CHEMICAL ENGINEERING TRANSACTIONS

VOL. 122, 2025

A publication of AIDIC

The Italian Association
of Chemical Engineering
Online at www.cetjournal.it

Guest Editors: Jeng Shiun Lim, Bohong Wang, Guo Ren Mong, Petar S. Varbanov

ISBN 979-12-81206-23-6; **ISSN** 2283-9216

DOI: 10.3303/CET25122073

Exploring the Research Hotspots and Frontiers of Consumer Behavior in Aviation Carbon Offset - Based on Bibliometric Research

Zhijian He[a], Syamsul Herman Mohammad Afandi[a,*], Shaufique Fahmi Ahmad Sidique[a], Sining Ma[b]

[a]School of Business and Economics, Universiti Putra Malaysia, 43300, Seri Kembangan, Selangor, Malaysia
[b]School of Energy and Constructional Engineering, Shandong Huayu University of Technology, Dezhou, Shandong, 253034, P.R. China
syamsulhma@upm.edu.my

This study provides a comprehensive bibliometric review of consumer behavior and willingness to pay (WTP) for voluntary carbon offsetting (VCO) in the aviation sector from 2007 to 2025. By analyzing 60 selected articles using VOSviewer, the research maps key themes, development trends, and methodological frontiers in the field. Three major keyword clusters emerged: (1) sustainable development and consumer behavior, (2) economic instruments and valuation, and (3) methodological and policy approaches. The temporal analysis highlights a significant rise in scholarly attention post-2016, coinciding with international policy developments like CORSIA. Despite increasing methodological diversity—including SEM, CVM, and CE—the literature remains constrained by reliance on stated preferences, lack of real behavioral data, and minimal integration of social sustainability dimensions. Addressing these gaps is essential for enhancing the credibility, effectiveness, and public acceptance of VCO programs in global aviation.

1. Introduction

The aviation sector contributes significantly to global greenhouse gas (GHG) emissions, accounting for approximately 2–3% of global CO_2 emission (Park et al., 2024). With the rapid growth in air travel, mitigating aviation-related emissions has become a critical component of climate action plans (Bergero et al., 2023). The International Civil Aviation Organization (ICAO) introduced the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016, aiming to stabilize international aviation carbon emissions at 2020 levels through a global market-based measure, which represents a critical milestone in addressing climate change within the aviation sector (ICAO, 2016). Among various mitigation strategies, voluntary carbon offsetting (VCO) programs have emerged as a market-based solution (International Air Transport Association, 2022.) These programs allow air passengers to compensate for their flight-related emissions by supporting carbon reduction projects. (Mello, 2024). Despite their environmental potential, VCO programs often face low participation rates, largely influenced by consumer behavior and willingness to pay (WTP) (Tang et al., 2024).
Despite this growing body of literature, the field remains fragmented. Studies often differ in their methodologies, geographic focus, and the variables examined, which limits the generalizability of their findings. Some meta-analyses have attempted to quantify WTP across regions, reporting variations based on scheme design and transparency (Wendt et al., 2024), while others have emphasized context-specific behavioral predictors, such as trust in airlines and familiarity with offset mechanisms (Fabiana Peixoto de and Macario, 2024). Moreover, while many studies focus on purchase intentions, relatively few examine actual purchasing behavior, highlighting a persistent intention–behavior gap (Park et al., 2024).Understanding the factors that drive or hinder consumer participation in carbon offsetting has therefore become a growing research interest. In this context, this review aims to synthesize and evaluate existing research on consumer carbon offsetting behavior in the aviation industry. Leveraging a comprehensive dataset of academic studies (2007–2025), this paper by employing a

Paper Received: 30 June 2025; Revised: 11 September 2025; Accepted: 13 September 2025
Please cite this article as: He Z., Mohammad Afandi S.H., Ahmad Sidique S.F., Ma S., 2025, Exploring the Research Hotspots and Frontiers of Consumer Behavior in Aviation Carbon Offset—Based on Bibliometric Research, Chemical Engineering Transactions, 122, 433-438 DOI:10.3303/CET25122073

bibliometric analysis, the study seeks to address its research objectives and propose actionable, sustainability-oriented recommendations for future policy development. This study aims to map the research hotspots and methodological frontiers of consumer behavior in aviation carbon offsetting programs, identifying knowledge gaps and providing future research directions. By consolidating insights across diverse studies, this review contributes comprehensively understand the research frontiers and directions of consumer behavior in aviation carbon offsets, and provide feasible suggestions for future researchers in related fields.

