

Carvajal-Camperos, Marisol; Almodóvar, Paloma

Article

Tracking the literature on strategic alliances in the biotechnology industry: Insights from a bibliometric approach over the last 30 years

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Tracking the literature on strategic alliances in the biotechnology industry: insights from a bibliometric approach over the last 30 years

Strategic
alliances in the
biotechnology
industry

245

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Marisol Carvajal-Camperos

Department of Business Economics,

Universidad Rey Juan Carlos – Campus de Vicalvaro, Madrid, Spain, and

Paloma Almodóvar

*Department of Business Organisation, Complutense University of Madrid,
Madrid, Spain*

Abstract

Purpose – The purpose of this study is to identify papers that have produced the most significant impact on research on strategic alliances in the biotechnology industry. The authors attempt to illustrate the thematic evolution of its intellectual structure through 616 papers published between 1992 and 2021.

Design/methodology/approach – The present research methodology relies on three distinct techniques, implemented using SciMat software: (1) bibliometric techniques, (2) scientific map analysis and (3) content analysis of research documents from the Web of Science (WoS). In this manner, the authors analyse the intellectual structure of the field of strategic alliances in the biotechnology industry, tracking its evolution over a period of three decades.

Findings – The study emphasises the relevance of “innovation” as a key theme and identifies several potential areas for future research, which could serve as a foundation for further investigations.

Originality/value – This study represents a novel contribution to the literature as it is the first to use the SciMat tool to analyse strategic alliances in the biotechnology industry. This research reveals that while strategic alliances have been assessed extensively across various industries, some topics, such as the types and formation of alliances, have not been specifically studied in the biotechnology industry. These areas as well as the barriers and variables influencing the formation of alliances offer promising avenues for future research in this field.

Keywords Strategic alliance, Biotechnology industry, Bibliometric analysis, Scientific mapping, Co-word analysis

Paper type Research paper

1. Introduction

A strategic alliance is characterised as a fluid mode of external expansion that entails two or more entities operating with legal and economic autonomy and without any financial obligations or hierarchical links. The underlying goal of such a partnership is to fulfil mutual objectives that may be difficult to achieve independently, such as enhancing competitive advantage, generating value and fostering synergies, by means of a time-limited contractual arrangement that governs the involvement of the participants (Carvajal-Camperos *et al.*, 2021,



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p. 303). In the biotechnology industry, strategic alliances are particularly important as they provide companies with access to new technologies that would otherwise be challenging to acquire due to the high costs and high risk of knowledge appropriation associated with this industry. Strategic alliances are instrumental in driving scientific, technological and innovative developments, which in turn foster sustainable economic growth, ultimately resulting in long-term success (Bengoa *et al.*, 2021).

The biotechnology industry is academically relevant due to its pivotal position in contributing to the national gross domestic product and generating job opportunities on a global scale. The substantial tax revenues generated by this industry further emphasise its importance. Recent events, such as the COVID-19 pandemic, have highlighted the critical role the biotechnology sector plays in safeguarding human lives. Notably, biotechnology accounts for seven out of 10 drugs currently in development worldwide. Additionally, this industry plays a key role in facilitating the transition to sustainable practices, such as the adoption of eco-friendly agricultural methods and the promotion of a bioeconomy. These efforts have contributed to an 18.4% reduction in the Environmental Impact Quotient and the conservation of water resources in crops (AseBio, 2021). The biotechnology industry is primarily composed of small- and medium-sized enterprises, except for pharmaceutical corporations (Leu, 2022). This sector is responsible for generating numerous ground-breaking innovations globally, which have propelled market growth. The biotechnology sector is also making significant contributions to the attainment of goal 17 of the 2030 Agenda for Sustainable Development (Agenda 2030, 2020).

As Carvajal-Camperos *et al.* (2021, p. 304) stated, strategic alliances have become fundamental to companies' competitive strategies as such partnerships facilitate the achievement of objectives that would otherwise be challenging to accomplish. Alliances present an opportunity for companies, particularly those in the biotechnology industry, to improve their capabilities in innovation, learning and training; to enhance their agility in responding to market demands; to optimise their efficiency and to distribute investment risks with their partnering companies (Lange and Wagner, 2021). However, there is a high risk of opportunism when partners want to leave the alliance, especially in research and development and innovation (R&D&i) activities (Palomeras and Wehrheim, 2021; Robinson and Stuart, 2007; Spieth *et al.*, 2021).

According to Chordà *et al.* (2007, p. 109), biotechnology is considered an emerging sector of advanced technology and is currently in the initial stages of its advancement, with no apparent limits to its potential growth. The authors also highlighted that biomedicine was the fastest-growing area of the sector as it was closely linked to the pharmaceutical industry. Thus, the utilisation of scientific discoveries and advancements for both commercial and public purposes is contingent upon entrepreneurs' initiatives to establish novel technology-oriented enterprises (Segers, 2015; Subramanian *et al.*, 2018).

