Bibliometric Mapping of Cost-Benefit Analysis

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Over time, the cost-benefit analysis has become a method that helps to clarify the pros and cons in many areas of human activity where both investment and non-investment projects are implemented. In researching for this article, we aimed to map the current state of publishing activities in the field of cost-benefit analysis and in order to accomplish this, four research questions had to be determined.

cost-benefit analysis   bibliometric analysis   co-occurrence   co-authorship   visualization

1. Introduction

Albeit the theory of cost-benefit analysis (hereinafter CBA) dates back to the nineteenth century, Hammond (1966) claims that the use of CBA goes back to the early twentieth century (1902, US Rivers and Harbor Act)—more precisely, from the time of its amendment in 1920, which explicitly mandated it. Nevertheless, Pearce (1971) states that the first practical use was in the USA as a part of a national appraisal mechanism for dam construction in 1936; within the Flood Control Act, the most systematic use of this method occurred in 1960s (Nas 2016). Sweden also started using CBA in the 1960s, similarly for the evaluation of national road investment projects (Hultkrantz and Svensson 2012). Ellig and McLaughlin (2012) showed that since 1974, all US presidents have issued executive orders requiring regulatory agencies to analyze the anticipated results and economic effects of proposed regulations. In 1975, the World Bank adopted the Trade Policy Approach (as one method of CBA), while in 1990, this institution shifted to the second approach—the Public Finance Method (Ward 2019).

From a theoretical point of view, the traditional approach to the theory of CBA prevailed in 1940s, which defined costs and benefits according to the effect of the projects. On the other hand, the 1970s saw a new, so-called "social" approach come into the force, which made use of social valuation (Ray 1990). According to Torriti and Ikpe (2014), in the 1950s, economists tried to provide a rigorous, consistent set of methods for measuring benefits and costs and for deciding whether a project is worthwhile. In the late 1960s, Musgrave (1969) wrote about CBA, declaring that "a new approach (to the theory of public finance) has emerged…". In 1987, Drèze and Stern (1987) presented a general theory of CBA by using the theory of shadow prices and the theory of reform. Layard and Glaister (1994) claimed that many studies on the cost-benefit analysis use the Hicks–Kaldor criterion, which asserts that a project can be supported provided the gainers could, in principle, compensate the losers even if they do not. A detailed list of contributions to the theory and practice of CBA by various researchers was also described by Ray (1990).

According to Persky (2001), cost-benefit analysis offers the dominant economic approach by which economists communicate with each other, with government bureaucrats, and with the general public about the desirability of public programs and investment projects. For example, in the European Union, CBA is explicitly required as a basis for decision-making on the co-financing of major projects included in the operational programs of the European Funds. This is an analytical tool used to appraise investment decisions in order to assess the welfare outcomes attributable to such investments and their contribution to EU cohesion policy objectives (European Commission 2014). Brent (2006), Giordano et al. (2012), or Noe and Graham (2020) stated that CBA is a necessary practical guide to social decision making. Abelson (2020) confirmed this by performing reviews of seven contemporary official guidelines to CBA. Turečková and Nevima (2020) add that CBA is based on the analysis of all implicit as well as explicit costs and benefits, which quantifies the investments' impact on society. In general, this kind of analysis is based on economic fundamentals, i.e., a cost-benefit comparison with variables such as net present value (Pearce and Moran 1994 or Hansjürgens 2004), producer and consumer surplus (Hanley and Spash 1993 or Hanley and Barbier 2009), shadow wage rate (Ray 1990), willingness to pay (Weatherly et al. 2014), internal rate of return or cost ratio (Florio et al. 2016), social discount rate (Abelson 2020), or externalities (Ramos et al. 2020a).