2. Research methodology

This review adopts a bibliometric approach to analysing existing studies on consumer behaviour toward carbon offset in the aviation sector. The analysis draws upon a dataset of 60 articles, compiled from scholarly sources between 2007 and 2025, and documented in a structured spreadsheet titled Final Database on Consumer Behaviour and Carbon Offsetting in Aviation.

2.1 Search strategy

Researchers performing literature reviews often utilize several online bibliometric tools, with Clarivate Analytics' Web of Science and Elsevier's Scopus acknowledged as the two principal platforms for thorough literature analysis and assessment owing to their vast disciplinary scope (Chi et al., 2025).

The search strategy was constructed using Boolean logic operators to ensure conceptual completeness (Scells et al., 2020), incorporating both primary keywords and their semantic equivalents. The search query was formulated as follows: (("air travel" OR "aviation") AND ("carbon offset" OR "carbon tax" OR "carbon offsetting" OR "carbon credit" OR "carbon compensation" OR "carbon neutrality")). The temporal scope encompasses the complete publication history from the inaugural article in this research domain (2007) through the most recent available data (2025). To maintain methodological precision while ensuring comprehensive retrieval, the search was restricted to the Topic field, which systematically searches three critical metadata fields: Title, Abstract, and Keywords. All retrieved bibliographic records were exported in plain text format containing full records and cited references. This dataset constitutes the foundational corpus for subsequent scientometric analysis in this investigation. Specifically, the search retrieved 389 records from the Scopus database and 209 records from the Web of Science Core Collection.

2.2 Data analysis

This review employs a tripartite analytical framework to examine 60 publications on aviation carbon offset mechanisms. The dataset comprises comprehensive bibliographic information including author metadata, publication details, institutional affiliations, and citation network data. Initial descriptive analyses revealed temporal publication patterns and geographic distribution of research outputs of scholarly productivity from 2007 to 2025.In the second stage, bibliometric analysis was performed using VOSviewer software (Tamala et al., 2022). Bibliometrics is a scientific method that employs statistical and quantitative analysis to study publications, authors, and their interrelationships, with the aim of revealing the development patterns, research hotspots, and trends within a specific field (Witting, 1978). Bibliometric analysis is a valuable technique for mapping and interpreting scientific knowledge accumulation and disciplinary evolution within large sets of unstructured data (Vlase and Lähdesmäki, 2023). To investigate developmental trends and emerging research hotspots in this field, keyword co-occurrence analysis (co-word analysis) was employed(Huang et al., 2024). Keyword co-occurrence analysis measures the number of publications in which two keywords simultaneously appear within the title, abstract, or keyword fields. Co-word analysis visualizes the similarities between frequently occurring keywords (i.e., topics) within the literature(Dwivedi et al., 2023). To improve the clarity and accuracy of the resulting visualization, a systematic synonym consolidation protocol (Table 2.1) was implemented to mitigate lexical ambiguities, enhancing the validity of cluster interpretations (Dalpiaz et al., 2019). At the last, methodological appraisal followed a structured taxonomy evaluating experimental designs, variable operationalization, and empirical findings across studies. This classification framework enabled systematic comparison of modelling approaches while documenting prevalent limitations in current methodologies. The integrated analytical approach facilitates longitudinal tracking of conceptual evolution in this emerging field, identifies current research frontiers, and provides empirically grounded recommendations for future investigations into aviation decarbonization strategies.

3. Results and Discussion

3.1 Co-occurrence of keywords and temporal evaluation of publications

Keywords exhibiting a rise in citations signify a substantial volume of citations during a specified timeframe. It might offer insights regarding the popularity of a specific academic field during recent years and highlight upcoming themes. It can also be utilized to discern research patterns, including the rise of novel topics and the decline of established ones(Haghani, 2023). This can assist researchers in comprehending the present research status of each discipline and formulating strategies for future inquiry. The topic of the research can be found by looking at the keywords. In this section, we group all keywords (including author keywords and system keywords) according to the frequency of their appearance together and create a keyword co-occurrence network. During the analysis, a database that has been cleaned was used to remove synonyms to improve the accuracy of the analysis. Since only 60 documents were entered into the database, a minimum co-occurrence frequency of 2-3 was selected when performing keyword co-occurrence to analyze the hot spots and classifications of the research. After comparison, we finally chose a visualization with a minimum co-occurrence of 2. Because when the co-occurrence is 3, many cutting-edge topics or hot spots will be ignored. In order to explore the future development of this field, we chose to retain the minimum 2 co-occurrences as the main body of the analysis (Chen et al., 2016). Figure 1 illustrates a keyword co-occurrence network using VOSviewer, revealing major themes in aviation carbon offset research. Keywords are color-coded by thematic clusters, with node size reflecting frequency and proximity indicating relationship strength.