In the biotechnology industry, strategic alliances face two primary hurdles. The first is the partners' ability to acquire current knowledge that is associated with intellectual property, and the second is funding (both public and private) to secure the necessary resources to undertake research projects and develop new products and processes that meet the needs of customers in an increasingly competitive and global market (Gilding *et al.*, 2020).

Researchers are interested in numerous areas of study in the field of strategic alliances in the biotechnology sector, but many topics remain to be developed; therefore, objective criteria must be used to evaluate the research that has been conducted to date, analyse its evolution and trends and identify gaps in the literature. To achieve these goals, we use bibliometric techniques: first, citation analysis to demonstrate the potential of the topic of strategic alliances; second, scientific mapping to study the evolution of this area of research and third, content analysis both to deepen the themes developed in the literature and to shed light on the topics that should be studied further. We then analyse the scientific output with SciMAT software (Cascón-Katchadourian *et al.*, 2020; Cobo Martín, 2012; Cobo *et al.*, 2015; Montero *et al.*, 2018).

The literature review shows that the scientific field of strategic alliances has experienced vast growth over the years, surpassing even some established scientific areas; however, this growth has not occurred in the biotechnology sector. Our research has two main objectives. The first is to analyse the evolution of strategic alliances in the biotechnology industry from 1992 to 2021 and to illustrate the intellectual structure of this discipline by identifying the key themes and theories that have attracted the attention of the research community. The second is to identify areas that must still be developed, and we hence define some avenues for future research.

Based on the literature review carried out in this research, our study is one of the first to apply bibliometric techniques to strategic alliances in the biotechnology industry over the last 30 years using SciMAT software. Prior to this study, there was a dearth of scholarly works that examined the intellectual framework and theoretical foundations of this area. This gap in research underscores the importance of the present work, which enhances the existing body of knowledge on strategic alliances in the biotechnology industry in particular.

The remainder of the paper is structured as follows: [Section 1](#) offers an introduction to the topic at hand. [Section 2](#) outlines the methodology employed in the research. [Section 3](#) presents the findings generated through the use of SciMAT, and it details the primary issues, theories and research gaps concerning strategic alliances within the biotechnology industry. [Section 4](#) offers an integrative analysis of the scientific mapping results. Finally, [Section 5](#) provides conclusive remarks on the research conducted, along with its limitations.

2. Research design and methodology

The extant literature offers various approaches to conducting a systematic literature review. Some scholars advocate for a traditional (manual) theoretical review, in which the researcher uses their expertise to select relevant documents and conduct a content analysis to derive insights about the state of knowledge in the field ([Carvajal-Camperos et al., 2021](#); [Gilal et al., 2019](#); [Paul and Rosado-Serrano, 2019](#)). Other scholars employ a meta-analysis approach that combines statistical results from multiple studies to identify patterns that may not be apparent from individual studies alone ([García Cruz and Ramírez Correa, 2004](#); [Gomes et al., 2016](#); [Knoll and Matthes, 2017](#); [Mariano et al., 2012](#)). Bibliometric analyses that systematically examine bibliographic data, such as publication and citation counts, are also utilised to gain insights into various aspects of scholarly communication ([Albort-Morant and Ribeiro-Soriano, 2016](#); [Chatterjee and Sahasranamam, 2018](#); [Dabić et al., 2020](#); [Fakhar et al., 2020](#)). Moreover, some researchers undertake in-depth hybrid analyses that combine bibliometric and content analysis ([de Diego and Almodóvar, 2021](#); [Rodríguez-Ruiz et al., 2019](#)). For the present study, we selected a hybrid approach to analyse the conceptual structure of strategic alliances in the biotechnology industry and to identify future research directions through the use of bibliometrics and content analysis.

In line with other literature reviews, we selected scholarly papers published in the main databases of the Web of Science (WoS) platform as our unit of analysis. The WoS provides access to a vast array of peer-reviewed bibliographic databases, thus ensuring the high quality of the published papers ([Bouckenoghe et al., 2021](#); [Fernandes et al., 2022](#); [Ferreira et al., 2022](#); [Klarin and Suseno, 2021](#); [Xu et al., 2021](#); [Zhang et al., 2021](#)). We specifically focused on the *Science Citation Index Expanded* and *Social Sciences Citation Index* databases, which are related to our research topic.

We based our research on [Cobo et al. \(2011\)](#) methodology, which involved using SciMAT ([Cobo et al., 2012](#); [Cobo et al., 2012](#); [Cobo et al., 2015](#)). This tool is based on the h-index and co-word analysis ([Callon et al., 1983](#); [Chen et al., 2016](#); [Gálvez, 2018](#); [Leung et al., 2017](#)). This methodology allowed us to visualise the behavioural subdomains of a specific area of research over a range of time. Specifically, we used the SciMAT workflow ([Cobo et al., 2012](#), p. 70), which includes four stages that are developed sequentially, as indicated in [Figure 1](#).

