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Systematic review of the scientific literature related to the quintuple helix innovation model and its correlation with business profitability: a bibliometric analysis

Revisión sistemática de la literatura científica relacionada con el modelo de innovación quíntuple hélice y su correlación con la rentabilidad empresarial: un análisis bibliométrico

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Resumen

El objetivo de esta investigación es realizar una revisión sistemática de la producción científica relacionada con el modelo de innovación quíntuple hélice. Específicamente, se busca identificar si existen trabajos previos que establezcan una relación entre dicho modelo de innovación y la rentabilidad empresarial. La metodología se basa en un análisis bibliométrico de la literatura científica en la base de datos académica Dimensions. Los resultados del análisis sugieren que no existen trabajos científicos previos que relacionen directamente el modelo de innovación de quíntuple hélice con la rentabilidad empresarial.

Palabras clave: Quíntuple Hélice, Innovación, Rentabilidad Empresarial, Bibliometría.

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Abstract

The objective of this research is to conduct a systematic review of the scientific production related to the quintuple helix innovation model. Specifically, it seeks to identify if there are previous works that establish a relationship between said innovation model and business profitability. The methodology is based on a bibliometric analysis of the scientific literature in the academic database Dimensions. The results of the analysis suggest that there are no scientific works that directly relate the quintuple helix innovation model with business profitability.

Keywords: Quintuple Helix, Innovation, Business Profitability, Bibliometrics.

Introduction

In 1995 Henry Etzkowitz and Loet Leydesdorff proposed an innovation model called the "triple helix" to describe the interactions between academia, industry, and government aimed at promoting socio-economic development in a given region (Etzkowitz & Leydesdorff, 1995). The authors argued that universities and industry, entities that have traditionally acted separately and distinctly, have taken on tasks that were previously primarily the other party's responsibility. For Etzkowitz and Leydesdorff, the role of government concerning university-business collaboration has evolved in apparently contradictory directions. Governments offer incentives, on the one hand, and pressure academic institutions to go beyond the traditional functions of cultural memory, education, and research. Also, Governments make a more direct contribution to wealth creation.

Later, during the first decade of the 21st century, Elias G. Carayannis and David F. J. Campbell extended the triple helix model to incorporate society as a fourth helix and the environment as a fifth helix (E. G. Carayannis & Campbell, 2010).

Carayannis and Campbell's quintuple helix model incorporates society as a fourth element through the concept of a "media-based democracy," which emphasizes that when the political system (government) designs an innovation policy to develop the economy, you must adequately expose your strategy with civil society through the media to obtain the necessary social support for its implementation (E. Carayannis & Campbell, 2009). In the same way, the quintuple helix innovation model emphasizes the importance of involving the natural environment (social ecology) in the creation of knowledge and innovation. In this sense, the authors suggest that socio-ecological interactions can lead to an innovative approach to address sustainable development, including climate change. The quintuple helix perspective can be described as the five subsystems (helices) it incorporates: academia, industry, government, society, and environment. Therefore, the quintuple helix comprises a model that describes collaboration between the government, industry, academia, civil society, and environment sectors to foster innovation and economic growth (E. Carayannis et al., 2012).

Although there are numerous studies on the quintuple helix and its impact on innovation and regional development, previous scientific research which specifically relates the quintuple helix to business profitability has yet to be identified. Studies suggest that the collaboration between the different actors of the quintuple helix can positively impact innovation and business competitiveness, which would affect the profitability of companies.

No previous research, correlating the quintuple helix model and business profits has been conducted previous to this work. The area of opportunity identified in this research, is the new analysis perspective of exploring the relationship between the quintuple helix innovation model and business profitability. The potential benefit is to approach the model from an innovative angle by exploring the implications of the quintuple helix in the profitability of companies from the Schumpeterian innovation theory of profit (Sweezy, 1943). In this way, Schumpeterian profitability can be defined as those benefits that arise when companies can appropriate the returns of innovative activity (Nordhaus, 2004).

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This research aims to carry out a bibliometric analysis to identify the level of development of the quintuple helix innovation model in scientific publications, specifically evaluating whether there is research that directly relates said innovation model to business profitability.

It is important to contextualize the approach undertaken in this research when analyzing the term "profits." For this work, the analysis of the correlation between business profits and the quintuple helix model in the scientific literature focuses on the relationship between this model and a company's financial performance, that is, the economic benefit realized from a firm's operations.

1. Previous works

The application of the quintuple helix model has been based mainly on the use of available and newly created "knowledge" to promote sustainable development and balance economic development with environmental demands (Iqbal et al., 2022). As will be observed in the following sections of this research, the main focus of the scientific works around the quintuple helix innovation model has been applications of the model concerning industry 5.0, technological innovation, entrepreneurship, sustainability, innovation systems, and participatory companies. Most of the research related to the quintuple helix since 2012 has focused on the relationship of the model with various disciplines. The most addressed subjects include sustainable development and social ecology, innovation and entrepreneurship, organizational relationships, and business competitiveness.

The quintuple helix model has been widely discussed in previous investigations. One of the main focuses has been on the field of innovation or organizational innovation since it is considered that the synergy between its actors will promote innovation and an economy based on innovation (Sudiana et al., 2020). The implementation of the model in the socio-ecological and socio-technological context has also been of interest in previous research (Provenzano et al., 2020). The model has also been studied from the point of view of regional development, where it is stated that cooperation between institutions of a diverse nature leads to positive results and increases economic activities in different regions (Bikse & Rivza, 2017). In the social, political, and ecological context, research on the model has focused on sustainable development through the socio-ecological transition of society and the economy, which drives additional knowledge and innovation (Sultanova & Bagaveeva, 2021).

Although there are several bibliometric studies regarding the quintuple helix innovation model, bibliometric research in this area is limited. Among the bibliometric studies carried out with the quintuple helix model, research has yet to identify the model's relationship with business profitability. It is important to notice that, following the Schumpeterian innovation theory of profit, empirical analysis has shown that innovation can positively affect a firm's profitability (Braunerhjelm & Svensson, 2010).

Previous investigations that have used bibliometric techniques for the analysis of the scientific production related to the quintuple helix have been carried out from the perspective of the evolution of the concept of the triple helix (Cai & Amaral, 2022); trends in knowledge-based economies (Giraldo et al., 2022); analysis and evolution of innovation in open markets (Caputo et al., 2022); ecosystems and competition (Sun et al., 2022); Literature review of the triple helix concept (Galvao et al., 2019); innovation systems analysis (López-Rubio et al., 2022); sustainable tourism and quintuple helix (Iqbal et al., 2022); innovation in triple helix model (Chung & Park, 2014); national innovation systems (Putera et al., 2022), mainly.