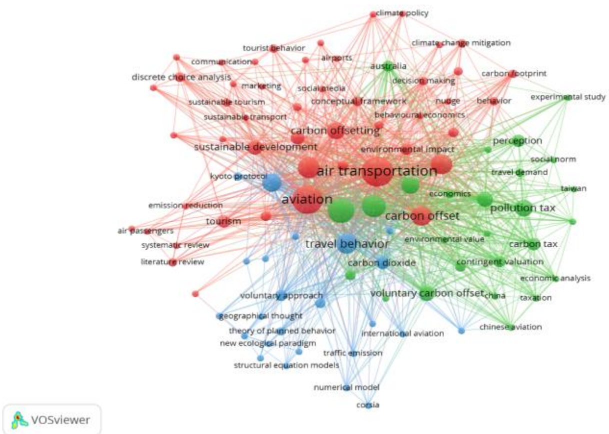

Figure 1: Keyword Co-occurrence Network Analysis of Consumer Behavior Research in Aviation Carbon Offsets

Cluster 1 (Red): Sustainable Development and Consumer Behavior. This largest cluster centers on sustainability and behavioral responses in aviation, with frequent terms like Air transportation, Carbon offsetting, and Sustainable development. Keywords such as Climate policy and Tourist behavior reflect intersections between policy, psychology, and environmental decision-making. Cluster 2 (Green): Economic Instruments and Valuation. Focused on economic mechanisms and consumer perceptions, this cluster includes Carbon tax, Contingent valuation, Social norm, and Environmental value, highlighting the role of economic analysis and willingness-to-pay (WTP) in offset adoption. Cluster 3 (Blue): Methodological and Policy Approaches. This group features behavioral theories and policy tools like Voluntary carbon offset, TPB, SEM, and CORSIA, alongside technical terms like Traffic emission and Numerical model, emphasizing methodological rigor and policy relevance. Overall, the network shows the interdisciplinary nature of this field, combining environmental policy, behavioral economics, and psychological theory. Key research trends include consumer acceptance of offsets, economic valuation, and robust theoretical application through models like TPB and SEM.

Figure 2 shows the temporal evolution of keywords in consumer behavior studies on aviation carbon offsetting from 2007 to 2024, with colors representing the average publication year—from dark blue (earliest) to yellow (latest). Early Phase (2007–2014; Dark Blue–Light Blue). Research centered on theoretical and methodological foundations. Frequent keywords included carbon dioxide, voluntary carbon offset, TPB, SEM, and Kyoto Protocol, reflecting initial focus on conceptual frameworks and consumer attitudes in aviation.

Mid Phase (2015–2019; Green Tones). Studies increasingly examined economic and social factors shaping participation. Prominent terms like willingness to pay, carbon tax, economic analysis, and social norm indicated a shift toward valuation methods and behavioral influences. Recent Phase (2020–2024; Yellow Tones). Recent research emphasizes behavioral economics, nudge, communication, social media, and experimental study, exploring psychological drivers and digital engagement. New keywords such as China and Chinese aviation reveal a rising focus on the country's policy landscape and consumer behavior. Overall, Figure 2 illustrates a transition from theoretical and economic valuation to behavioral, social, and policy-linked research, with growing interest in China's aviation carbon market. Future work will likely integrate psychological factors and valuation methods (e.g., SEM, CVM, DCE) to improve the design and effectiveness of carbon offset programs.