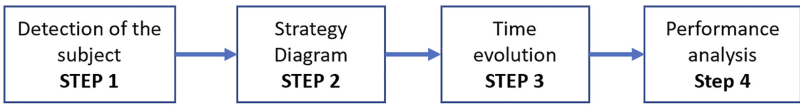
Topic detection was based on the analysis of bibliometric performance indicators through published papers and citations received (Brandão, 2019; de Diego and Almodóvar, 2021; Egghe and Rousseau, 2020; Hu *et al.*, 2020).

In the WoS search, we used the terminology identified by Carvajal-Camperos *et al.* (2021, p. 293) regarding the concept of “strategic alliance” (e.g. “alliance”, “cooperation”, “coalition”, “joint venture”, “joint action” and “bilateral agreement”, along with derivations thereof). In addition, the search was limited to biotechnology industry publications and refined by “management” or “business” categories. Finally, we only included published academic papers and reviews because they are considered “certified knowledge” (Fernandez-Alles and Ramos-Rodríguez, 2009; Ramos-Rodríguez and Ruíz-Navarro, 2004). These conditions ensured a high level of data quality (Fernandez-Alles and Ramos-Rodríguez, 2009; Ramos-Rodríguez and Ruíz-Navarro, 2004).

The data were obtained from the WoS on 1 June 2021. The search yielded 772 articles, and we screened abstracts and manuscripts to discard papers that did not meet the required criteria. A total of 616 papers met the search equation. Figure 2 shows the evolution of these publications and their citations on strategic alliances in the biotechnology industry by year. This allowed us to study the maturity of the topic over a period of almost 30 years.

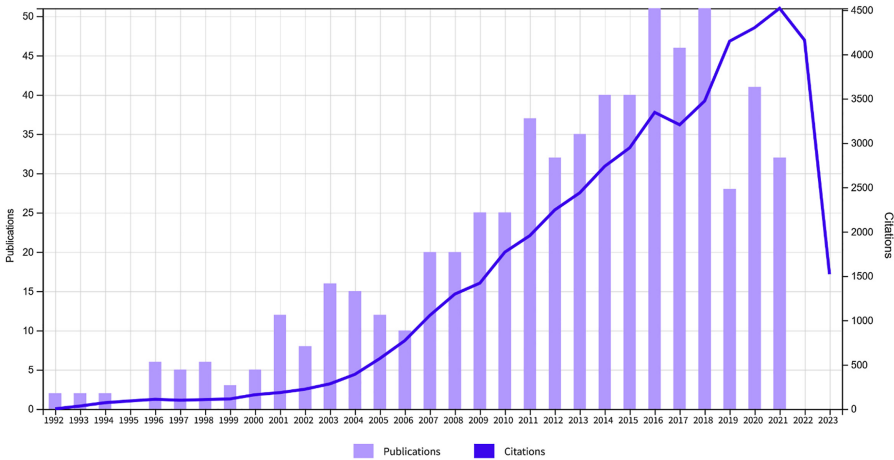
The present study involved exporting 616 articles to the SciMAT software for further analysis. To ensure the accuracy and reliability of the data, we comprehensively refined the set of keywords. This involved consolidating keywords that conveyed similar meanings (e.g. singular and plural forms) and eliminating terms with vague or overly general connotations that failed to contribute substantively to the analysis (such as “research” or “study”). The initial set of 1,946 keywords was subsequently reduced to 992 through a

Figure 1.
Workflow of the steps
of the methodology



Source(s): Cobo Martín (2011: 70)

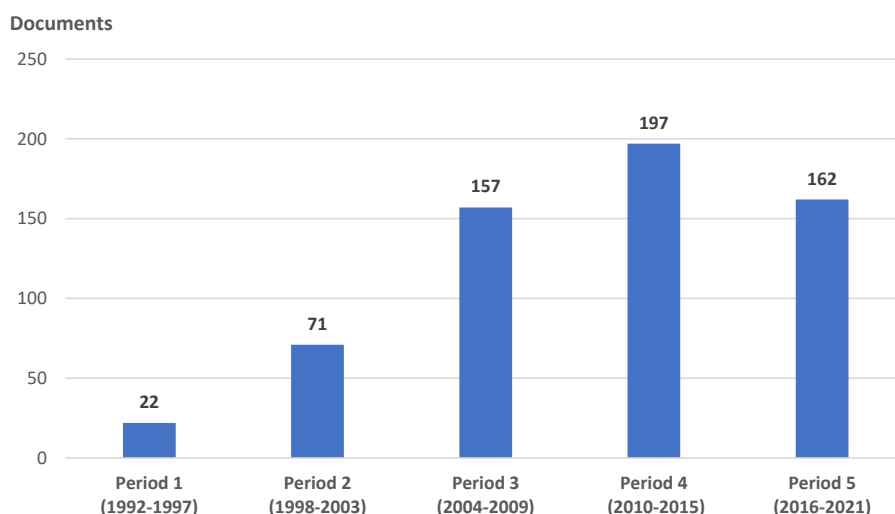
Figure 2.
Evolution of
publications and
citations in WoS on
strategic alliances in
the biotechnology
industry