Even though a wide diversity in the scientific production related to the quintuple helix innovation model has been identified, there's scant literature about the relationship between the quintuple helix model implementation and its impact on company profits. An issue that we want to prove herein with a bibliometric review. The systematic review approach of the scientific literature developed concerning the quintuple helix model can be considered innovative by implementing bibliometric techniques for analysis from the perspective of the relationship between the quintuple helix model and business profitability.

2. Methodology

The method used in this research has been bibliometric analysis. Said analysis is defined as the quantitative study of the publications through statistical data extraction; it is a reliable method to study the authors, the processes, and the evolution of the research using scientific publications as their representation (Belter, 2015). This type of analysis makes it possible to identify the evolutionary nuances of a specific field of study while shedding light on emerging research areas.

The bibliometric analysis introduces a systematic, transparent, and reproducible review process and, therefore, achieves a deep understanding of the evolution in research related to the quintuple helix model of innovation and approaches to scientific production over time. The statistical techniques used in the bibliometric analysis have been practical in describing, evaluating, and monitoring scientific research related to the quintuple helix innovation model, published since 2010.

The parameters defined to evaluate the evolution of the quintuple helix model through scientific publications, as well as its relationship with the concept of business profitability, are the following:

a) Knowledge areas (research categories)
b) Number of publications per year
c) Number of citations per year
d) Number of publications by author
e) Number of citations by author
f) Co-authorship
g) Number of publications by an institution
h) Number of publications by country
i) Number of publications by source (journal)
j) Identification of articles with the highest number of citations
k) keyword identification

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The strategy described below has been carried out for the search of terms in the bibliometric analysis.

1. Search for main terms. A search for scientific publications containing the term "quintuple helix" was conducted.

2. Search for secondary terms in combination with the term "quintuple helix." Several searches of scientific publications have been carried out combining terms related to business profitability and the term "quintuple helix" since this research's central theme is establishing the relationship between the five-fold helix innovation model with the profitability of companies. For this purpose, the terms used have been: asset, business, company, corporation, equity, financial, firm, gain, impact, industry, investment, listed, market, performance, private, profit, public, return, return on assets, return on capital, return on investment and Schumpeter.

The search criteria followed during the bibliometric analysis is the following:

a) Areas of knowledge through which the search for scientific publications has been filtered: sociology, commerce, administration, business, economics, political science, education, information technology

b) The areas of knowledge biology, engineering, and those related to medical sciences have been excluded from the search because they are not related to the research.

c) Type of publications: scientific article and book chapter

d) Patents and unpublished works are excluded from the search

e) Year of publication chosen from 2010 to 2022 (since 2010 was the year of the first publication related to the concept of the quintuple helix innovation model).

f) The search has been limited to terms included in the title and abstract of scientific publications.

g) Additionally, when searching for publications, the following fields are also considered: Unique document identifiers (Dimensions Publication ID, DOI, Crossref ID, PubMed ID, PubMed Central ID, ReadCube ID); MeSH terms (for publications indexed in MEDLINE); Keywords (provided by some publishers and for MEDLINE-indexed publications).

The search for the term "quintuple helix" has been carried out both in the title and in the abstract of scientific publications in the fields of research related mainly to studies in human society, commerce, administration, tourism and services, business and administration, politics and administration, economics, and political science. The type of publications to which the search has been limited has been scientific articles and book chapters.

Visualizing the results obtained is an essential part of the bibliometric analysis; The idea of visualizing bibliometric networks, often referred to as "science mapping," has received much attention since the early days of bibliometric research. Visualization has proven to be a powerful approach for analyzing

various bibliometric networks, ranging from networks of citation relationships between publications or journals to networks of co-authorship relationships between researchers or networks of occurrence relationships between keywords (Van Eck & Waltman, 2014).

We used the VOSviewer software as a tool to build and visualize bibliometric networks.

We used Dimensions as the source database for the analysis. New academic databases, such as Dimensions, have emerged in the last few years. Several studies have compared different databases, either through a direct comparison of article coverage or by comparing citations in the databases. The results indicate that the databases have significantly different coverage of scientific publications and sources of information, with Web of Science being the most selective and Dimensions the most exhaustive. Approximately 99.11% and 96.61% of the journals indexed in Web of Science are also indexed in Scopus and Dimensions, respectively. Scopus has 96.42% of its indexed journals also covered by Dimensions. The Dimensions database has the most comprehensive journal coverage, with 82.22% more journals than Web of Science and 48.17% more than Scopus (Singh et al., 2021).

It is important to note that VOSviewer and Dimensions are free-access web-based tools, which present an advantage for any researcher conducting a bibliometric analysis. Dimensions is today the world's largest linked dataset of research information, covering millions of research publications connected by more than 1.6 billion citations, supporting grants, datasets, clinical trials, patents, and scientific papers. In this way, Dimensions is the database that offers a complete collection of scientific data linked in a single platform (Why Did We Build Dimensions | Dimensions, 2023).

The search for information in the database was carried out between August 1 and 8, 2022.

A current artificial intelligence methodology that can be compared to a bibliometric analysis is natural language processing (NLP)-based text analysis. NLP uses machine learning algorithms and techniques to extract information and understand the meaning of texts. Like a bibliometric analysis, which focuses on quantitative analysis of the scientific literature, NLP can process large amounts of text to identify patterns, trends, and relationships (Atanassova et al., 2019).

NLP-based text analysis can perform tasks such as:

- Information Extraction: Identify and extract entities, such as names of people or places, key concepts, and relationships between them in texts.
- Sentiment analysis: Determine the polarity or emotional tone of a text, for example, if it is positive, negative, or neutral. Such analysis can help analyze user opinions in reviews and comments on social networks.
- Automatic summary: Generate a concise and coherent summary of a text or group of long texts, providing a quick and practical overview.
- Text Classification: Categorizing texts into different classes or categories, such as identifying the theme or intent behind a text.
- Theme analysis: Discover main themes or topics within texts using theme modeling or topic detection techniques.

 ISSN 2992-6823

These NLP methodologies can be applied to various texts, including scientific publications, news articles, legal documents, customer reviews, and other textual data types. Like a bibliometric analysis, NLP-based text analysis can provide valuable information about the evolution of a field of study and the opinions of users or clients and help make informed decisions based on the analysis of large volumes of text (Taskin & Al, 2019).

