

ADVANCED ECONOMETRIC MODELS IN THE DIGITAL AGE: BIBLIOMETRIC ANALYSIS

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Abstract

This research highlights the importance of econometrics and advanced econometric models in the analysis and forecasting of complex economic phenomena. Econometrics is presented as a fundamental interdisciplinary discipline that integrates statistical and mathematical methods into economic theory and provides a rigorous framework for understanding economic dynamics. Based on the Web of Science database (1975-2024), bibliometric analysis using the VOSviewer programme was used to identify the main research directions, authors and countries that have made significant contributions in this field. The results revealed key trends, including increased interest in "multiple regression", "production function (Cobb-Douglas)", "Logit", "ARIMA", "SARIMA", "ARCH", "GARCH", "SVAR" models, as well as the integration of artificial intelligence methods into econometric analysis. The conclusion highlights the crucial role of econometric models in supporting economic decisions and making reliable forecasts, demonstrating the dynamic and adaptable nature of contemporary econometrics.

Keywords: Bibliometric analysis; production function; Logit; ARIMA; SARIMA; ARCH, GARCH; SVAR.

JEL Classification: C01, C51

INTRODUCTION

The global economy has evolved over time, influenced by various factors such as technological innovation, economic crises, globalisation, monetary and fiscal policies, and regulations on domestic and international financial markets. From the first industrial revolution to the digital age, the global economy has undergone a series of major transformations that have fundamentally changed the structure and functioning of the world economic system. The Industrial Revolution 1.0 marked the transition from agriculture to industry and the development of international markets and trade. The second industrial revolution (2.0) was marked by the development of mass production, the emergence of new technologies, and increased trade flows at the national and international levels. In the second half of the 20th century, when the third industrial revolution (3.0) took place, globalisation and international economic integration came to the fore. The development of international trade, through the liberalisation of financial markets, was supported by the rise of transport and telecommunications. The digital age (Industrial Revolution 4.0) revolutionised the functioning of the global economy through digital technologies (the internet and e-commerce). In this context, the dynamics of international trade have undergone numerous changes due to the emergence of digitalisation and automation. These have transformed traditional industries and created new economic sectors, the digital economy and data-processing industries. The evolution of macroeconomic phenomena/processes, which are increasingly complex, continues to shape the global economy and lead us towards the Industrial Revolution 5.0. Thus, the global economy has experienced accelerated development and spectacular evolution (Westphal, 2002), but it has not been "immune" to vulnerabilities. Throughout history, economic crises have highlighted the fragility of economic systems/phenomena by exploiting the weaknesses of the economy caused by various factors, such as the development of flawed political strategies, social and economic imbalances, and unforeseen external events (pandemics, natural disasters). These have demonstrated that the economy is not a "perfectly self-regulating system" and that the evolution of the global economy does not always follow a linear upward trend.

An analysis of global economic developments highlights the fact that complexity and uncertainty have generated the need for advanced data analysis methods to understand economic phenomena and processes. Therefore, econometrics through econometric methods has become indispensable for analysing economic trends at global and regional level.

I. LITERATURE REVIEW

Econometrics, a fundamental field of economics, has developed in parallel with the development of economic theory, statistics and information science. The literature emphasises that the main objective of econometric is to transform theoretical economic relationships into quantifiable models that can explain and predict macro- and microeconomic behaviour (Gujarati & Porter, 2009).

The first econometric models appeared in the first half of the 20th century. They were based on simple or multiple regression and were used to analyse causal economic relationships between fundamental variables such as income, consumption and investment (Tinbergen, 1939; Frisch, 2024). These models laid the foundations for modern empirical analysis, symbolising the transition from purely descriptive theories to quantitative analysis of economic phenomena. A decisive step in the development of the literature was the development of the Cobb-Douglas production function (Cobb & Douglas, 1928), which allowed the quantification of the relationship between capital and labour and economic performance (GDP). Subsequently, the literature diversified, expanding from linear to nonlinear models and incorporating concepts such as elasticity, profitability, and total factor productivity (Solow, 1957; Mankiw et al., 1992). In the 1970s and 1980s, econometric research focused on dynamic models capable of mapping temporal relationships between variables. ARIMA (Box & Jenkins, 1976) and SARIMA models became indispensable for time series analysis and economic forecasting. At the same time, volatility assessment models such as ARCH and GARCH (Engle, 1982; Bollerslev, 1986; Straetmans & Candelon, 2008) were developed and became widely used in the analysis of financial markets and investment risks. VAR and SVAR models (Sims, 1980) made it possible to understand the complex relationships between macroeconomic variables without the need to prescribe strict causal structures, leading to a paradigm shift in empirical economic analysis.

Contemporary literature highlights a shift towards advanced econometric models based on the integration of digital technology, machine learning techniques and artificial intelligence algorithms (Varian, 2014; Athey, 2019). These hybrid models combine classical econometric approaches with machine learning techniques (e.g., elastic regression, random forests, LSTM), improving the ability to predict and identify complex patterns in large data sets. Current trends point to the following research directions: the development of non-parametric and semi-parametric models, the application of Bayesian methods for uncertainty estimation, the integration of spatial and spatiotemporal analysis, and the increased use of neural networks and deep learning models in econometric analysis.

