western Balkans can vary depending on the context, but the following countries are generally included: Albania, Bosnia and Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia and Serbia. It is worth noting that some organizations and institutions may include different countries in their definition of the Western Balkans region. For example, some definitions may include Slovenia or Bulgaria. We herein investigate, however, only Albania, North Macedonia and Servia. The state of the art in such research concerning Western Balkans research performance could be outlined mainly considering the following facts and literature.

The research performance in the Western Balkans (WB) is characterized by significant challenges and opportunities. While there has been a notable improvement in innovation performance over the past decade, the region still lags European benchmarks in research and development (R&D) expenditure and capacity. This overview highlights key aspects of the current research landscape in the WB.

Table 1. Key works related to research performance regarding to the Western Balkan countries.

Key works on the subject	A brief analysis
Research Management and Administration in the Western Balkans [1]	Research performance in the Western Balkans is significantly lower than the EU average, with R&D expenditure around 0.4% of GDP compared to the EU's 2.3%. Serbia leads the region at 0.9%, while Bosnia and Herzegovina trails at 0.2%.
Supporting an Innovation Agenda for the Western Balkans - Tools and Methodologies [2]	Research performance in the Western Balkans shows stable growth in scientific publication production, although patent activity remains low. The region's economies are at varying stages of building research and innovation capacities, necessitating enhanced focus on technology transfer and collaboration.
Western Balkans regional research and development strategy for innovation: overview of the research and innovation sector in the Western Balkans [3]	The research performance in the Western Balkans is improving but still lags behind international benchmarks. Challenges include significant brain drain, insufficient funding, and a mismatch between research facilities and economic needs, affecting overall sector performance.
Research and development in post-transition: a case study of western Balkans countries [4].	The status of research performance in the Western Balkans is characterized by low innovation potential and under-developed national innovation systems, resulting from long-term economic, political, and social impacts that have eroded R&D capacity and efficiency.
Managing Performance in the Western Balkan Civil Service Structures [5]	Performance management is steadily developing in the Western Balkans' public sector, with individual appraisals becoming integral. However, challenges include linking appraisals to organizational goals and developing objective performance indicators, while reducing politicization remains a key focus for improvement.

Development of science and education in the Western Balkan countries: competitiveness with the EU [6]	The research performance in the Western Balkans shows a growing number of publications in SCIe, SSCI, A&HCI, and SJR journals from 1996 to 2018, indicating an improvement in scientific output and citation impact among researchers in the region.
Productivity and Competitiveness of the Western Balkan countries: An Analysis Based on the wiiw Western Balkan Productivity Database [7]	The paper indicates that productivity growth in the Western Balkan countries has stalled since the crisis, although they have surpassed Bulgaria's productivity levels from 2007. Advancing the EU accession process is deemed both viable and necessary for improvement.
WB-bibliometric analysis [8]	The research performance in the Western Balkans, as indicated by the WB dataset from Scopus, highlights diverse themes such as digitalization and societal challenges, showcasing evolving research trends and collaborative efforts within the region.
Research policy, financing and performance: Croatia, Serbia and Slovenia in comparative perspective [9]	The paper provides empirical data on research performance in Croatia, Serbia, and Slovenia, highlighting the impact of financing as a policy instrument on scientific research development, which is crucial for understanding the status in the Western Balkans.

R&D Expenditure and Capacity

The average R&D expenditure in the WB is approximately 0.4% of GDP, significantly lower than the EU average of 2.3% (Marčić & Pepić, 2023) [1].

Serbia leads the region with 0.9% of GDP allocated to R&D, while Bosnia and Herzegovina trails at 0.2% (Marčić & Pepić, 2023) [1].

The number of R&D personnel is also low, with Serbia at 0.71% of total employment compared to the EU average of 1.44% (Marčić & Pepić, 2023) [1].

Innovation and Collaboration

Despite improvements, patent activity remains low, and the focus on medium- and low-technology exports persists (Andonova Elena et al., 2018)[2].

The region's integration into EU funding programs, such as Horizon Europe, has facilitated collaboration and capacity building, with nearly 1,000 organizations participating (Marčić & Pepić, 2023) [1].

Challenges and Recommendations

Key challenges include brain drain, insufficient funding, and a mismatch between research outputs and economic needs (Correa et al., 2013) [[4]].