Traditional bibliometric analysis and NLP-based text analysis have advantages and specific applications. However, a traditional bibliometric analysis may be better in specific research contexts. First, traditional bibliometric analysis is based on bibliographic data collected from reliable sources, such as scientific databases and libraries. These data are usually rigorously curated and verified, which provides greater confidence in the results obtained. Second, traditional bibliometric analysis uses well-established metrics such as impact factor, h-index, and citation count, which have been widely accepted and used in the evaluation of scientific research. These metrics offer an objective quantitative measure of the influence and relevance of scientific publications. Third, the traditional bibliometric analysis focuses on scientific production, that is, on documents published in scientific journals. Such focus makes it possible to assess the productivity and impact of specific researchers, institutions, and subject areas in a given field of study. Fourthly, the traditional bibliometric analysis makes it possible to identify long-term trends in scientific research, such as changes in the direction of research, the evolution of subject areas, and the detection of possible gaps or areas of opportunity. Finally, traditional bibliometric analysis can analyze scientific collaboration networks, identify co-authorships and institutional collaborations, and provide information on collaboration and knowledge sharing between researchers and research groups.

Although NLP-based text analysis has its strengths in processing large volumes of text and semantic analysis, traditional bibliometric analysis remains a valuable and reliable tool in evaluating scientific research and understanding the dynamics in a specific field of study.

3. Results

The results have been structured in two sections. First, the bibliometric analysis derived from the search for the primary term (quintuple helix) is shown. Secondly, the bibliometric analysis derived from the search for secondary terms in combination with the term "quintuple helix" is shown.

3.1. Main term search: "quintuple helix."

In the literature review, a total of 191 scientific publications related explicitly to the term "quintuple helix" have been found under the determined search criteria, and where the said term is found in the title of the publication and the abstract of the publication.

The highest number of publications per year was found in 2021 (43), which indicates that the term presents a growing interest in the scientific community and remains current in the related literature. Scientific productivity shows a decrease in the year 2022 (26), which can be attributed to a decrease in activity derived from the pandemic caused by the SARS-CoV-2 virus (COVID-19) (Abramo et al., 2022). Productivity per year has been increasing since the first publication in 2010, indicating a growing interest in the term in the scientific community. Table 1 shows the scientific productivity by year of publication.

Table 1

Scientific productivity, "quintuple helix" by year of publication

Year	Publications
2010	1
2011	5
2012	1
2013	5
2014	6
2015	7
2016	11
2017	14
2018	21
2019	16
2020	33
2021	43
2022	26

Note. Own elaboration

3.1.1. Authoring and Co-authoring Productivity

Through the bibliometric analysis, it has been possible to identify that the author with the most significant number of scientific publications is Elias G. Carayannis, with 41 publications since 2010. Next is David FJ Campbell, with 33 publications in the same period. The authors Evangelos Grigoroudis, Thorsten D. Barth, and Maria RUD Tambunan have eight, five, and five publications, respectively. Finally, the following authors have three publications each in the same period: Massimo Arnone, Yuzhuo Cai, Luís Farinha, João J. Ferreira, Mykola Petrushenko, Vincenzo Provenzano, Scheherazade S.Rehman, Haula Rosdiana, and Maria Rosaria Seminar. The other authors identified in the bibliometric analysis have two fewer publications in indexed journals. Table 3 shows the number of publications directly related to the quintuple helix model by an author from 2010 to 2022.

Regarding co-authorship networks, 79 collaborations between different authors have been identified. The author with the most co-authorships is Elias G. Carayannis, with more than 49 contributions, followed by David FJ Campbell, who has more than 20 co-authorships related to the quintuple helix model. 12 authors have collaborated in scientific publications through one or more co-authorships, as seen in Figure 1.

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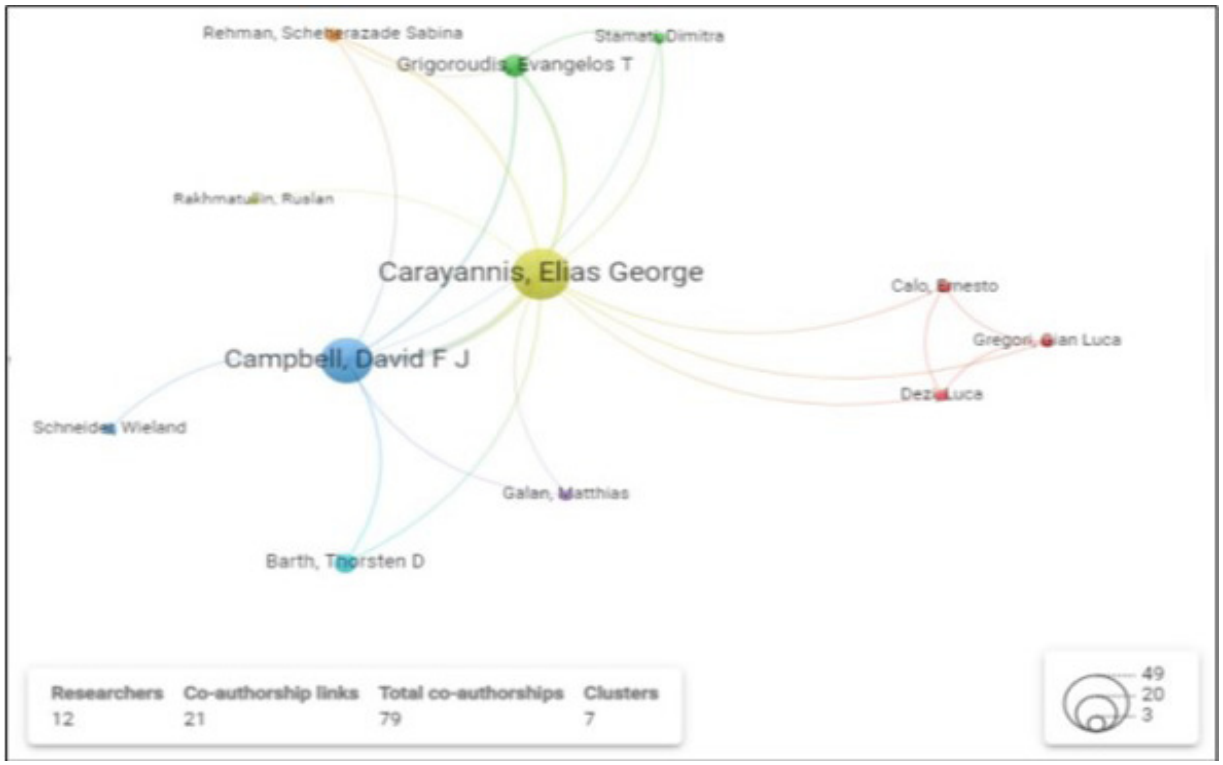
Figure 1

Co-authorship networks in scientific publications



Note. Own elaboration based on VOSviewer

This research identified seven clusters of co-authorship networks in scientific publications regarding the quintuple helix topic. It is important to highlight the benefits of such collaborations. A cluster of co-authorship collaboration in scientific research brings together diverse expertise, fosters creativity and innovation, improves efficiency, provides access to resources and funding, ensures quality assurance, expands networks, broadens impact and visibility, and facilitates professional development. These benefits collectively contribute to advancing scientific knowledge and addressing complex research challenges more effectively (Liu et al., 2023).