The literature reflects a gradual transition from simple models based on linear relationships to complex, adaptive models that capture the nonlinear nature, dynamism, and interdependence of economic phenomena. This methodological evolution shows that econometrics is no longer just a tool for testing economic theories, but an interdisciplinary field that combines statistics, computer science and data analysis to create applied knowledge. We believe that bibliometric analysis of literature has become a key tool for identifying research trends, scientific collaboration networks and the degree of innovation in the field of advanced econometric modelling.

II. RESULTS AND DISCUSSIONS

The bibliometric analysis of the specialised literature in relation to the evolution of advanced econometric models reflects the importance of research and trends in the field. It provides a picture of methodological developments and highlights innovation and collaboration between researchers and institutions in different parts of the world (Grosu et al. 2022; Melega et al., 2022).

To perform a bibliometric analysis, the VOSviewer programme was used, which allowed clusters to be built by country, author and topic in order to visualise two-dimensional maps of the selected relationships. In order to develop the bibliometric analysis, the keywords "multiple regression", "production function (Cobb-Douglas)", "Logit", "ARIMA", "SARIMA", "ARCH", "GARCH", "SVAR" were used, and the following scientific areas were selected: Economics, Business Finance, Operations Research Management Science, Management, Business, Social Sciences Mathematical Methods, Mathematics Interdisciplinary Applications, Statistics Probability, Computer Science Interdisciplinary Applications, Mathematics Applied, Computer Science Artificial Intelligence, Computer Science Information Systems, International Relations and Automation Control Systems. For this analysis, a total of 19,448 articles on the chosen topic were found for the entire period analysed, 1975-2024, on the Web of Sciences platform.

Using the VOSviewer programme, a bibliometric analysis was performed, which allowed the construction of country clusters and the visualisation of two-dimensional maps of selected relationships. In this part of the study, an analysis of the specialist literature was carried out for the period 1975–2024, using the Web of Science platform. As in the above analyses, the search terms were 'multiple regression', 'production function (Cobb-Douglas)', 'Logit', 'ARIMA', 'SARIMA', 'ARCH', 'GARCH', 'SVAR', and the following scientific areas were selected: Economics, Business Finance, Operations Research Management Science, Management, Business, Social Sciences Mathematical Methods, Mathematics Interdisciplinary Applications, Statistics Probability,

Computer Science Interdisciplinary Applications, Mathematics Applied, Computer Science Artificial Intelligence, Computer Science Information Systems, International Relations, and Automation Control Systems.

Based on the searched topic, VOSviewer creates a complete map based on all keywords and associated terms that have been assigned to the topic using the Web of Science database. The size of the clusters indicates which terms are closest and most commonly used in relation to the searched topic. An interesting point shown in Figure 1 is the diversity of countries that have addressed this topic.