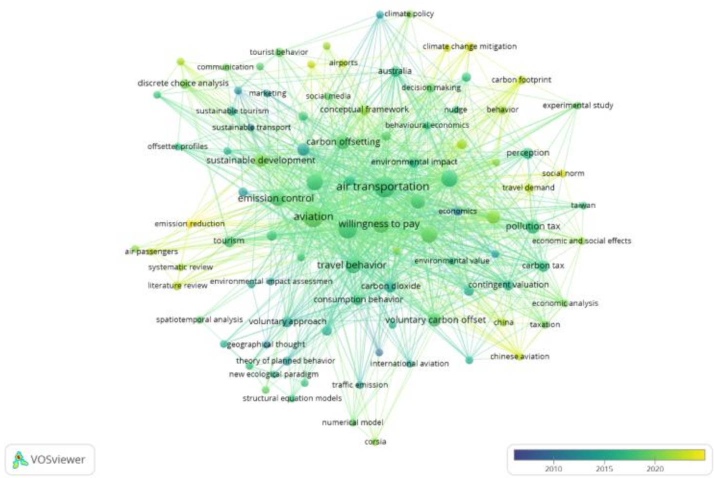

Figure 2: Temporal Evolution and Hotspots of Consumer Behavior Research in Aviation Carbon Offsets (2007–2024)

Figure 3 presents the trends in consumer behavior research related to carbon offsets in the aviation industry from 2007 to 2025. The analysis utilizes annual publication data along with a moving average line, which helps in visualizing broader trends and smoothing out short-term fluctuations. The overall trend in consumer behavior research within this domain demonstrates a clear upward trajectory, especially noticeable from 2016 onwards. Between 2007 and 2015, the number of annual publications was relatively low and inconsistent, fluctuating between zero and three publications per year. Notably, in 2012, there were no publications identified, possibly indicating limited academic attention or research interest during this period. A notable shift occurs from 2016 onward, where the field sees a consistent increase in research interest, peaking in 2024 with eight publications. Specifically, a sharp increase is observed starting from 2018 (four publications) to 2022 (seven publications), indicating a growing recognition of the importance of consumer behavior in aviation carbon offset research. The moving average line, depicted by the red dashed line, further emphasizes this rising trend, reaching its highest point between 2020 and 2024. The subsequent projected decline in 2025 (one publication) because of incomplete data for that year.

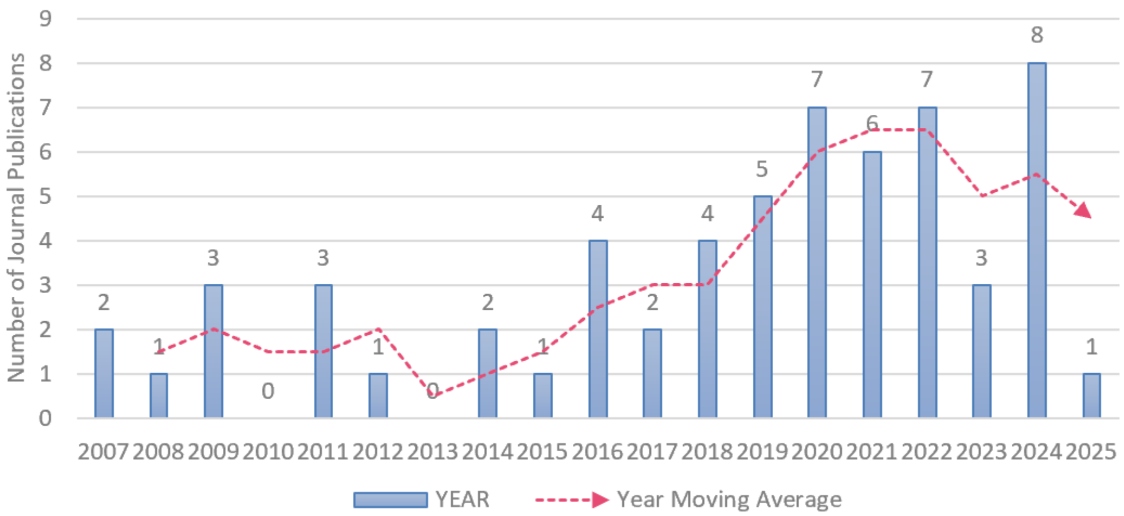

Figure 3: Consumer Behavior Research Trends In The Aviation Industry Carbon Offset Field During The Period 2007–2025

Overall, this visualization strongly indicates an increased scholarly attention to consumer behavior in aviation carbon offsetting, particularly around the period of increased international policy developments (e.g., implementation of CORSIA in 2016 and subsequent climate-related policy discussions). These policy milestones likely acted as catalysts for intensified research interest.