Source(s): Web of Science (2021)

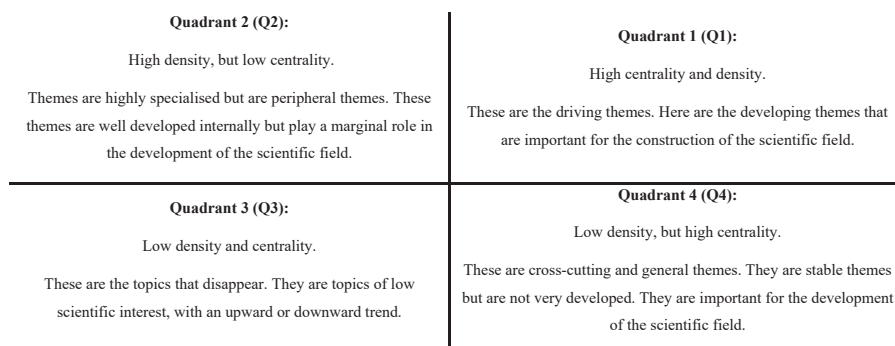
process of manual filtering. The temporal scope of the study spanned 30 years, from 1 January 1992 to 1 June 2021. Following the approach of [Cobo *et al.* \(2011\)](#), we divided the 30-year time frame into five consecutive periods, each spanning 6 years. The distribution of the number of documents per period is presented in [Figure 3](#).

Once we created the periods, we analysed the data following the methodology outlined by [Cobo Martín \(2011, p. 152\)](#). At the end of the 10 steps, we analysed the scientific maps showing two types of visualisations: longitudinal and by period. In the longitudinal visualisation, we present the evolution maps, which identify the development of the themes over the periods, as well as their continuity or disappearance. In the period visualisation, we show detailed information from the results obtained in each period and present strategic diagram. [Figure 4](#) illustrates the implications arising from the distribution of topics across the four quadrants.



Source(s): Authors' own elaboration

Figure 3.
Number of documents per period



Source(s): Authors' own elaboration

Figure 4.
Strategic diagram of research themes

3. Analysis of the scientific map of strategic alliances in the biotechnology industry

Figure 5 displays the thematic evolution of the research field over the five periods. In the first period, research on strategic alliances focuses on a single topic, namely “innovation” in the biotechnology industry. As time progresses, research on “innovation” is maintained, and “transaction costs” theory (TCT) and different approaches to the resource-based view (RBV; “dynamic capabilities” and “capabilities”) come into play. In addition, the specific case of “networks”, “technological discontinuities” and new topics related to corporate finance (“investments” and “public offerings”) are addressed. In the third and fourth periods, there is a large proliferation of different topics, with 12 and 13 topics of high relevance, respectively. In the fifth period, there is a reduction in the number of topics analysed, indicating that academics focus their research on 10 specific sub-areas.

A noteworthy observation pertains to the enduring prominence of the “innovation” theme, which has garnered sustained research attention over time, with varied facets of this theme being investigated directly or indirectly. The biotechnology industry poses unique challenges, as companies operating within this sphere require rapid and secure knowledge generation despite typically being comprised of small or medium-sized entities with limited resources, negotiating skills and project management experience and possessing a limited or scarce client portfolio. Consequently, extant literature has focused considerably on examining the benefits and drawbacks of collaborative R&D&i processes involving external organisations. For a specific analysis of the themes developed in each of the periods, it is necessary to design strategic diagrams.