Recommendations for improvement include enhancing institutional support for research management and increasing networking opportunities among researchers (Marčić & Pepić, 2023) [3].

Conversely, while the WB faces significant hurdles in research performance, the potential for growth exists through strategic investments in R&D and enhanced collaboration with EU frameworks, which could lead to a more robust innovation ecosystem in the future.

The contribution of the current research lies mainly in building specific relevant linear prediction models of research outputs in Western Balkans considering peer reviewed reputed databases as SCOPUS, while all previous works presented descriptive statistics results. To the best of our knowledge time series analysis with linear predictive analytics in order to compare research performance in countries level is first time herein proposed.

METHODOLOGY AND RESULTS

In the dynamic landscape of academia, quantifying and predicting research performance is paramount for institutions, funding bodies, and individual researchers. This study explores the use of linear predictive modelling to evaluate and forecast research performance by utilizing a comprehensive range of bibliometric indicators, such as publication counts, citation metrics, h-index, and collaborative networks as found in SCOPUS research database. More such indexing databases could be involved like LENS, Academic Scholar etc. in order to obtain more reliable data about indexed research, collecting data from prominent academic databases to ensure a robust and representative dataset across multiple disciplines and time frames. Using linear regression techniques, we herein attempt to introduce identification of both intrinsic and extrinsic factors that significantly influence research output and impact. Intrinsic factors include an individual's past performance metrics, while extrinsic factors encompass institutional resources and collaboration networks. However, the herein study its only a preliminary version of the needed conclusive study.

Empirical analysis has been conducted on the SCOPUS peer-reviewed indexing bibliographic dataset of researchers and documents. The findings demonstrate that linear predictive modelling could effectively forecast future research performance, offering actionable insights for strategic planning and resource allocation in country level,

concerning Western Balkans countries, but it is applicable to any other group of countries too.

Our study contributes to the discourse on research evaluation by presenting a transparent and interpretable approach to performance prediction. The simplicity and effectiveness of linear models make them accessible to stakeholders with varying levels of expertise in predictive analytics. We conclude with recommendations for integrating linear predictive models into institutional and country level research management systems to promote data-driven decision-making processes.

Linear predictive modelling is a statistical technique that involves using a linear equation to predict the value of a dependent variable based on one or more independent variables. The technique is often used in regression analysis, where the goal is to find a linear equation that best fits the data and can be used to make predictions.

The basic idea behind linear predictive modelling is to use a set of independent variables (also known as predictors) to estimate the value of a dependent variable (also known as the response variable). The linear equation (1) used for this purpose is typically of the form:

$$Y = a + b_1X_1 + b_2X_2 + ... + b_nX_n \quad (1)$$

where Y is the predicted value of the dependent variable, a is a constant term, X_1, X_2, ..., Xn are the independent variables, and b1, b2, ..., bn are the coefficients that determine the relationship between the independent variables and the dependent variable.

To build a linear predictive model, one typically starts by collecting data on the variables of interest and selecting a set of independent variables that are likely to be related to the dependent variable. The next step is to estimate the coefficients of the linear equation using a statistical method such as ordinary least squares regression. Once the coefficients have been estimated, the model can be used to make predictions about the value of the dependent variable for new observations.

Linear predictive modelling has a wide range of applications in fields such as economics, finance, engineering, and social sciences. It is often used to predict outcomes such as stock prices, customer behaviour, or disease progression. However, it is important to note that linear predictive models are only approximations of reality and may not be accurate in all situations. It is therefore important to validate the model using data that was not used to estimate the coefficients and to assess the model's accuracy and reliability.

Following such a linear predictive modelling approach involving research outputs regarding the three aforementioned and compared countries, namely, Albania, North Macedonia and Serbia the results obtained are presented in the next figures 1,2,3, and 4.