3.2 Mapping existing literature

Despite the growing academic interest in voluntary carbon offsetting (VCO) in aviation, current research remains methodologically fragmented and conceptually incomplete. This review identifies two overarching categories of limitation—methodological blind spots and research design exclusions—which together constrain the field's ability to generate robust, actionable insights for advancing sustainable aviation behavior and consumer policy. Although Contingent Valuation Method (CVM) and Choice Experiment (CE) approaches dominate VCO valuation research, their application reveals three persistent limitations: (1) insufficient integration of behavioral constructs, (2) failure to account for cognitive and contextual biases, and (3) underutilization of triangulated and behaviorally validated methods. First, many CE and CVM studies fail to incorporate core social-psychological variables—such as subjective norms, moral obligation, and institutional trust—which have been shown in SEM-based studies to strongly predict pro-environmental behavior. For instance, studies such as Rotaris et al., (2020) and MacKerron et al., (2009) focused solely on economic attributes, neglecting the social drivers that explain *why* certain offsets are preferred or avoided. This lack of integration leads to fragmented behavioral insight and restricts the explanatory power of valuation models. Second, cognitive biases such as anchoring, framing effects, and default sensitivity remain largely untested. Studies like Ma et al., (2021) and Lu and Shon, (2012) used pre-set bid ranges without controlling for anchoring or priming effects. In contexts like carbon offsetting—where consumers often face unfamiliar, complex, and low-salience decisions—failing to diagnose these design-related biases risks inflating or distorting WTP estimates. Third, although empirical studies using real booking data offer behavioral realism, they lack psychographic data and are rarely integrated with segmentation models (Berger et al., 2022). Meanwhile, qualitative studies offer deep insights into emotional responses, identity dilemmas, and moral disengagement—but these findings remain siloed and underutilized in valuation survey design. Survey-based studies further suffer from narrow samples, overrepresentation of high-income Western populations, and lack of behavioral validation, limiting generalizability and practical application. Beyond methodological gaps, current voluntary carbon offset (VCO) research largely overlooks social sustainability—particularly how perceived social impacts influence consumer judgment, satisfaction, and behavior. While most CE and CVM studies focus on environmental outcomes and cost, social aspects like labor rights, equity, and community benefits are often vaguely labeled as "co-benefits" or ignored. Notably, no study has adopted the Social Life Cycle Assessment (SLCA) framework to structure social impact metrics. Indicators such as fair wages, stakeholder engagement, and gender equity are absent from offset attributes in existing CE designs, leaving their potential influence on willingness to pay (WTP) untested. A major conceptual gap is the unexplored link between social performance and consumer satisfaction—and whether satisfaction mediates WTP. Ethical consumption literature suggests that perceived social responsibility boosts satisfaction and, in turn, WTP. However, this mechanism remains unexamined in the VCO context. Incorporating satisfaction into valuation models would shift analysis beyond trade-offs to include emotional and moral responses, offering insights into program credibility, long-term engagement, and trust—vital in voluntary markets. Moreover, existing research is skewed toward high-income countries, with little attention to emerging markets like China. Despite its aviation growth and climate commitments, studies on Chinese consumers are limited, often based on narrow samples. Given China's collectivist values and state-driven carbon governance, it is critical to explore how Chinese consumers perceive social impacts and institutional credibility. SLCA-framed attributes may be interpreted differently depending on whether projects emphasize national development or global equity goals.

4. Conclusion and Recommendations

This review offers a comprehensive synthesis of literature on consumer behavior and willingness to pay (WTP) for voluntary carbon offsetting (VCO) in aviation. Through bibliometric analysis, it traces the field's evolution from 2007 to 2025, highlighting growing interest—especially post-2016—and increasing methodological diversity, including the use of SEM, CVM, and CE to examine psychological, economic, and social drivers.

However, critical gaps persist. Most studies rely on stated preferences, neglect social life cycle impacts, and lack interdisciplinary integration. Research remains disproportionately focused on high-income regions, with limited attention to emerging economies like China. To advance the field, future work should adopt mixed-method approaches, incorporate social sustainability indicators, and examine the mediating role of consumer satisfaction. Greater emphasis on real-world behavior and culturally relevant research—particularly in non-Western contexts—is essential. Addressing these issues will strengthen the legitimacy, effectiveness, and public acceptance of carbon offset programs, supporting global climate goals and promoting consumer engagement in aviation decarbonization.