A cluster of co-authorship collaboration in scientific research offers several benefits that contribute to advancing knowledge and the scientific community. Collaboration within a cluster of co-authors allows researchers from different backgrounds and disciplines to come together, bringing their unique expertise and perspectives. This diversity enhances the quality of research by incorporating multiple viewpoints and approaches. Furthermore, collaboration stimulates creativity and fosters the generation of innovative ideas. Working together, co-authors can brainstorm, exchange thoughts, and build upon each other's concepts, leading to novel research directions and breakthroughs. Scientific innovation relies on collaboration as it enables the sharing of ideas and broadens the spectrum of perspectives regarding a particular topic (Liu et al., 2023).

Sharing the workload among co-authors significantly increases productivity and efficiency. Each researcher can focus on their strengths and contribute specific skills, accelerating the research process. Collaborators can divide tasks, conduct parallel experiments, and analyze data collectively, leading to faster completion of projects. Moreover, collaborative research often opens doors to additional resources and funding opportunities. Researchers within a cluster can pool their resources, such as laboratory equipment, datasets, and software tools, maximizing the utilization of available assets.

Collaborative efforts help ensure the quality and rigor of scientific research. Co-authors can critically evaluate each other's work, provide constructive feedback, and perform peer reviews, enhancing the validity and reliability of the findings. This process helps catch errors, improve methodologies, and strengthen the scientific output. Engaging in a cluster of co-authorship collaboration also expands researchers' professional networks. The shared expertise and connections within the cluster may lead to joint projects, symposiums, conferences, and other collaborative opportunities (Fransman et al., 2021).

The principal authors collaborating towards scientific production related to the quintuple helix innovation model include Elias G. Carayannis, David F.J. Campbell, Evangelos Grigoroudis, Thorsten D. Barth, Maria Rud Tambunan, and Massimo Arnone. The primary approach and contribution to the research of the quintuple helix model is briefly described below.

Elias G. Carayannis is a renowned scholar in innovation and entrepreneurship. His contributions to the research of the quintuple helix innovation model include developing and refining the concept of the quintuple helix framework, which emphasizes the involvement of academia, industry, government, civil society, and the public in the innovation process. Carayannis has also highlighted the importance of social innovation, knowledge creation, and collaborative governance in fostering sustainable and inclusive development (E. G. Carayannis, Campbell, et al., 2022).

David F.J. Campbell has contributed to the quintuple helix innovation model research by exploring its application in the context of regional development and smart specialization. His work emphasizes the role of universities as catalysts for regional innovation, promoting the collaboration between academia, industry, government, civil society, and citizens. Campbell's research focuses on practically implementing the quintuple helix model to enhance regional competitiveness and address socio-economic challenges (E. G. Carayannis & Campbell, 2021).

Evangelos Grigoroudis has contributed to the research of the quintuple helix innovation model by applying data-driven approaches and multi-criteria decision-making. His work involves developing decision support systems that incorporate the interactions among the helices and evaluating innovation projects from a multi-stakeholder perspective. Grigoroudis' research enhances the understanding of how different helices contribute to innovation outcomes and assists policymakers in making informed decisions regarding innovation policies and strategies (Kitsios et al., 2021).

Thorsten D. Barth has contributed to the quintuple helix innovation model research through his work on open innovation and collaboration among the helices. He explores the dynamics and mechanisms of knowledge transfer, technology commercialization, and open innovation practices within the quintuple helix model. Barth's research sheds light on the strategies and processes that facilitate effective collaboration and knowledge exchange among the helices, leading to successful innovation outcomes (E. G. Carayannis, Barth, et al., 2022).

 ISSN 2992-6823

Maria Rud Tambunan has contributed to the quintuple helix innovation model research by focusing on its application in the context of developing countries. Her work explores how the quintuple helix model can be adapted to address the unique challenges and opportunities developing economies face. Tambunan's research emphasizes the role of government policies, institutional frameworks, and international collaborations in promoting innovation and sustainable development in these contexts (Tambunan, 2018).

Massimo Arnone's contributions to the quintuple helix innovation model research involve exploring the role of information and communication technologies (ICT) in facilitating collaboration and knowledge exchange among the helices. His work investigates how ICT platforms and tools can support the implementation of the quintuple helix model, enabling effective communication, data sharing, and collaborative decision-making processes. Arnone's research contributes to understanding digital transformation and its impact on innovation ecosystems (Provenzano et al., 2018).

3.1.2. Citations by year of publication and by author

The bibliometric analysis has made it possible to identify the number of citations per year of publications that include the term "quintuple helix" in the title or abstract. It can be seen in Table 2 how said citations have increased considerably, starting with 19 citations in 2011 and reaching 538 citations in 2022, and Graph 1 shows a visual representation of the citations by year of publication. The above shows a growing interest of the scientific community in the subject, derived from applying the quintuple helix model in various areas of knowledge.

Table 2

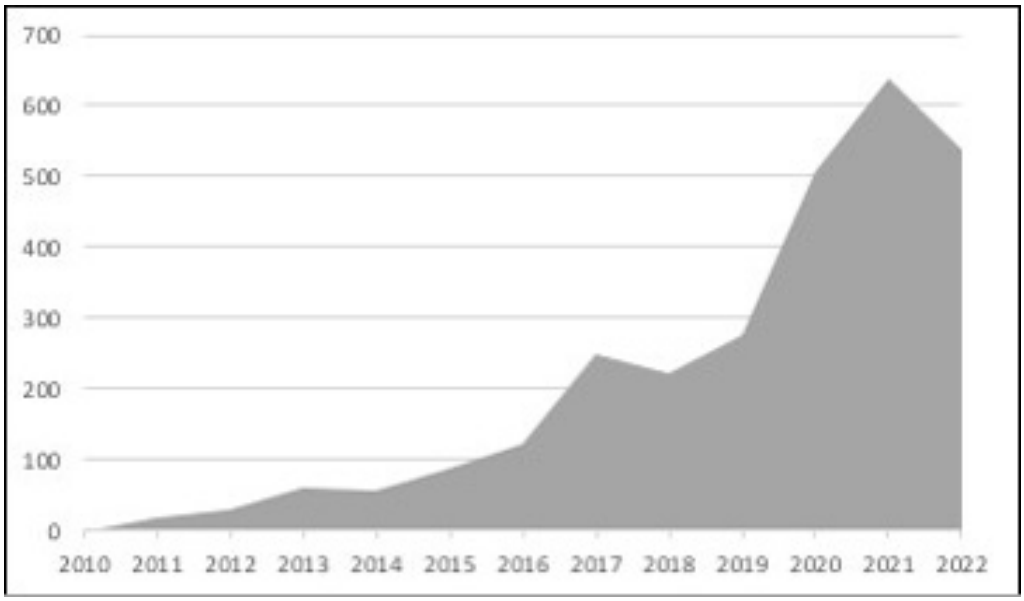
Citations by year of publication

Year	Quotes
2010	0
2011	19
2012	30
2013	59
2014	58
2015	89
2016	122
2017	250
2018	224
2019	278
2020	508
2021	640
2022	538

Note. Own elaboration

Graph 1

Progression of citations by year of publication



Note. Own elaboration based on Vosviewer

Regarding the number of citations per author, it has been identified through the analysis that three authors constitute 85% of the total citations attributed to articles directly related to the quintuple helix model from 2010 to 2022. David FJ Campbell is the author with the highest number of citations (2,570), followed by Elias Carayannis and Evangelos Grigoroudis, with 1,989 and 266 citations, respectively. Table 3 shows the total citations by an author between 2010 and 2022.