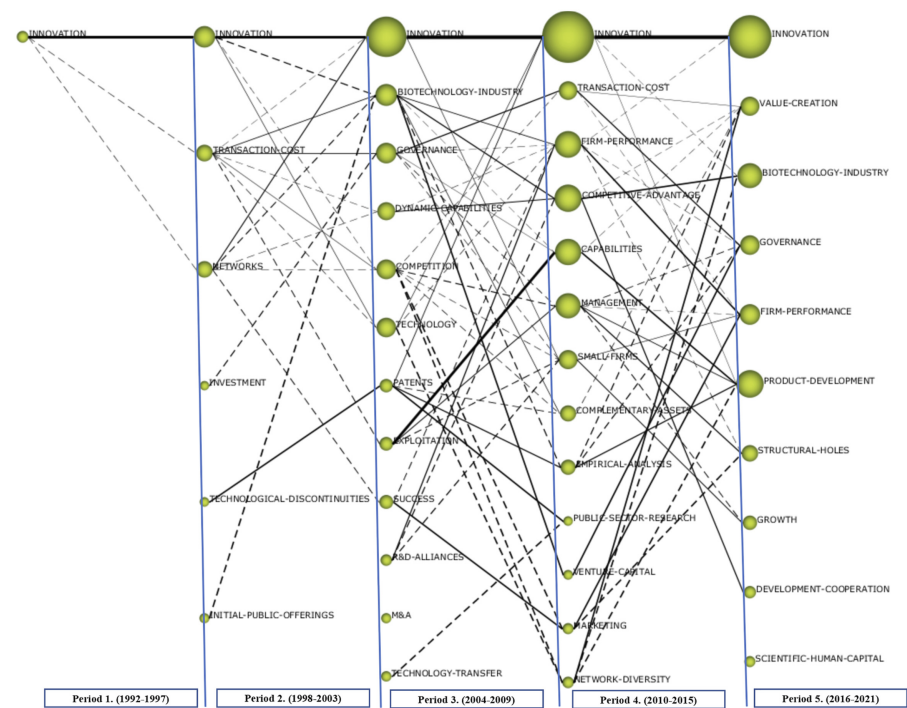


Figure 5.
Evolution of the longitudinal map of strategic alliances in the biotechnology industry

Source(s): Own elaboration using SciMat software

3.1 Strategy diagram analysis: period 1 (1992–1997)

The strategic diagram presented in [Figure 6](#) pertains to Period 1 and provides an overview of the single cluster that characterised this period, along with its corresponding performance indicators, including centrality/density values, h-index and the number of citations.

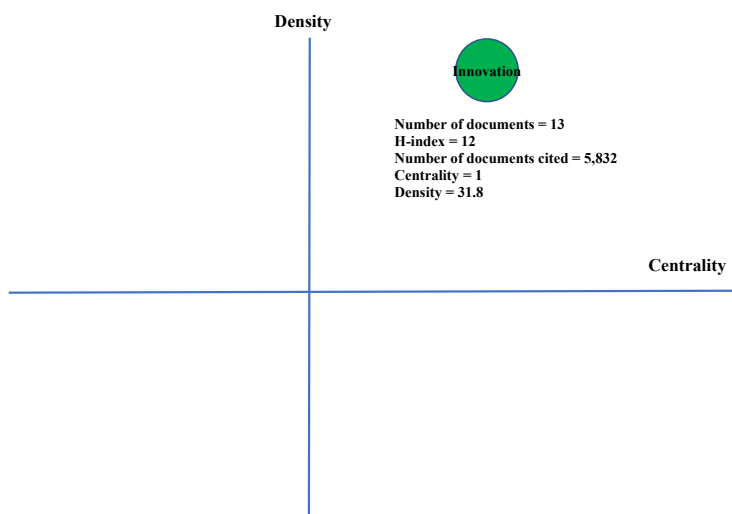
Notably, this diagram highlights the fact that strategic alliances within the biotechnology industry revolve around a singular theme, namely “innovation”. This driving theme is characterised by a centrality value of 1, a density value of 31.18, an h-index of 12 and 5,832 citations. This finding suggests that innovation is a central and highly valued aspect of strategic alliances within the biotechnology industry during this period.

3.2 Strategy diagram analysis: period 2 (1998–2003)

In Period 2 (1998–2003), the strategic diagram indicates that strategic alliances in the biotechnology industry revolve around six research themes. [Figure 7](#) shows the strategic diagram for the period and the groupings with their performance indicators.

The cluster “innovation,” located in the Q1 quadrant, has the following indicators: a centrality of 128.89, a density of 37.86, an h-index indicator of 41 and 19,161 citations. From this, it can be inferred that innovation is a driving theme, of great interest to researchers and important for the structure of strategic alliances in the biotechnology industry. The density of 37.86 is not the highest in Period 2, but it is the cluster of greatest interest to researchers. Two other themes are important to researchers. The first is the “networks” cluster, located in quadrant Q4, with a centrality of 76.87 and a density of 11.55. These figures suggest that the topic under consideration holds significant relevance for advancing the scientific domain, given its consistent, yet underdeveloped nature. The second theme is the “transaction costs” cluster, with a centrality of 65.63 and a density of 34.15. This cluster lies at the intersection of quadrants Q1 and Q4, denoting a theoretical framework that is progressively employed to elucidate diverse facets of strategic alliances.