The CBA method is thus applicable to almost all areas of human life, and it is also used in the international research project that this paper is a part of. It was naturally selected as the most suitable tool for determining the effectiveness of using smart technologies in various areas of human life (health, social work, transport, ICT, etc.). Since reviews are often required by research funders to establish the state of existing knowledge (Clarke 2011), we started our quest to determine how and where CBA has been used; we found that there was no publication that gave an overview of the global use of this method in practice. Only ten studies in individual areas have analyzed CBA issues by bibliometric analysis—their overview (including topic and results) is given in the Appendix A (**Table A1**). Thus, there is no all-encompassing output related to the interrelationships of this method in terms of who, in what area, in which country, which language, co-authorship, and which topic used CBA. In our opinion, the handing over and dissemination of experiences, attitudes, and solutions, possibly their critical analysis, is all very important for the deeper development of cost-benefit approaches, both on the theoretical and practical levels. Researchers, scientists, and policy decision-makers can benefit from the existing general analysis and description of the current developments and applications of the CBA. Performing the missing analysis on the current state of research in this area (through the research questions below) and identifying the gaps and major issues in this field that may be addressed in the future were the main motivations for writing this article.

2. Discussion

Using the advanced search of the term "cost benefit analysis", 595 outputs were generated between the years 1990 and 2020. There has been an increase in outputs in the last ten years, which indicates a growing interest of experts in this topic. In our opinion, there are two reasons for this increase—a growing need for an economic evaluation of (non)investment projects and pressure on experts to publish the valuable and highly rated results of their research. Most of these outputs were articles, followed by proceedings papers, and then reviews (the difference between these types was more than 400 outputs). The quality of the outputs was high, which is also

confirmed by the high impact factors of the journals in which these articles were published. The country where most of the authors came from was the USA, which produced 30% more outputs during the monitored period than the second and third countries (Australia and the United Kingdom). If we include only the "top ten" countries in the statistics, this difference would be as much as six percent more.

In spite of the fact that we cannot compare the results of the bibliometric analysis in the field of CBA in terms of co-occurrences due to the absence of similar publication outputs, we can support some results of previous studies in other research areas in relation to our other findings.

Firstly, with regard to the trend in research interest involving CBA, we found that despite the predominance of economically oriented research (in all areas), environmental issues have come to the fore. This view is also shared by Molinos-Senante et al. (2010) who argued that the use of CBA has three phases of development: 1. traditional (a clear economic) approach, 2. socio-economic approach (equitable income distribution), and 3. environmental approach (environmental externality valuation). This corresponds to both the results of the articles´ analyses published in WoS and the results of the bibliometric analysis.

Secondly, concerning the leading countries in research, Hou et al. (2015) claimed that the US was the most productive country in the field of life cycle assessment; Lindhjem et al. (2015) found the same results in the field of health intervention. Similarly, Acevedo Prins et al. (2017) or Capobianco-Uriarte et al. (2019) stated that the United States was the most productive country in terms of scientific papers about competitiveness. In the field of smart technologies, Fellnhofer (2018) claimed that the USA, Germany, England, the Netherlands, and Australia were the top five countries in terms of outputs, which is very similar to our findings.

Thirdly, the predominance of English, as the lingua franca of science is due to the fact that it is the language most able to transcend national boundaries and enhance research impact. Moreover, English publications in mainstream impact journals have the additional value of fulfilling one of the most important requirements for research assessment. Stockemer and Wigginton (2019) stated that those researchers who agree with the statement that publishing in English increases the reputation of their work submit 63% of their articles in English. Ramírez-Castañeda (2020) mentioned an even higher share—she claimed that 98% of scientific publications are written in English. We found the same result: 98% of CBA-related publications have been published in English. This means that one percent of ENR produced 1.5 percent of the articles on average, in comparison with non-ENR who have written only 0.07% outputs per one percent of persons during the monitored period. These results confirm our assumption set in Q2 and show the publishing gap among ENR and non-ENR. Closing this gap is a challenge, and the reasons are clear—publishing in a prestigious and international range of journals is connected with increasing one's professional reputation or with institutional requirements for funding.