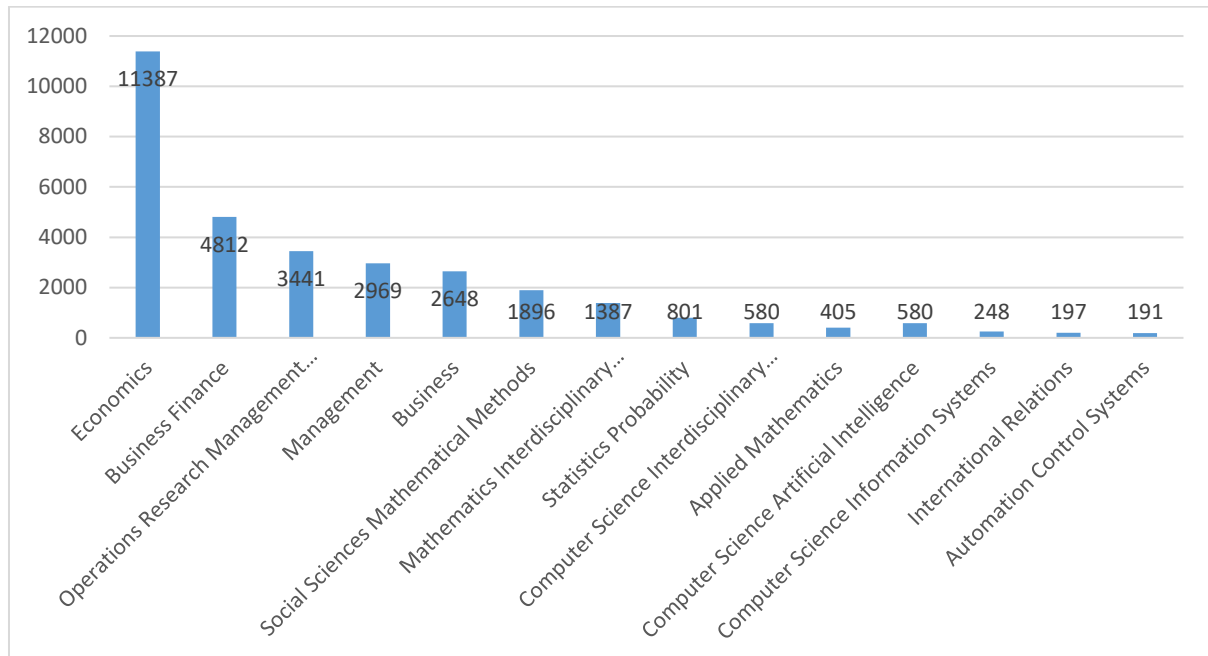


Figure 1. Number of articles by scientific field

Source: author's processing

Based on the searched topic, VOSviewer creates a complete map based on all keywords and associated terms that have been assigned to the topic using the Web of Science database. The size of the clusters indicates which terms are closest and most frequently used in relation to the searched topic. An interesting point shown in Figure 3 is the diversity of countries that have addressed this topic.

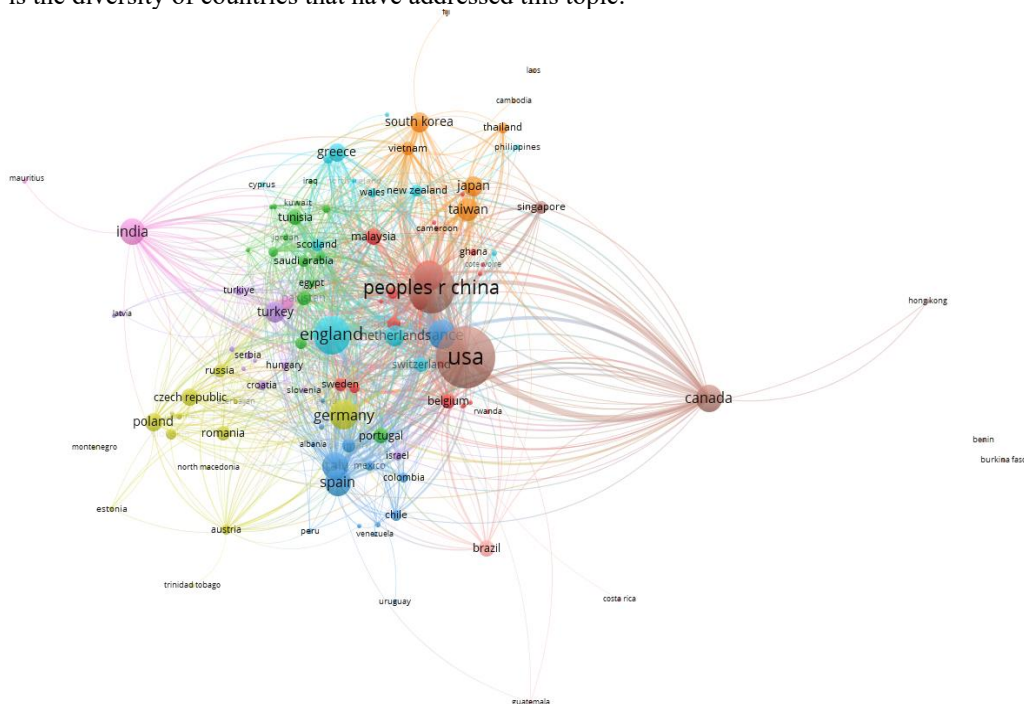


Figure 2. Bibliometric analysis of the number of articles by country

Source: Author's processing in the VOSviewer programme

Figure 2 contains the keywords that resulted from the sample analysed using the Web of Science database. The bibliometric analysis contains 10 clusters represented by different colours with 113 items for the analysis period 1975-2024. The map in Figure 3 highlights the scientific links between the concepts specific to the topic searched by country, as well as the intensity of the connections. The 10 clusters are:

Table 1. Analysis of the literature in relation to the number of articles by country

Cluster	Frequency	Percent	Countries
Valid 1	21	18.6	Australia, Belgium, Botswana, Brunei, Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Indonesia, Kenya, Malaysia, Nigeria, Norway, Rwanda, South Africa, Sri Lanka, Sweden, Tanzania, Uganda, Uzbekistan, Zimbabwe
2	16	14.2	Bahrain, Bangladesh, Egypt, Finland, Iraq, Jordan, Kuwait, Lebanon, Mongolia, Oman, Pakistan, Portugal, Qatar, Saudi Arabia, Tunisia, United Arab Emirates
3	15	13	Albania, Algeria, Argentina, Chile, Colombia, Denmark, Ecuador, France, Italy, Mexico, Morocco, Peru, Spain, Uruguay, Venezuela
4	14	12.4	Austria, Azerbaijan, Czech Republic, Estonia, Germany, Macedonia, Montenegro, North Macedonia, Poland, Romania, Russia, Slovakia, Trinidad, Tobago, Ukraine
5	13	11	Cyprus, England, Greece, Ireland, Kazakhstan, Luxembourg, Netherlands, New Zealand, Northern Ireland, Philippines, Scotland, Switzerland, Wales
6	12	10	Bosnia & Herzegovina, Bulgaria, Croatia, Hungary, Israel, Kosovo, Latvia, Lithuania, Malta, Serbia, Slovenia, Turkey
7	8	7	Cambodia, Fiji, Japan, Laos, South Korea, Taiwan, Thailand, Vietnam
8	7	6	Benin, Burkina Faso, Canada, Hong Kong, People's Republic of China, Singapore, USA
9	4	3.5	India, Iran, Mauritius, Nepal
10	3	2.7	Brazil, Costa Rica, Guatemala
Total	113	100	