Whilst the “innovation” cluster demonstrates the greatest impact, the “transaction costs” and “networks” clusters are in close proximity. This is reflected in the individual citation counts of 19,161, 16,559 and 5,832, respectively, which far exceed the combined total of the



Source(s): Authors' own elaboration

Figure 6.
Strategic diagram with
performance
indicators. Period 1
(1992–1997)

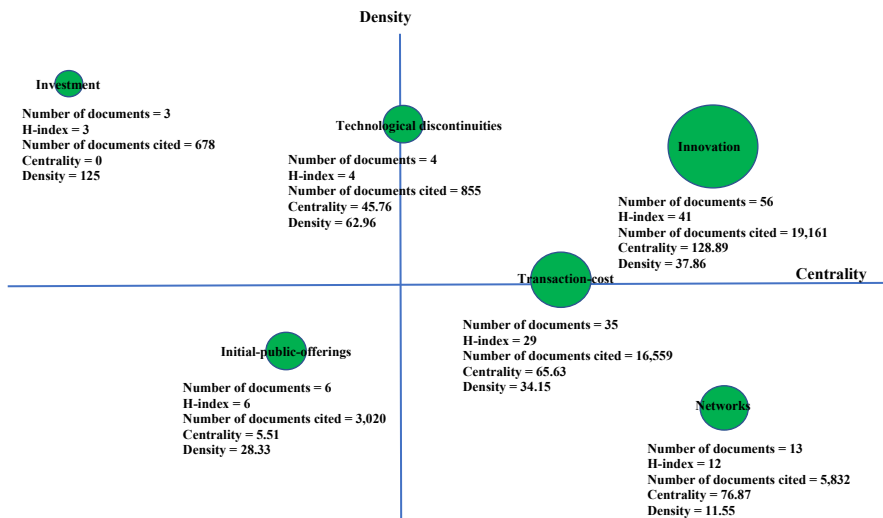


Figure 7.
Strategic diagram with
performance
indicators. Period 2
(1998–2003)

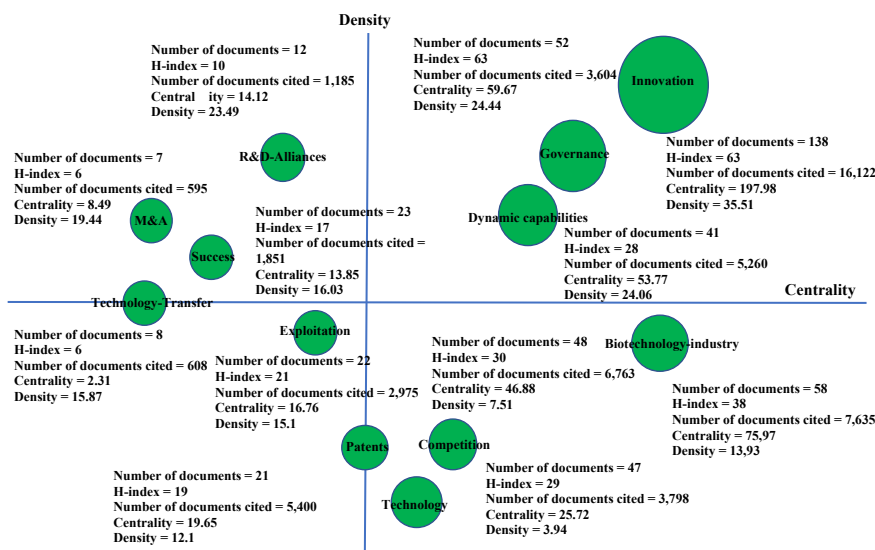
Source(s): Authors' own elaboration

remaining three themes, amounting to a mere 4,553 citations. These three themes encompass the “investment”, “technology discontinuities” and “initial public offerings” clusters, yet their respective indicators indicate that they remain underdeveloped. For example, the cluster “initial public offerings”, located in quadrant Q3, has a density of 5.51 and a centrality of 28.33; this means that it is underdeveloped and has not evolved much. The last two clusters, “investment” and “technological discontinuities”, present less relevant indicators.

3.3 Strategy diagram analysis: period 3 (2004–2009)

In Period 3 (2004–2009), the strategy diagram indicates that partnerships in the biotechnology industry centre on 12 research themes. Figure 8 displays the strategic diagram, featuring distinct clusters and their corresponding performance indicators.

The “innovation” cluster remains in the first quadrant, with a centrality of 197.98 and a density of 35.51, an h-index of 63 and 16,122 citations, which are the highest values of the period. In the same quadrant Q1, we observe the clusters “governance”, with a centrality of 59.67 and a density of 24.44, and “dynamic capabilities”, with a centrality of 53.67 and a density of 24.06. These values indicate that the above-mentioned themes are in full development and are of great interest to researchers. Quadrant Q4 features other topics of interest: “biotechnology industry”, “competition” and “technology”, with centrality scores of 75.97, 46.88 and 25.72 and density values of 13.93, 7.1 and 3.94, respectively. These topics, although relevant for the advancement of the scientific field, are underdeveloped. In quadrant Q2, the clusters “R&D alliances”, “success” and “mergers and acquisitions” are of marginal importance for the development of the scientific field. From the position of the cluster “exploitation” in quadrant Q3, we deduce that this is a disappearing theme, as it has both low density and low centrality. The cluster “technology transfer” is located between quadrants Q2 and Q3, with a low centrality of 2.31 and a density of 15.87, which could indicate that it is an under-researched topic and could disappear because it is of little interest to researchers. Finally, the “patents” cluster, located between quadrants Q3 and Q4 and with a centrality of 19.65 and a density of 12.1, is growing and may develop in the future.