Fourthly, the issue of co-authorship, which is closely linked to the use of English. With respect to this, we have the same opinion as Perianes-Rodríguez et al. (2010) who claimed that the resulting groups showed not only individual relationships, but rather how these relationships were able to draw authors together in larger structures. We also corroborated the result of Acedo et al. (2006) about the growing tendency of co-authored papers. Adams (2012)

claimed that collaborative papers tended to get cited more often because the authors were more likely to be doing excellent research—for example, research papers published jointly by UK and US authors are cited, on average, more often than those published by either nation domestically. The results of our bibliometric analysis support the opinion of Flowerdew and Li (2009) that Chinese scientists are taking an increasingly large share of the total science publications, which is accompanied by co-authorships. In this respect, more intensive cooperation in larger teams is positive, which also brings with it a relevant transfer of information. On the other hand, this brings about some negative aspects—gaps. The first gap is the limited diversification of these teams—at best, it is an entirely bilateral cooperation, with the multinational character missing, the benefits of which were mentioned in the previous section. The second gap is the insufficient level of cooperation between ENR and non-ENR. Most of the outputs are written by ENR, but they have not been among the co-authors in recent papers (they publish mainly separately). There is the possibility, or even the need, for closer cooperation between these two groups of authors in order to increase international cooperation and the amount of quality outputs. Moreover, our findings are similar to the result of Adams (2013), which stated that growth in collaboration has come from bilateral partnerships, and that multinational programs are still marginal (as drivers of performance). In the case of CBA, in the first part of the monitored period (1990–2000), there was cooperation between Israeli and English or American authors. In the second phase (2001–2020), Chinese authors collaborated with either Norwegian or Dutch authors. The share of non-dominant authors is the same in both cases—it is at around 20%. Another claim of Adams (2013) was that 75% of the research output of China has remained entirely domestic, differing slightly from our result, which shows 67% of domestic publications (four of the six co-authorship clusters created are purely Chinese).

Fifthly, the issue of co-occurrence yielded three clusters. Although all were logically connected by a term related to cost-benefit issues, each of them had its own specifics. The first cluster was spatially smaller, but the terms had closer ties and their occurrence was more frequent than in the other two clusters. The second cluster was spatially and conceptually the most extensive, without a significant dominance of any of the concepts and with a narrower time range (at the beginning of the observed period). The third cluster was characterized by the predominance of ties with other clusters rather than within itself. In terms of time, the dynamics of published research areas was evident: at the beginning of the monitored period, medical topics were in the center of attention; over the time, there was an increase in the use of economic and financial terms. This development followed the development of publications in individual research areas—from health issues to environmental issues. This issue of co-occurrence has certain limitations that would be useful to fill or eliminate in future research. It is interesting that there are some items that did not co-occur in any cluster, or that occurred to a very small extent, which in our opinion is very closely related to the issue of CBA. Specifically, there were the expressions of "externality"—which had no co-occurrence, and "profitability"—which had very low co-occurrence in cluster one. Both of these items are necessary for the correct quantification of the cost-benefit analysis; therefore, they should be given due attention, and from the point of view of bibliometric analysis, their occurrence should be more frequent and dominant.

3. Conclusions

In order to more thoroughly describe the current state of using cost-benefit analysis in the scientific literature, and at the same time fill the gap that was found in this direction, data from the Web of Science database were selected and a bibliometric analysis with three kinds of visualizations from the VOSviewer software was used. To meet the above-described objectives, four questions were set.

During of our study we obtained results that helped us to answer these questions. It was first examined whether the economic area of research was most frequented field of CBA outputs (Q1). The answer is ambiguous, depending on the input data; if we analyze the categories and areas in detail, we can answer in the affirmative. However, if we synthesize the categories into larger branch groups, the economic area falls into third place, behind the environmental and health issues. This corresponds to the results of the studies mentioned in the introduction (Appendix A, **Table A1**). The second question (Q2) concerned to dominance of the English language and English native researchers (ENR) in the area we observed. The results show that almost 98% of outputs published in English are generated by 65% of authors from English-speaking countries.