 ISSN 2992-6823

Table 3

Scientific production and citations by authors with more than three publications

Author	Publications	Quotes
Carayannis, Elias	41	1989
Campbell, David FJ	33	2570
Grigoroudis, Evangelos	8	266
Barth, Thorsten D.	5	34
Tambunan, Maria RUD	5	0
Rehman, Scheherazade S.	3	134
Farinha, Luis	3	18
Ferreira, Joao J.	3	18
Arnone, Massimo	3	12
Cai, Yuzhuo	3	12
Provenzano, Vincenzo	3	12
Seminara, Maria Rosaria	3	12
Rosdiana, Haula	3	3
Petrushenko, Mykola	3	0

Note. Own elaboration

3.1.3. Knowledge areas

The review has made it possible to identify that most of the scientific production is related to the area of knowledge of Economics (41) and Commerce, Management, Tourism, and Services (36). On the other hand, the areas of Language, Communication, Culture, and Environmental Sciences show 20 and 11 publications, respectively. The rest of the publications found have been related to the areas of knowledge of Built Environment and Design, Information and Computing Sciences, Biological Sciences, Chemical Sciences, Education, Engineering, Physical Sciences, Agricultural and Veterinary Sciences, Medical Sciences and Health, Psychology and Cognitive Sciences, Law and Legal Studies, and Philosophy and Religious Studies, identifying less than 11 publications by area. The main areas of knowledge related to the scientific publications found are shown in Table 4.

Table 4

Areas of knowledge related to scientific production

Knowledge area	Publications
16 Studies in Human Society	51
14 Economy	41
15 Trade, Management, Tourism, and Services	36
20 Language, Communication, and Culture	20
05 Environmental Sciences	11
12 Built environment and design	11
08 Information Sciences and Computing	10
06 Biological Sciences	6
03 Chemical Sciences	5
13 Education	5
09 Engineering	4
02 Physical Sciences	1
07 Agricultural and Veterinary Sciences	1
11 Medical and Health Sciences	1
17 Psychology and Cognitive Sciences	1
18 Law and Legal Studies	1
22 Philosophy and Religious Studies	1

Note. Own elaboration

It is interesting how the scientific research on the quintuple helix innovation model focuses on seven major knowledge areas: Studies in Human Society; Economy; Trade, Management, Tourism, and Services; Language, Communication, and Culture; Environmental Sciences; Built environment and design; and Information Sciences and Computing. The main focus of the scientific articles identified in each area can be summarized as follows:

Studies in Human Society: The quintuple helix model focuses on the interaction and collaboration between stakeholders, including academia, industry, government, civil society, and the general public. This model promotes social innovation and the inclusion of diverse perspectives, making it highly relevant to studies in human society. The model's emphasis on social dynamics, knowledge

 ISSN 2992-6823

sharing, and participatory approaches attracts sociology, political science, anthropology, and social psychology researchers. Furthermore, studying the quintuple helix model can provide insights into the societal impact of scientific advancements and technological innovations.

Economy: The quintuple helix model recognizes the crucial role of economic factors in innovation and development. It emphasizes the close relationship between academia, industry, and government, aiming to foster economic growth through knowledge transfer, technology commercialization, and entrepreneurship. As a result, there is significant scientific research on the quintuple helix model in economics. Researchers explore innovation ecosystems, regional development, industry-academia collaborations, and the economic impact of open innovation. Understanding and enhancing the interactions among the five helices can lead to more effective economic policies and strategies.

Trade, Management, Tourism, and Services: The quintuple helix model provides a comprehensive framework for studying trade, management, tourism, and services. These areas often involve complex interactions between academia, industry, government, civil society, and consumers. The model's emphasis on collaboration, knowledge exchange, and co-creation aligns with the goals of these fields. Researchers can investigate innovation in service industries, public-private partnerships, sustainable tourism, and stakeholder engagement. By applying the quintuple helix model, scholars can gain valuable insights into optimizing trade, management, tourism, and services for societal and economic benefits.

Language, Communication, and Culture: The quintuple helix model recognizes the importance of effective communication and cultural understanding in fostering innovation and development. Language, communication, and culture significantly facilitate collaboration and knowledge exchange among the helices. Researchers in this knowledge area explore how language barriers, intercultural communication, and cultural differences impact innovation ecosystems. They also investigate the role of cultural diversity in promoting creativity and enhancing problem-solving capabilities. Understanding the quintuple helix model can provide valuable insights into improving stakeholder communication and cultural integration.

Environmental Sciences: The quintuple helix model's focus on sustainability and societal well-being aligns with the goals of environmental sciences. The model acknowledges the need for environmental responsibility and the involvement of various stakeholders in addressing environmental challenges. Scientific research on the quintuple helix model in environmental sciences explores sustainable development, eco-innovation, green technologies, and the role of different helices in promoting environmental conservation. Understanding the interactions between academia, industry, government, civil society, and the public is crucial for effectively addressing environmental issues and achieving sustainable outcomes.

Built Environment and Design: The quintuple helix model has relevance in the built environment and design field due to its emphasis on collaboration and multidisciplinary approaches. The model recognizes that the design and development of physical spaces impact multiple helices, including academia, industry, government, civil society, and end-users. Researchers in this field can investigate topics such as urban planning, architecture, smart cities, and sustainable infrastructure from the perspective of the quintuple helix model. Understanding how these helices interact and influence the built environment can lead to innovative and sustainable design solutions.

Information Sciences and Computing: The quintuple helix model intersects with information sciences and computing due to its focus on knowledge sharing, technology transfer, and digital innovation. The model recognizes the critical role of information and communication technologies in facilitating collaboration among academia, industry, government, civil society, and the public.

3.1.4. Publication sources

The bibliometric analysis shows that four specialized journals concentrate more than half of the publications in the field of the quintuple helix: Journal of The Knowledge Economy, Encyclopedia of Creativity, Invention, Innovation, and Entrepreneurship, Handbook of Cyber-Development, Cyber-Democracy, And Cyber-Defense and Sustainability, as shown in Table 5.