Source: Author's processing based on the VOSviewer database

According to the bibliometric analysis, the geographical distribution of the 19,448 articles obtained on the Web of Science platform includes 113 countries on all continents. This global distribution reflects international interest in the research topic specified and the involvement of the scientific community in different countries in the development and publication of articles in the field or interdisciplinary field. The evolution of the number of articles by country is presented in the map (Figure 3).

It is noteworthy that throughout the analysed period 1975-2024 on the Web of Sciences platform, there has been a diversification of continents that have addressed the analysed topic.

Figure 4 shows that the United States of America (USA) has the largest share in terms of the number of papers on the specified topic, with a total of 2,393 published papers (12.30%). The USA is also the first country to publish papers on this topic, confirming its position as a world leader in research. It is a country that is internationally recognised as one of the most important centres of research from a scientific point of view. Its research and innovation policy is supported by state institutions benefiting from the support of the Office of Science and Technology Policy and the US Congress. In the US, funding for research and innovation is provided through government agencies such as the Department of Defence (DoD), the Department of Health and Human Services (HHS), NASA, the Department of Energy (DOE) and the National Science Foundation (NSF). These agencies play an important role in stimulating scientific and technological progress by providing substantial funding for the development of advanced research projects and innovations that contribute to the country's global competitiveness and scientific impact.

The top countries are followed by the United Kingdom in second place, with 1,631 articles (8.39%) on this topic, and China in third place, with 1,375 articles (7.07%). The next countries to publish on the topic searched are France (909 articles, 4.67%), Australia (885 articles, 4.55%), Germany (844 articles, 4.34%), Canada (737 articles), Italy (595 articles, 3.06%), the Netherlands (559 articles, 2.87%) and Spain (551 articles, 2.83%). Among the countries concerned with this topic is Romania, in cluster 4, ranked 105th with 72 articles, representing 0.37% of the total publications. Romania's contribution reflects its active and growing interest in research in this field, although it is modest at the global level compared to other important countries. In this context, Romania's

participation highlights the importance of involving Romanian researchers in international scientific cooperation networks in order to increase the impact and visibility of the results obtained at the global level. Despite its interest in research, the Republic of Moldova is not included in the list of countries where papers on the analysed topic have been published, highlighting the need to develop scientific infrastructure and support research in areas of global interest.

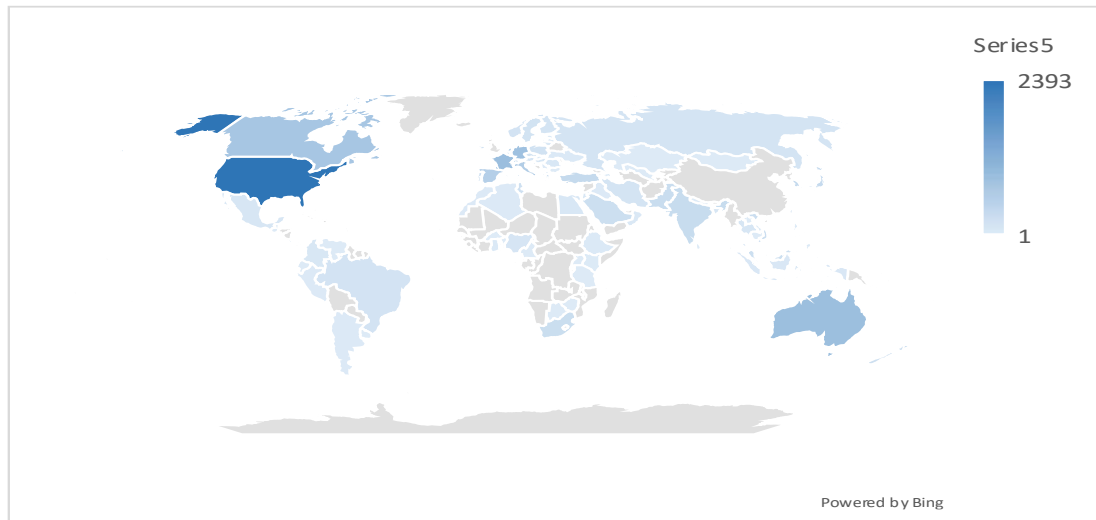


Figure 3. Map of the analysis of the specialised literature in relation to the number of articles
Source: Author's processing based on the VOSviewer database

The bibliometric analysis of the specialised literature for the period 1975–2024 also includes an analysis of the authors who publish articles on the topic analysed.