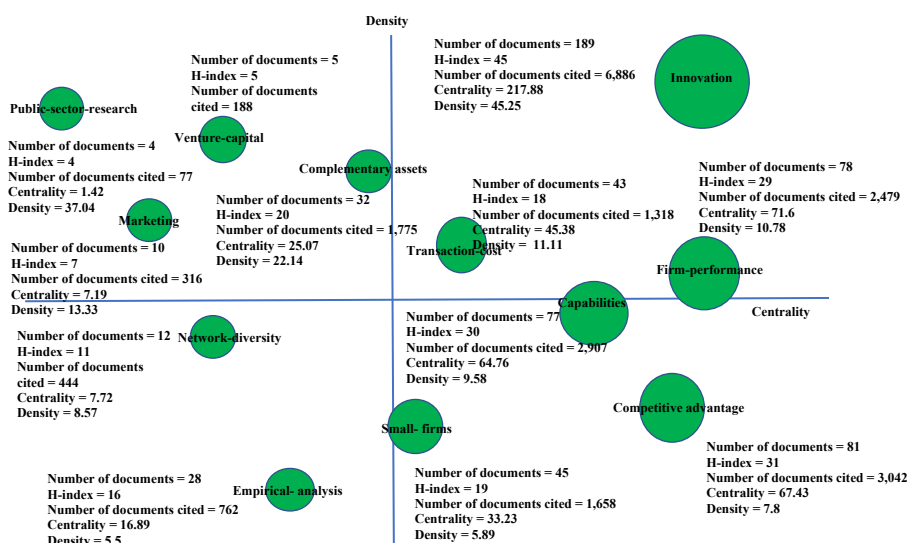
Source(s): Authors' own elaboration

Figure 8. Strategic diagram with performance indicators, Period 3 (2004–2009)

3.4 Strategy diagram analysis: period 4 (2010–2015)

In Period 4 (2010–2015), the strategic diagram indicates that strategic alliances in the biotechnology industry revolve around 13 research themes. Figure 9 shows the strategic diagrams and the full set of indicators.

In the first quadrant, “innovation” emerged as the foremost cluster, with a centrality score of 217.88, a density of 45.25, an h-index of 45 and 6,886 citations. Notably, this cluster appears



Source(s): Authors' own elaboration

Figure 9. Strategic diagram with performance indicators, Period 4 (2010–2015)

to have already undergone significant development; nevertheless, scholarly interest in innovation remains consistent. Quadrant Q1 also contains the cluster “transaction costs”, with a centrality of 45.38 and a density of 11.11. TCT first appeared in Period 1, located between quadrants Q1 and Q4, and is now fundamental to the construction of the scientific field of strategic alliances. In the transition between quadrant Q1 and Q4, we observe the cluster “firm performance”, with a centrality of 71.6 and a density of 10.78. While the performance indicators for these clusters are noteworthy, they fall short of those exhibited by the “innovation” cluster, thus suggesting that these areas remain subjects of ongoing research and development. Quadrant Q4 features several enduring clusters that are relevant for the academic community; however, they require further refinement and expansion. These clusters include “competitive advantage” and “management”, with centrality scores of 67.43 and 56.63 and density values of 7.8 and 5.79, respectively. Moreover, “small firms”, with a centrality of 33.23 and a density of 5.89, is located at the intersection of quadrants Q3 and Q4. In quadrant Q3, we observe the clusters “network diversity” and “empirical analysis”, with centrality scores of 7.72 and 16.89 and density values of 8.57 and 5.5, respectively. Quadrant Q2 contains the clusters “public sector research”, “venture capital” and “marketing”, which are poorly developed and play a marginal role in the development of the scientific field. Finally, the cluster “complementary assets”, with a centrality of 25.07 and a density of 22.14, is located between quadrants Q1 and Q2. These values indicate that the theme has attracted the attention of researchers but that its links with other themes are not well developed because they are highly specialised.

3.5 Strategy diagram analysis: period 5 (2016–2021)

In Period 5 (2016–2021), the strategic diagrams indicate that strategic alliances in the biotechnology industry centred around 10 research themes. The results are presented in Figure 10.