Table 5

Publication sources and citations by source

Fountain	Publications	Quotes
Journal of The Knowledge Economy	23	764
Encyclopedia of Creativity, Invention, Innovation, and Entrepreneurship	10	19
Handbook of Cyber-Development, Cyber-Democracy, And Cyber-Defense	9	9
Sustainability	9	81
International Journal of Social Ecology and Sustainable Development	6	477
Bisnis & Birokrasi Jurnal Ilmu Administrasi Dan Organisasi	5	0
Triple Helix	5	14
Journal of Innovation and Entrepreneurship	4	507
Ieee Transactions on Engineering Management	3	36
Innovation, Technology, And Knowledge Management	3	18
International Journal of Innovation	2	2
IOP Conference Series Earth and Environmental Science	2	1
R&D Management	2	170
Scientometrics	2	73
Technological Forecasting and Social Change	2	60
Technology Innovation Management Review	2	29
Фгу Science Научный Журнал	2	0

Note. Own elaboration

3.1.5. Productivity by type of Institution and Country

The institutions with the highest number of publications and citations related to the quintuple helix model, identified through the bibliometric study, are the following: George Washington University, University of Klagenfurt, University of Applied Arts Vienna, University of Vienna, and Danube University Krems. The number of publications and citations by an institution can be seen in detail in Table 6.

Table 6

Scientific publications by an institution

Institution	Publications	Quotes
George Washington University	3. 4	1572
University of Klagenfurt	28	1081
University of Applied Arts Vienna	22	734
University of Vienna	17	464
Danube University Krems	13	48
Technical University of Crete	6	90
Polytechnic University of Valencia	4	25
University of Beira Interior	4	64
National Academy of Sciences of Ukraine	3	1
Polytechnic Institute of Castelo Branco	3	18
Pontifical Catholic University of Peru	3	23
Tampere University	3	12
University of New Mexico	3	4
University of Palermo	3	12
Adam Mickiewicz University in Poznań	2	14
Autonomous University of Madrid	2	57
Ghent University	2	29
National and Kapodistrian University of Athens	2	3. 4
Ramon Llull University	2	3
Telkom University	2	24
University of Amsterdam	2	9
University of Barcelona	2	8
University of California, Berkeley	2	15
University of Florida	2	6
University of Guelph	2	8
University of Naples Federico II	2	4
University of Salento	2	17
University of Stuttgart	2	10
Yeungnam University	2	73

Note. Own elaboration

Regarding the origin of scientific publications, the analysis shows that six countries concentrate 64% of the total scientific production: The United States, Austria, Spain, Italy, Greece, and the United Kingdom, as seen in Table 7. It is important to note that even though most of the scientific production occurs in seven countries, scientific articles directly related to the quintuple helix have been published in 25 countries in America, Europe, and Asia.

Table 7

Scientific publications by country of origin

Country	Publications	Quotes
USA	45	1644
Austria	32	1231
Spain	12	106
Italy	10	35
Greece	9	273
United Kingdom	8	76
Porcelain	5	85
Germany	5	13
Indonesia	5	24
Portugal	5	109
Ukraine	5	6
Belgium	4	40
Brazil	4	3
Australia	3	46
Canada	3	30
Finland	3	12
Malaysia	3	0
Peru	3	23
Poland	3	14
Russia	3	118
South Korea	3	81
France	2	51
Netherlands	2	9
Sweden	2	70
Thailand	2	20

Note. Own elaboration

 ISSN 2992-6823

3.1.6. Articles with the highest number of citations

The most cited articles and their source of publication, year, and authors have been identified through the bibliometric analysis and are shown in Table 8.

Table 8

Number of citations per article

Qualification	Fountain	Year	Authors	Quotes
Triple Helix, Quadruple Helix, and Quintuple Helix and How Do Knowledge, Innovation, and the Environment Relate To Each Other? A Proposed Framework for a Trans-disciplinary Analysis of Sustainable Development and Social Ecology	International Journal of Social Ecology and Sustainable Development	2010	Carayannis, Elias G.; Campbell, David FJ	426
The Quintuple Helix innovation model: global warming as a challenge and driver for innovation	Journal of Innovation and Entrepreneurship	2012	Carayannis, Elias G; Barth, Thorsten D; Campbell, David FJ	337
The Quadruple/Quintuple Innovation Helixes and Smart Specialization Strategies for Sustainable and Inclusive Growth in Europe and Beyond	Journal of the Knowledge Economy	2014	Carayannis, Elias G.; Rakhmatullin, Ruslan	198
The ecosystem as helix: an exploratory theory building study of regional cooperative entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models	R&D Management	2017	Carayannis, Elias G.; Grigoroudis, Evangelos; Campbell, David FJ; Meissner, Dirk; Stamati, Dimitra	170
Open Innovation Diplomacy and a 21st Century Fractal Research, Education and Innovation (FREIE) Ecosystem: Building on the Quadruple and Quintuple Helix Innovation Concepts and the Mode 3 Knowledge Production System	Journal of the Knowledge Economy	2011	Carayannis, Elias G.; Campbell, David FJ	166

Mode 3 Knowledge Production in Quadruple Helix Innovation Systems	Springer Briefs in Business	2011	Carayannis, Elias G.; Campbell, David FJ	135
Developed democracies versus emerging autocracies: arts, democracy, and innovation in Quadruple Helix innovation systems	Journal of Innovation and Entrepreneurship	2014	Carayannis, Elias G; Campbell, David FJ	128
Quadruple Helix Structures of Quality of Democracy in Innovation Systems: the USA, OECD Countries, and EU Member Countries in Global Comparison	Journal of the Knowledge Economy	2015	Campbell, David FJ; Carayannis, Elias G.; Rehman, Scheherazade S.	87
A Quadruple and Quintuple Helix Approach to Regional Innovation Systems in the Transformation to a Forestry-Based Bioeconomy	Journal of the Knowledge Economy	2016	Grundel, Ida; DahlstrÃ¶m, Margareta	70
Interweaving isomerism and isomerization of molecular chains	Chemical Communications	2011	Zhang, Jie-Peng; Qi, Xiao-Lin; He, Chun-Ting; Wang, Yu; Chen, Xiao Ming	60
Transition from the Triple Helix to N-Tuple Helices? An interview with Elias G. Carayannis and David FJ Campbell	scientometrics	2013	Park, Hanwoo	60
Bridging the gap between circular economy and climate change mitigation policies through eco-innovations and Quintuple Helix Model	Technological Forecasting and Social Change	2020	Durán-Romero, Gemma; Lopez, Ana M.; Belyaeva, Tatiana; Ferasso, Marcos; Garonne, Christophe; Jones, Paul	51

Note. Own elaboration

 ISSN 2992-6823

3.2. Search for secondary terms in combination with the term "quintuple helix."

In order to determine if there are scientific publications that relate the quintuple helix innovation model with business profitability, a search of scientific literature was carried out to establish the correlation between the quintuple helix and business profits using bibliometric techniques in the sources mentioned above of information.