Based on visualization maps, we can answer another question concerning a change in cooperation between the authors of publications in the monitored period (Q3). There was a change in three directions—geographical, subject of research, and dominance of the authors. In terms of territorial designation, in the sense of shifting from an East-West cooperation (between Israel and English-speaking countries such as the UK and the USA) to a collaboration among non-ENR researchers, such as that between Chinese and North European authors (Norway and Netherlands). A second change was observed in the field of the research topic, which shifted from healthcare to environmental and ICT. This corresponds with the current trend—increasingly more attention is paid to environmental issues, which also brings forth the need for an economic evaluation of related projects that are to be financed with public funds. The last and third change concerns the level of dominance. While the beginning of the observed period is characterized by the model of the predominance, or a central author in collaboration with non-dominant co-authors, the second phase is characterized by the chaining of co-authors without a significant dominance.

The last question (Q4) concerned the similarity and statics of co-occurrence over time. For this purpose, three clusters were created: the most frequent was the cluster connected to the field of the economic financial analysis (with items such as benefit analysis, cost ratio, or net present value). The second cluster had fewer common co-occurred terms related to health issues (with items such as "program", "intervention", and "cost benefit/effectiveness"). The third one was related to the application process of CBA, with terms such as "benefit cost analysis", "case study", "article", or "development".

This paper´s contribution to the theory has two dimensions—originality and utility. The originality of the paper lies in the fact that it presents a collection of publishing activities in the field of cost-benefit analysis in last three decades by using different visualizations of the issue. The utility of our paper could be represented as follows: The findings, including recommendations, can be used as a basis for the outputs of other authors, especially from the perspective of the state of current knowledge, filling the gaps as well as the controversies found. The collaboration of authors from various countries can improve the knowledge on this topic and spread it faster to other researchers

and scientists. Similarly, from the perspective of governments and policy makers, the identification of research topics and the support for research teams can be important, not only in terms of finding effective types of publicly funded projects, but also in terms of competitiveness. Increasing competitiveness through R&D, with a focus on multinational projects, and the support of excellent researchers in order to speed up the dissemination of knowledge and skills should be given priority by all policy makers in this field. The findings and results also have practical implications, which are relevant to the content and required results of the project within which this article was created, and in which CBA is the main method used for evaluating the impact of smart technologies in various areas of life and on its quality. Our findings can be used in the pedagogical practice for describing theoretical and practical approaches to cost-benefit analysis, within courses that are focused on the economic evaluation of projects, business plans, or public procurement.

We are aware of the limitations associated with this article, especially with the use of a single source database, one kind of counting in bibliometric analysis, or the use of (only) the CBA. As this is the first mapping of this topic, we will try to perform a deeper analysis in terms of using other source databases (Scopus, grey literature databases) or software in the near future. It may be interesting to compare two methods of bibliometric analyses—while we used binary counting in the case of co-occurrence, subsequent research may be based on the clustering of terms through the method of full counting, which can produce different outputs. We believe that we can find interesting results published by non-ENR and those non-indexed in the Clarivate Analytics database. We would also like to extend our findings to co-citation analysis and compare the related methods such as cost utility or cost effectiveness analysis with CBA, as they can also reveal interesting results or gaps.

Although Barfod and Salling (2015) argued that CBA is inadequate to incorporate and assess multiple and often conflicting objectives, criteria, and attributes, we object to it. Based on a search of the available literature and its use in practice, this method is especially beneficial for determining costs and (social) benefits as well as necessary for the decision-making processes of project implementation. We can thus support the idea of Sen (2000) that although the CBA is a general discipline with foundational principles, which are not altogether controversial, it is nevertheless considered plausible.

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