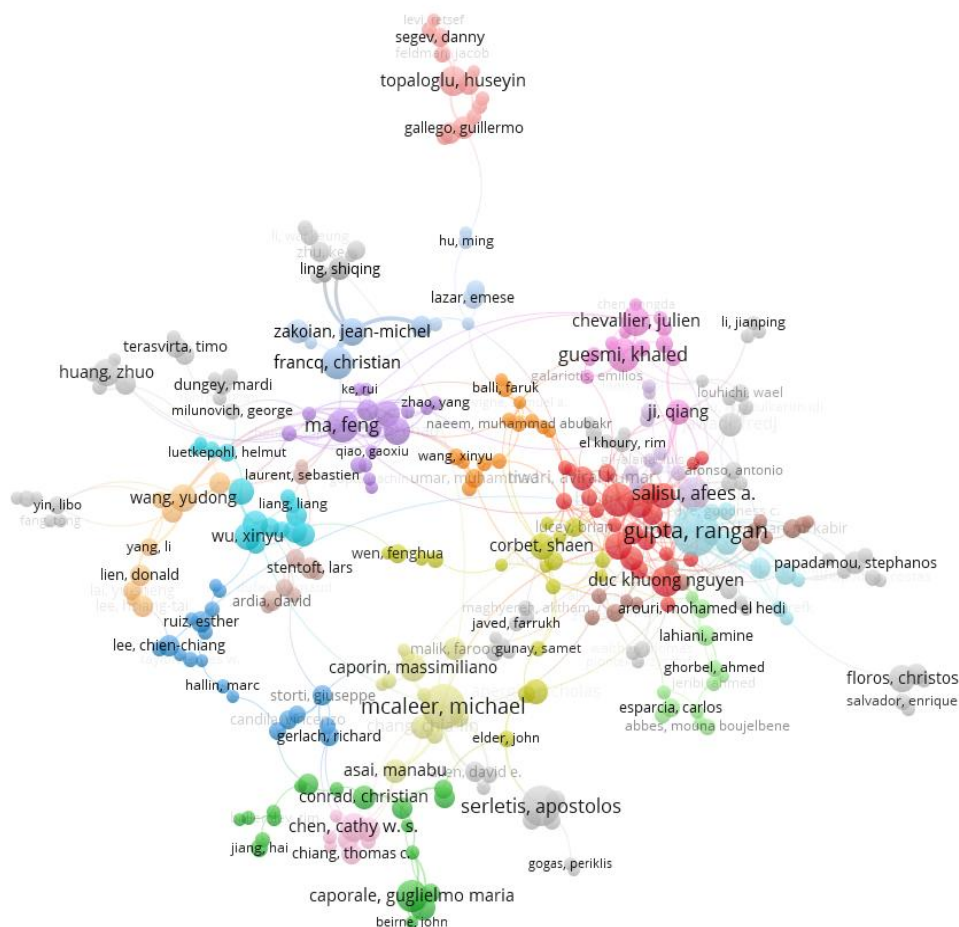


Figure 4. Bibliometric analysis of the specialised literature in relation to authors
Source: Author's processing in the VOSviewer programme

The analysis of the specialised literature in relation to the author is necessary to understand the context of their work and their contribution to the field. Its purpose is to evaluate the originality of the author's ideas, identify the theory studied and compare it with other related articles. Figure 4 includes the authors who resulted from the sample analysed using the Web of Science database. The bibliometric analysis contains 33 clusters with 327 items (authors) for the analysed period and is presented in the table:

Table 2. Analysis of the specialised literature in relation to authors by clusters

	cluster	Frequency	Percent		cluster	Frequency	Percent
Valid	1	25	7.6	Valid	18	8	2.4
	2	19	5.8		19	8	2.4
	3	19	5.8		20	8	2.4
	4	18	5.5		21	7	2.1
	5	17	5.2		22	6	1.8
	6	15	4.6		23	6	1.8
	7	14	4.3		24	6	1.8
	8	14	4.3		25	5	1.5
	9	14	4.3		26	5	1.5
	10	13	4.0		27	5	1.5
	11	12	3.7		28	5	1.5
	12	12	3.7		29	3	.9
	13	12	3.7		30	3	.9
	14	11	3.4		31	3	.9
	15	10	3.1		32	3	.9
	16	9	2.8		33	3	.9
	17	9	2.8		Total	327	100