The analysis of the review of scientific articles that combine the term "quintuple helix" with terms related to business profitability is shown in Table 9.

Table 9

Scientific articles that combine the term "quintuple helix" with terms related to business profitability

Term	Articles	Authors	Year	Origin
Assets	2	Elias George Carayannis Evangelos T. Grigoroudis David F. J. Campbell Dimitra Stamati Dirk Meisner Scheherazade Sabina	2017, 2019	USA, Greece, Austria, Russia, Italy
Business	20	Elias George Carayannis Evangelos T. Grigoroudis Natasha Drvenkar C. Patrick Heidkamp Victor Gonçalves Cremonez Yunizar Yunizar Marcelo Gonçalves Do Amaral David F. J. Campbell	2015-2022	USA, Greece, Brazil, Indonesia, Austria, Russia, United Kingdom, Australia, Portugal, India, Ukraine, Romania, Turkey, Croatia, France

Company	13	Nuno Octavio G. Thais Assis De Souza Norsyahida Mohammad Siti Indati Mustapa Azlina Mohamad Jais Marcelo Gonçalves Do Amaral Fbio Lazzarotti Mykola Petrushenko Elias George Carayannis Kristina Sisilia Waznatol Widad Mohamad Ishak	2017 - 2022	Portugal, Brazil, Malaysia, Ukraine, USA, Indonesia, Peru, Spain, France, United Kingdom, Italy, Greece
Corporation	0	NA	NA	NA
Equity	0	NA	NA	NA
Finance	5	Thorsten D Barth Gilbert Ahamer Vanessa Ratten Anderson Rei Galvão Carla Susana Da Encarnação Marques BV Phani Olga Viunyk Joao Jose De Matos Ferreira Carla Mascarenhas	2013 - 2022	Austria, Australia, Portugal, India, Ukraine
Company	8	Elias George Carayannis David F. J. Campbell Stavros Sindakis Dimitra Stamati Ernesto Calo Ji Hwan Lee Gian Luca Gregori Luca Dezi Dirk Meisner Irina Safitri Zen Hiroko Shibakawa	2013 - 2022	USA, Austria, China, Greece, Italy, Korea, Russia, Malaysia, Japan, Thailand, South Korea

 ISSN 2992-6823

Gain	4	C. Patrick Heidkamp Victor Dos Santos Paulino Joana Costa Michaela garland Irena Łącka Christina Theodoraki Joao Carlos Oliveira Matias	2020 - 2022	USA, France, Portugal, Poland
Impact	20	Elias George Carayannis David F. J. Campbell Wieland Schneider Abbas Ghanbari Baghestan Stavros Sindakis Xavier Ferras-Hernandez Sabrina Mohd Rashid Mohd Sobhi Ishak Lutz Peschke Seldağ Güneş Peschke Joel Yutaka Sugano	2016 - 2022	USA, Austria, Iran, China, Spain, Malaysia, Turkey, Brazil, Poland, Indonesia, Germany, United Kingdom, France, Ukraine, Romania, and Thailand.
Industry	46	Elias George Carayannis David F. J. Campbell Han Woo Park Ernesto Calo Gian Luca Gregori Luca Dezi Rosdian Haula Evangelos T. Grigoroudis Yuzhuo Cai Thorsten D Barth Gislayne Da Silva Goulart	2013 - 2022	USA, Austria, Iran, China, Spain, Malaysia, Turkey, Brazil, Poland, Indonesia, Germany, United Kingdom, France, Ukraine, Romania, Thailand, Russia, and Holland.

Investment	12	Mykola Petrushenko Natalia Andryeyeva Nuno Octavio Garcia Fernandes David F. J. Campbell Elias George Carayannis Hanna Tiutiunnyk Marta Peris Peris-Ortiz Artur Vitaliyovych Zhavoronok Luis MC Farinha Olga Viunyk Yuri Safonov	2013-2022	Ukraine, Portugal, Austria, USA, Spain, Portugal, Romania, Brazil
Listed	0	NA	NA	NA
Market	10	Elias George Carayannis David F. J. Campbell Mykola Petrushenko Juvenal Rodriguez Resendiz BV Phani Shantha Indrajith Hikkaduwa Liyanage Christopher Ziemnowicz Jose Manuel Alvarez-Alvarado Fulu Godfrey Netswera Gaye Acikdilli	2013-2022	USA, Austria, Ukraine, Mexico, India, Botswana, South Africa, Turkey
Performance	12	Elias George Carayannis Evangelos T. Grigoroudis Thais Assis De Souza Gislayne Da Silva Goulart Marcelo Gonçalves Do Amaral David F. J. Campbell Renan Costa Filgueiras Kristina Sisilia Agni Alam Awirya Andréa Aparecida Da Costa Mineiro Cleber Carvalho De Castro	2019-2022	USA, Greece, Brazil, Austria, Indonesia, Thailand, Italy

 ISSN 2992-6823

Private	11	Elias George Carayannis David F. J. Campbell Abbas Ghanbari Baghestan Sabrina Mohd Rashid Fred W. Pries Mohd Sobhi Ishak Alina A. Ilinova Alexey E Cherepovitsyn Hadi Khaniki Angie Fernandez Lorenzo Carmelo Reverte	2013-2022	USA, Austria, Iran, Malaysia, Canada, Russia, Ecuador, Spain, France
Profit	0	NA	NA	NA
Public	30	David F. J. Campbell Elias George Carayannis Wieland Schneider Natasha Drvenkar Thorsten D Barth Fotis C Kitsios Julia Zielke Lutz Peschke Seldağ Güneş Peschke Alina A. Ilinova Alexey E Cherepovitsyn	2013-2022	Austria, USA, Greece, Germany, Turkey, Russia, Italy, Spain, United Kingdom, Ecuador, Sweden, Ukraine, Romania, Portugal, Guatemala, Croatia,
Return	1	Natasha Drvenkar Dražen Živic	2015	Croatia
Roa	0	NA	NA	NA
Roe	0	NA	NA	NA
Roi	0	NA	NA	NA
Schumpeter	1	Elias George Carayannis Christopher Ziemnowicz Gaye Acikdilli	2019	USA, Türkiye
Stock	0	NA	NA	NA

Note. Own elaboration

From the systematic review of the scientific literature, searching for publications that relate the term "quintuple helix" with each of the proposed secondary terms, no articles have been found that directly relate the quintuple helix model with business profitability.