Acknowledgments

We recognize the contributions of all authors to this research and express our gratitude to Universiti Putra Malaysia (UPM) for providing their resources for this study.

References

Berger, S., Kilchenmann, A., Lenz, O.,Schlöder, F., 2022, Willingness-to-pay for carbon dioxide offsets: Field evidence on revealed preferences in the aviation industry, Global Environmental Change, 73, 102470.

Bergero, C., Gosnell, G., Gielen, D., Kang, S., Bazilian, M., Davis, S. J., 2023, Pathways to net-zero emissions from aviation, Nature Sustainability, 6(4), 404–414.

Chen, X., Chen, J., Wu, D., Xie, Y., Li, J., 2016, Mapping the Research Trends by Co-word Analysis Based on Keywords from Funded Project, Procedia Computer Science, 91, 547–555.

Chi, J., Mohammad Afandi, S. H., Al Matthew, N. K., 2025, Mapping Hotspots and Emerging Trends in Global Wetlands Research: A Scientometric Analysis (2002–2022), Journal of Environmental and Earth Sciences, 7(2), 101–116.

Dalpiaz, F., van der Schalk, I., Brinkkemper, S., Aydemir, F. B., Lucassen, G., 2019, Detecting terminological ambiguity in user stories: Tool and experimentation, Information and Software Technology, 110, 3–16.

Dwivedi, R., Nerur, S., Balijepally, V., 2023, Exploring artificial intelligence and big data scholarship in information systems: A citation, bibliographic coupling, and co-word analysis, International Journal of Information Management Data Insights, 3(2), 100185.

Haghani, M., 2023, What makes an informative and publication-worthy scientometric analysis of literature: A guide for authors, reviewers and editors, Transportation Research Interdisciplinary Perspectives, 22, 100956.

Huang, Y., Makmor, N., Mohamad, S. H., 2024, Research progress analysis of live streaming commerce based on CiteSpace, Heliyon, 10(16).

ICAO, 2016, Session of ICAO Assembly Adopts Resolution on Market-based Measure for International Aviation Emission Reductions, No. Resolution A39-3, Montréal, Canada.

International Air Transport Association., 2022, Aviation Carbon Offsetting Guidelines for Voluntary Programs, No. Verson III.

Lu, J.-L., Shon, Z. Y., 2012, Exploring airline passengers' willingness to pay for carbon offsets, Transportation Research Part D: Transport and Environment, 17(2), 124–128.

Ma, W., Zhang, Y., Cui, J., 2021, Chinese future frequent flyers' willingness to pay for carbon emissions reduction, Transportation Research Part D: Transport and Environment, 97, 102935.

MacKerron, G. J., Egerton, C., Gaskell, C., Parpia, A., Mourato, S., 2009, Willingness to pay for carbon offset certification and co-benefits among (high-)flying young adults in the UK, Energy Policy, 37(4), 1372–1381.

Mello, F. P. de., 2024, Voluntary carbon offset programs in aviation: A systematic literature review, Transport Policy, 147, 158–168.

Park, J., Ryu, Y., Kim, Y., 2024, Factors influencing air passengers' intention to purchase voluntary carbon offsetting programs: The moderating role of environmental knowledge, Journal of Air Transport Management, 118, 102619.

Rotaris, L., Giansoldati, M., Scorrano, M., 2020, Are air travellers willing to pay for reducing or offsetting carbon emissions? Evidence from Italy, Transportation Research Part A: Policy and Practice, 142, 71–84.

Tamala, J. K., Maramag, E. I., Simeon, K. A., Ignacio, J. J., 2022, A bibliometric analysis of sustainable oil and gas production research using VOSviewer, Cleaner Engineering and Technology, 7, 100437.

Tang, B.-J., Yan, R., Chen, J.-Y., Ji, C.-J., 2024, Are air travelers willing to pay for mandatory carbon emission policies? Evidence from China, Sustainable Production and Consumption, 52, 111–123.

Vlase, I., Lähdesmäki, T., 2023, A bibliometric analysis of cultural heritage research in the humanities: The Web of Science as a tool of knowledge management, Humanities and Social Sciences Communications, 10(1), 1–14.

Witting, G. R., 1978, Documentation Note: Statistical Bibliography—A Historical Footnote, Journal of Documentation, 34(3), 240–241.