Source: Author's processing based on the VOSviewer database

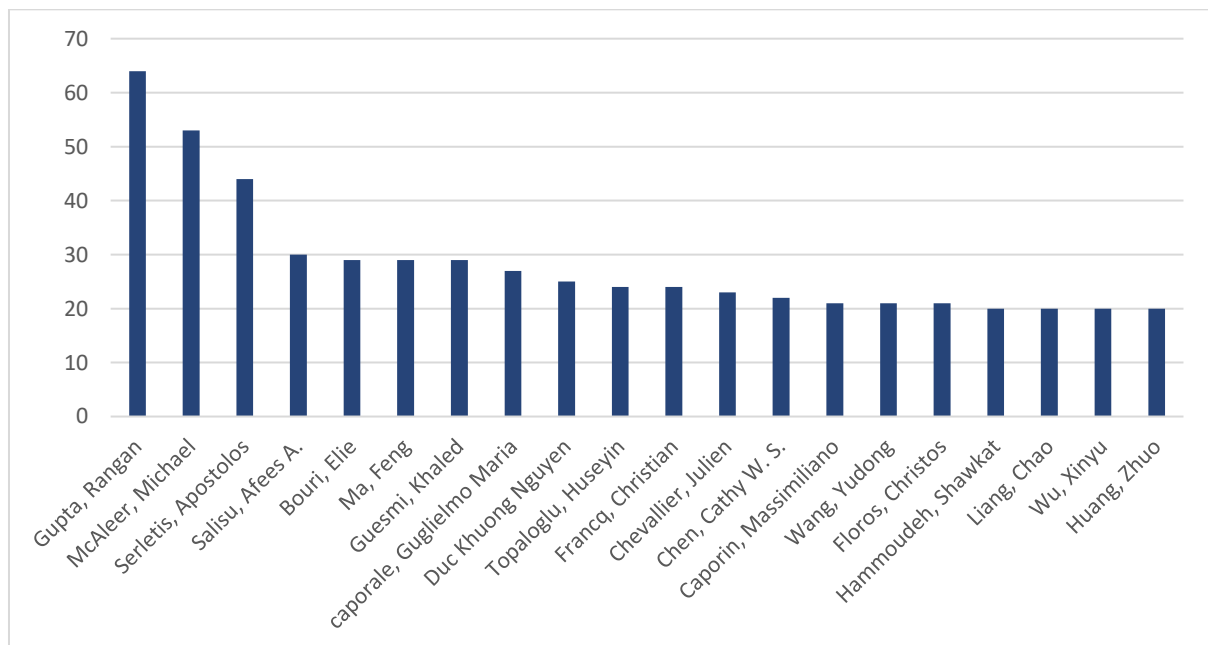


Figure 5. Analysis of authors (top 20) by number of articles

Source: author's processing

The first author to contribute to works on the topic under analysis is Gupta Rangan. He collaborates with other researchers on topics related to business strategies, volatility, uncertainty in emerging markets and globalisation, and develops/researches the effects of uncertainty in business using advanced econometric methods. He has published 64 articles on the topic analysed. For example, the paper (Bouri et al., 2024) presents a logistic model for forecasting recessions in the US based on a complex database with financial variables. His research

makes a significant contribution to investors and policy makers, providing tools for forecasting market volatility and risk under conditions of uncertainty. Another author interested in the topic under discussion is McAleer Michael, who has published 53 articles together with other researchers. He is known for his work in financial econometrics, particularly in volatility and GARCH models. For example, in the paper (Asai & McAleer, 2022), the authors present an innovative model, MEGARCH (Matrix-Exponential Realised GARCH), which uses information from device returns as well as realised co-volatility metrics to analyse volatility and manage risk in financial markets. Third place in the bibliometric ranking for the topic analysed is occupied by Serletis Apostolos, who is known for his contributions to emerging economies (Azad & Serletis, 2024), including econometric modelling (VAR, GARCH, SVAR, time series) and has published 44 articles. Economist Salisu Afees A. is the next author to have published research papers on the analysed topic (30 articles). Together with other renowned researchers, he is interested in the volatility of financial markets and the uncertainty of economic policies through the application of econometric models (semi-parametric model with uniform variable coefficient, GARCH-MIDAS).

The bibliometric analysis of the specialised literature between 1975 and 2024 also contains an analysis of the topic. Using the VOSviewer programme, a bibliometric analysis was developed through a systematic search of terms associated with the topic sought through various works published throughout the analysed period. This perspective offers the possibility to identify research developments and trends, highlighting the main contributions and links between different concepts associated with the analysed topic.