A large number of articles have been found that combine, in the title and abstract of the publication, the term "quintuple helix" with the terms "industry", "business", "company", "financial", "firm", "gain", "impact", "investment", "market", "performance", "private", "public", "return" and "Schumpeter". However, the focus of these publications is focused on society and industry 5.0, social innovation, sustainability, the competitiveness of small and medium-sized companies, implications for government policy, sustainable development, tax incentives, knowledge production, economic development, national structures, linking, and innovation models, mainly. None of these investigations explores the direct relationship between the quintuple helix model of innovation and business profitability.

On the other hand, no scientific article has been found that combines the term "quintuple helix" with the terms: "corporation", "equity", "listed", "profit", "ROA", "ROE", "ROI", or "stock" in the title and abstract of said publication.

4. Conclusions

The objective of this research has been to systematically review the existing scientific literature on the quintuple helix, specifically evaluating whether there is research that directly relates said innovation model to business profitability.

After reviewing the scientific production available in the databases consulted, no studies were found that directly related the quintuple helix innovation model with business profitability. However, research has shown that the quintuple helix model can be proposed as a framework for transdisciplinary analysis of sustainable development and social ecology. The scientific articles found that the quintuple helix stands out as a model of innovation that can lead to success by using available and newly created "knowledge" within a particular country subsystem. While the quintuple helix model highlights social sharing and knowledge transfer, its direct impact on business profitability has not been explored in scientific research until 2022.

Joseph Schumpeter's theory of innovation is widely recognized for its focus on the relationship between innovation and economic growth (Metcalfe, 2012). According to Schumpeter, innovation is a crucial driver of long-term economic prosperity, and several interrelated factors drive the innovation process.

The quintuple helix model is a conceptual framework highlighting the importance of collaboration between different actors in the innovation process. Based on the analysis of the scientific literature identified in this research, the correlation between each of the actors of the quintuple helix model and business profitability (from a Schumepetrian perspective) could be justified as follows.

Academia: Academic institutions, such as universities and research centers, are essential knowledge and technology generation sources. Collaboration between academia and companies can lead to the transfer of knowledge and technology, which in turn can improve the innovative capacity of companies (Shi et al., 2020). Such collaboration can translate into new product development, more efficient processes, and a competitive advantage, which can increase business profitability.

 ISSN 2992-6823

Industry: Companies play a central role in the innovation process since they are the ones that implement and commercialize new ideas and technologies. A company's ability to innovate and adapt to changes in the business environment can significantly impact its profitability (Nkundabanyanga et al., 2020). Collaboration with other actors, such as academia and government, can provide access to additional resources and specialized knowledge, improving the capacity for innovation and, therefore, the company's profitability.

Government: Government plays a vital role in promoting innovation through appropriate policies and regulations (Zuo & Lin, 2022). Policies to support research and development, tax incentives, and subsidies can encourage business innovation. In addition, the government can establish a favorable environment for collaboration between the different actors of the quintuple helix, facilitating the transfer of knowledge and technology, thus boosting business profitability.

Civil society: The participation of civil society in the innovation process can impact business profitability through various mechanisms. For example, consumer demand and preferences can drive the adoption of innovative new products and services, increasing revenue for companies. In addition, civil society can play a role in disseminating knowledge and raising awareness of the importance of innovation, which can improve the business environment and promote long-term profitability (Nordberg et al., 2020).

Natural environment: Companies adopting best practices and investments towards environmental responsibility can positively impact their profitability (Shabbir & Wisdom, 2020). By reducing natural resource consumption and minimizing waste and pollution, companies can achieve greater operational efficiency and reduce costs. In addition, adopting sustainable and environmentally friendly practices can improve the image of the company and its reputation with consumers and society in general, which can increase the demand for its products or services and, ultimately, boost sales and income. In short, best practices in environmental responsibility can generate tangible economic benefits and improve long-term business profitability.

Even though no scientific papers have been found that directly relate the quintuple helix innovation model to business profitability, the existing literature suggests that innovation can positively affect companies' profitability, potentially encouraging innovation. The previous scientific works found that the quintuple helix stands out as a model of innovation that can lead to a company's success by using available and newly created "knowledge" within a particular country (or region) subsystem. After reviewing the scientific production available in the databases consulted, no studies were found that test the link between this five-fold helix innovation model and business profitability. However, research has shown that the quintuple helix model can be proposed as a framework for transdisciplinary analysis of sustainable development and social ecology.

From this rationale, a key topic for further research (given the present paper's proof) is testing a positive relationship between company profitability and using the quintuple helix in a country, industry, or geopolitical region. This task implies testing the positive validity of the quintuple helix model in terms of benefits to companies, the most significant wealth and welfare producers in almost all the economies worldwide.

Finally, there are several possible lines of research on the quintuple helix innovation model and its relationship with business profitability, depending on the chosen approach and area of knowledge.

Analysis of the influence of collaboration in the quintuple helix on business profitability: This line of research can explore how effective collaboration between academia, industry, government, civil society, and the general public can directly affect the profitability of companies. It is possible to investigate how collaboration in the generation and transfer of knowledge, the co-creation of products and services, and participation in joint innovation initiatives can boost the competitiveness and profitability of companies.

Case study of innovative companies in quintuple helix contexts: This line of research can analyze cases of companies that have achieved outstanding business profitability by taking advantage of the synergies between the quintuple helix actors. Examples of companies that have established successful partnerships with universities, collaborated with the government to access financial or regulatory resources, or worked with civil society to develop sustainable and socially responsible solutions can be investigated. These case studies can reveal effective practices and strategies that have led to greater business profitability.

Evaluation of performance indicators in the quintuple helix: In this line of research, specific indicators can be developed and evaluated to measure business profitability in the context of the quintuple helix. These indicators can consider variables such as revenue growth, financial profitability, market penetration, innovation capacity, and shared value creation. By establishing performance indicators adapted to the quintuple helix, it is possible to understand better how the different actors and their collaboration influence business profitability.

Study of enabling factors and barriers to business profitability in the quintuple helix: This line of research can analyze the factors that facilitate or hinder the relationship between the quintuple helix and business profitability. Aspects such as governance and regulatory frameworks, the availability of financial resources, innovation support policies, business culture, and management capacities can be explored. Understanding the enablers and barriers in the context of the 5-fold helix can provide valuable insights for improving business profitability through collaboration and innovation.

Impact of social and environmental responsibility on business profitability in the quintuple helix: This line of research focuses on investigating how integrating social and environmental responsibility in business strategy can affect profitability in the context of the quintuple helix. The economic benefits derived from sustainable practices, shared value creation, access to more conscious markets and customers, and compliance with environmental regulations can be examined. Investigating how companies can achieve higher profitability through effectively integrating social and environmental responsibility may be relevant to the quintuple helix model.

 ISSN 2992-6823

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