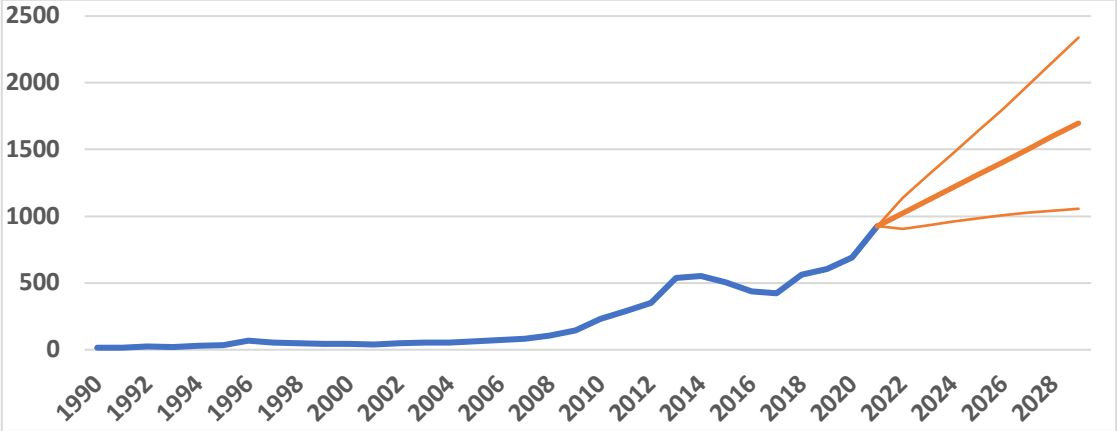

Figure 1. The time series of SCOPUS research outputs concerning Albania. In blue the time series data. In orange the max and min confidence interval predictions. The bold orange represents predicted values.

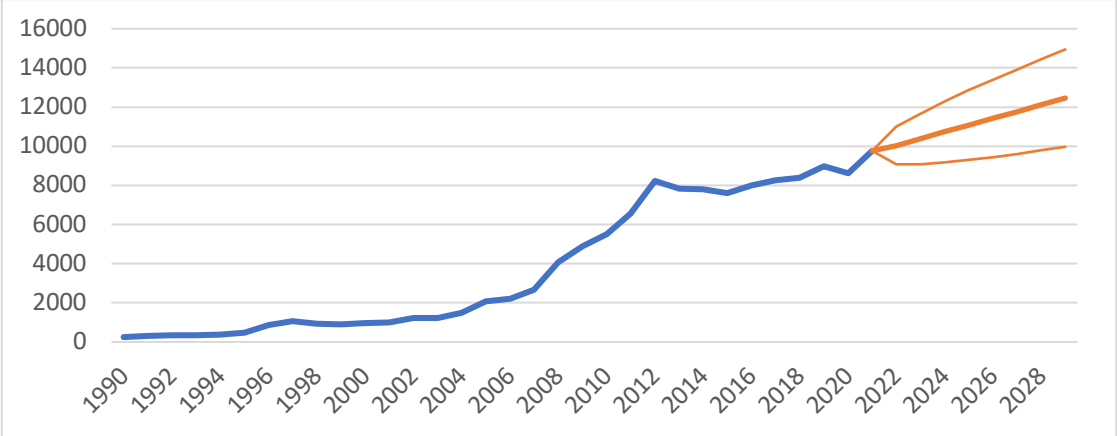

Figure 2. The time series of SCOPUS research outputs concerning Serbia. In blue the time series data. In orange the max and min confidence interval predictions. The bold orange represents predicted values.

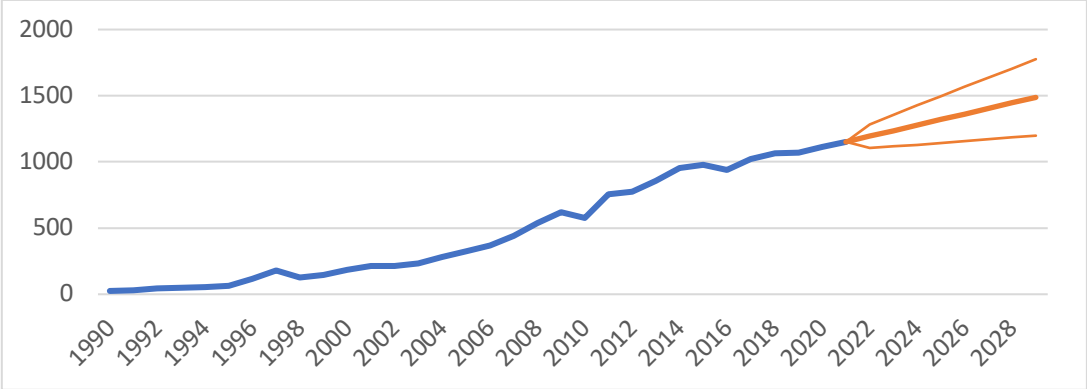

Figure 3. The time series of SCOPUS research outputs concerning North Macedonia. In blue the time series data. In orange the max and min confidence interval predictions. The bold orange represents predicted values.