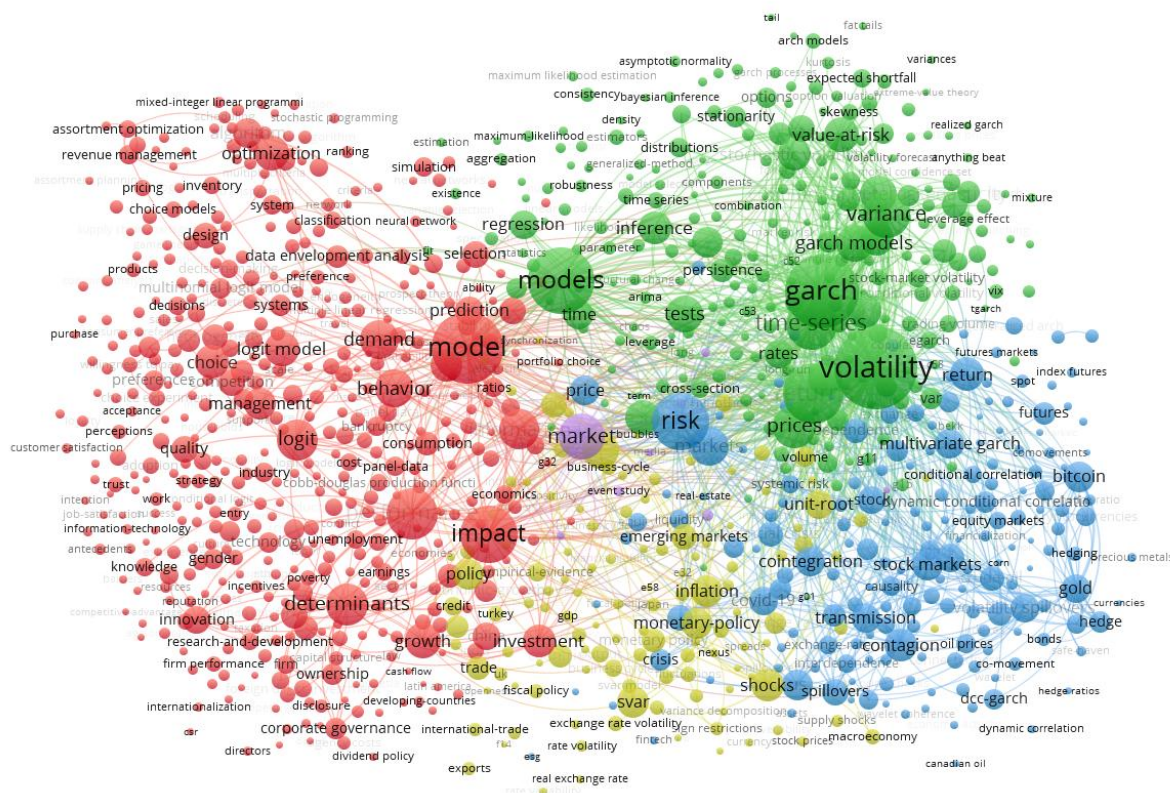


Figure 6. Bibliometric analysis of the specialised literature in relation to the analysed topic
Source: Author's processing in the VOSviewer programme

Figure 6 shows the key terms that came up from the sample analysed using the Web of Science database. The bibliometric analysis has 5 clusters with 1,000 items for the period analysed. Cluster 1 contains 448 items (the largest number of terms), cluster 2 contains 245 items, cluster 3 contains 177 items, cluster 4 contains 122 items, and the last cluster, cluster 5, contains 8 items. The five clusters are highlighted by five distinct colours:

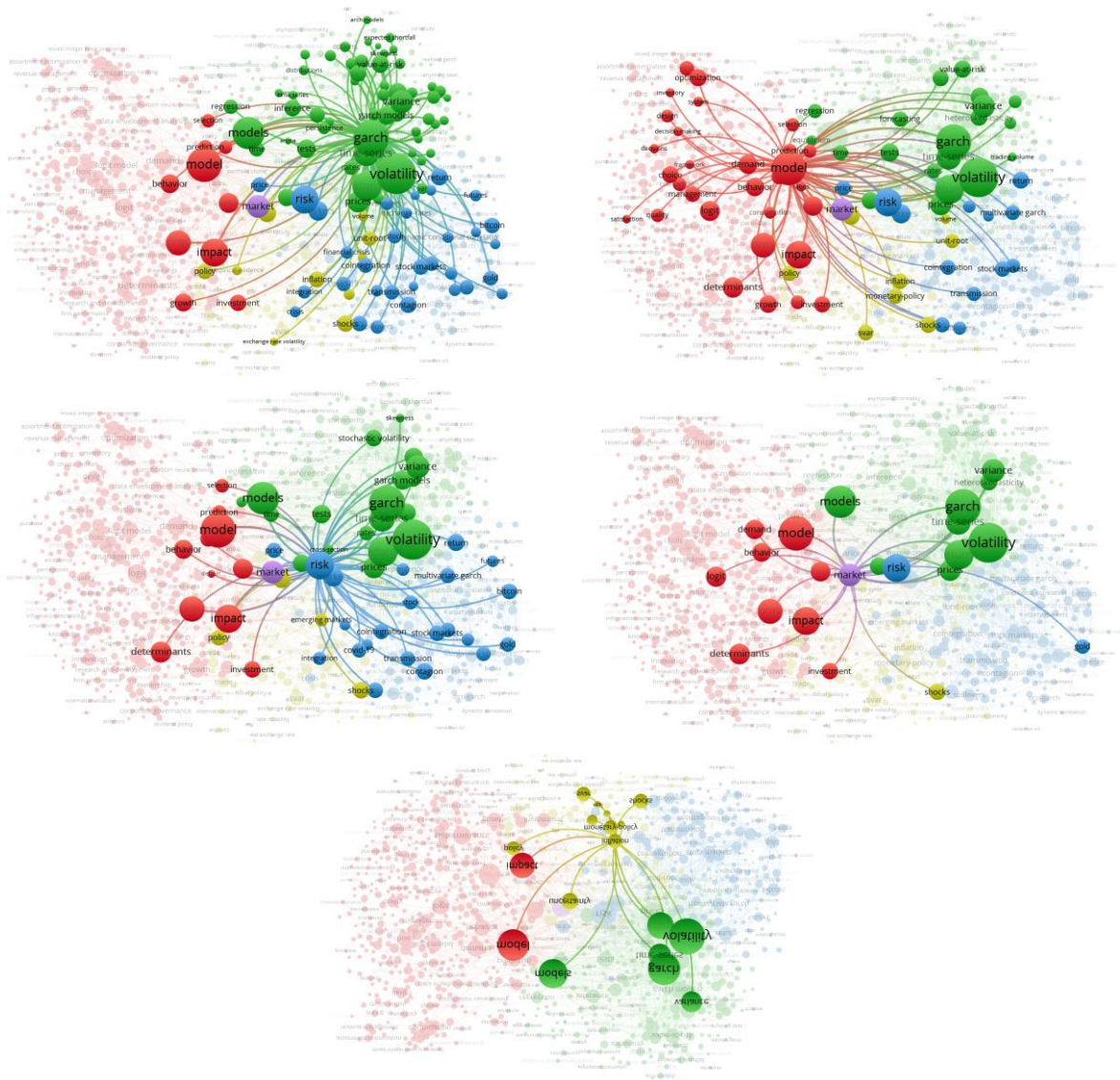


Figure 7. Typology of clusters for the analysed topic
Source: Author's processing in the VOSviewer programme

The map in Figure 7 highlights the scientific links between the concepts specific to the searched topic, as well as the intensity of the connections. Therefore, based on the searched topic, VOSviewer creates a complete map based on all keywords and associated terms that have been assigned to the topic using the Web of Science database. The size of the clusters indicates which terms are closest and most frequently used in relation to the searched topic.

Table 3. Analysis of the literature in relation to the topic

	Cluster	Frequency	Percent	Keywords
Valid	1	448	44.8	Model, GARCH, return, impact, performance, determining factors, Logit, Probit, demand, behaviour, growth model, optimisation, investments, efficiency, prediction, innovation, impact, evaluation, foreign direct investments, quality competition, mixed integer linear programming, effectiveness, game theory, supply chain management, production, financial turnover, etc.
	2	245	24.5	Volatility, time series, SARIMA, variables, price, test, heteroscedasticity, stochastic volatility, inference, forecasting, ARCH, Monte Carlo simulation, ARIMA, portfolio selection, estimator, Markov chain, Bayesian inference, asymptotic normality, seasonality, etc.

3	177	17.7	Risk, volatility spillover effects, side effects, dynamic conditional correlations, safe haven, coverage ratio, spillover effects, portfolio optimisation, etc.
4	122	12.2	Uncertainty, stock, inflation, SVAR, monetary policies, unit root, financial stability, structural change, business cycle, etc.
5	8	.8	Market, event study, white noise, macroeconomics
Total	100	100.0	

Source: Author's processing based on the VOSviewer database

The importance of the topic analysed is based on its impact on the evolution of study and research in the field. Several articles lead to scientific progress in the field, the identification of gaps in research and cooperation between researchers. In this context, bibliometric analysis provides a clearer view of the dynamics of innovation/development, research and geographical spread.

IV. CONCLUSION

This study has highlighted the importance of econometrics and econometric models in the analysis and forecasting of complex economic phenomena. Econometrics has been analysed as a fundamental discipline that integrates statistical methods with economic theory and provides a rigorous analytical framework for economic data. It has been emphasised that econometrics allows raw information to be transformed into applicable knowledge, which is essential for informed economic decision-making. Advanced econometric models play an essential role in economic forecasting and data analysis, providing a solid methodological framework for quantifying the relationships between economic variables. They enable decision-makers to understand and predict the dynamics of complex and uncertain economic systems, and to assess the impact of economic policies and other external factors on economic performance/sustainability/volatility. Various types of econometric models that integrate statistical and mathematical methods with economic theory were analysed to examine diverse phenomena such as GDP growth, domestic investment, foreign direct investment, inflation and unemployment. These models help to identify trends and causal relationships and are an essential tool for reliable and well-informed economic forecasting.

A bibliometric analysis was conducted to demonstrate the importance and relevance of econometric modelling in current research. This analysis highlighted trends in the literature and highlighted key contributions that have led to the development and improvement of econometric methods. By highlighting the most cited works and the most important research directions, it was demonstrated that econometric modelling is not only fundamental to economic analysis, but also constantly evolving and adapting to new economic and technological challenges. In this context, the study emphasises that econometric modelling is important for understanding complex economic phenomena/processes, which are certainly uncertain, and for making reliable economic forecasts based on solid theories and supported by renowned research in the field.

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32. ** VOSwiewer
33. ** Web of Science

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