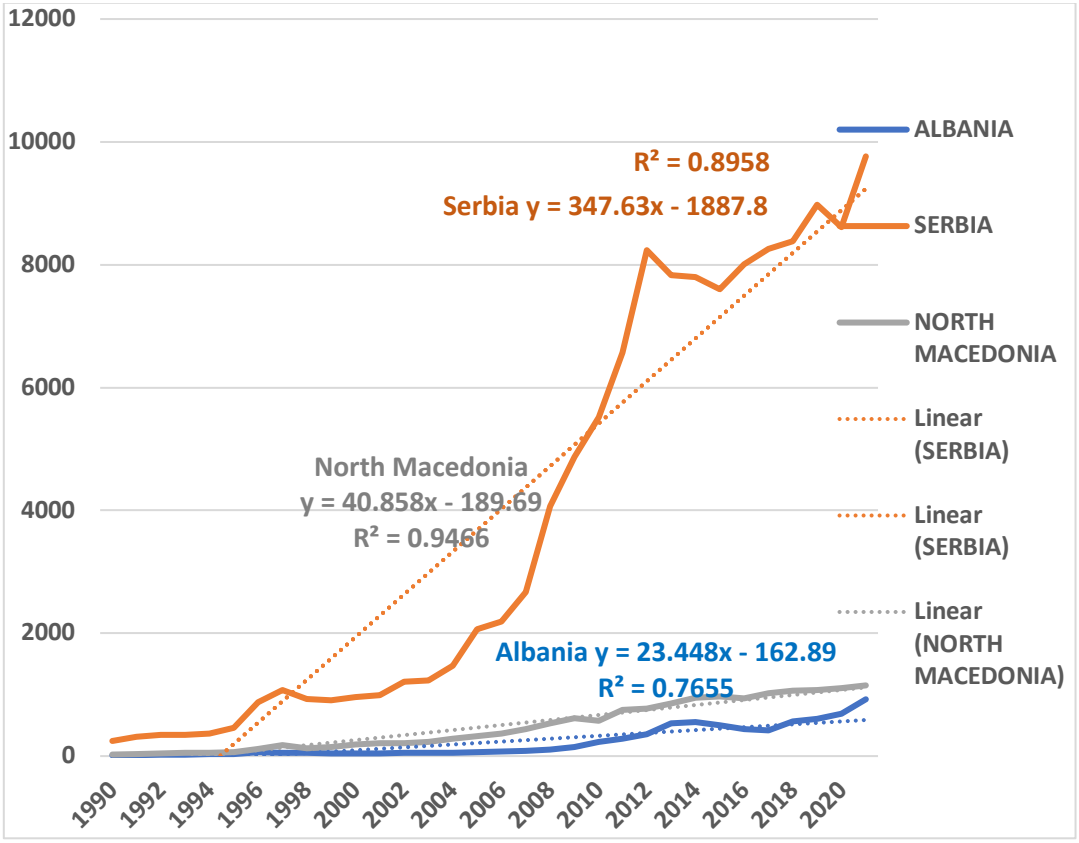

Figure 4. The comparative analysis diagram for the research outputs of the three aforementioned Western Balkan countries, where the linear predictive models are completely defined. Sorted regarding to their slopes it is obvious the potential of Serbia, with second North Macedonia and third Albania. But according to figure 1 it is obvious that Albania has more potential in the future according to predictive analytics regarding the confidence intervals.

CONCLUSION

Following a linear predictive approach this paper considers the research performance trends in three countries of Western Balkans, namely, Albania, North Macedonia and Serbia. Through the presented methodology we build linear predictive analytics models that could forecast corresponding research outputs with good accuracy, achieving relatively high or very high R2 coefficients, especially in the case of North Macedonia and Serbia. Albania presents more uncertainty and according to the predictive analytics of figure 1 more future potential.

CONFLICT OF INTERESTS

The author confirms that there is no conflict of interest associated with this publication.

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