Quadrant Q1 continues to show the “innovation” cluster in the first position. The high relevance of this cluster is supported by a centrality of 210.72, a density of 41.06, an h-index of

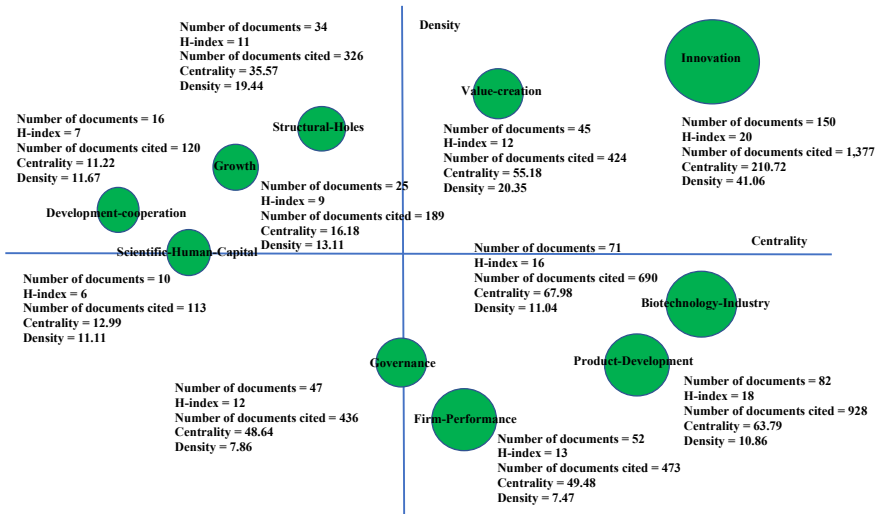


Figure 10.
Strategic diagram with
performance
indicators. Period 5
(2016–2021)

Source(s): Authors’ own elaboration

20 and 1,377 citations. According to these indicators, “innovation” remains the cluster of greatest interest to researchers, and the values may indicate that, after 30 years of research, it has reached maturity. Quadrant Q1 also contains the “value creation” cluster, which has a centrality of 55.18 and a density of 20.35 – indicators that are considered high but not as high as those of the “innovation” cluster.

In addition, Figure 10 illustrates a number of noteworthy themes, including the cluster called “biotechnology industry”, which repeats its location in the Q4 quadrant of Period 3, albeit with a higher number of citations, from 58 to 71 (an increase of 18.30%), and a reduced cluster density, from 13.93 to 11.04 (a decrease of 29.74%). This trend may suggest that researchers are exploring other areas of interest alongside the biotech industry. The clusters “product development” and “firm performance” are also located in quadrant Q4, with centrality scores of 63.79 and 49.48 and densities of 10.86 and 7.47, respectively. These results indicate that these are important themes for the advancement of the scientific field but have undergone little development. As for the theme “governance” (located at the intersection of quadrants Q3 and Q4, but which was located in Q1 in Period 3), its centrality value decreased from 59.67 in Period 3 to 48.64 in Period 5 and its density decreased even more: from 24.44 to 7.86. These data could indicate that interest in the topic is declining. The cluster “scientific human capital”, located between quadrants Q2 and Q3, has a centrality of 12.99 and a density of 11.11. These values, and their location, indicate that the themes are underdeveloped and marginal; it is not yet known whether their evolution will be upward or downward. Finally, in quadrant Q2, we observe the clusters “structural holes”, “growth” and “development cooperation”, all of which have a negligible impact on the progress of the scientific domain.

4. Integrative considerations on the results of scientific mapping: Exploring the main theoretical underpinnings

4.1 Exploring the primary approaches employed in investigating strategic Alliances within the biotechnology industry

One of the main contributions of this review is the identification of the main theories used to support strategic alliances in the biotechnology industry. Through content analysis of 616 articles, we found that TCT (Coase, 1937; Hennart, 1988, 1991; Williamson, 1975, 1979) and RBV (Barney, 1991; Barney *et al.*, 2001; Grant, 1996; Wernerfelt, 1984) exert the greatest influence on the literature on strategic alliances in the industry. Based on these theories, research was conducted on different topics in the biotechnology industry, such as R&D, networks, entrepreneurship, cooperation, governance, organisation, firm performance, complementary assets, technology and technological change, capabilities, markets and product development.

TCT represents the foremost theory in the realm of strategic alliances and is primarily concerned with the minimisation of contract costs to facilitate optimal partner selection and transaction agreement (Dadfar *et al.*, 2014; Di Dio and Correani, 2020; Grant and Baden-Fuller, 2004; Reuer and Ariño, 2002; Williamson, 1991). According to TCT, strategic alliances are an intermediate formula between the internalisation of activities and market exchanges, as they partially internalise an exchange. This theory posits that alliances will be chosen when one of two situations occurs (1) transaction costs are neither too high (i.e. internalisation is not preferable); nor too low (i.e. going to the market is not preferable) but somewhere in-between (Gulati, 1995a, b; Williamson, 1991) or (2) full internalisation is the preferred option, but some constraints prevent it (e.g. lack of resources or expertise), and a second-best option, i.e. semi-internalisation, is thus chosen (Thomas *et al.*, 1997). The TCT perspective assumes opportunistic behaviour, which is associated with alliance performance, whose associated risks are sought to be minimised by optimal partner selection (Ali *et al.*, 2021; Judge and Dooley, 2006). According to TCT, partnerships may fail to materialise or may break down due

to opportunistic conduct stemming from inadequate trust and commitment between partnering entities (Dadfar *et al.*, 2014; Reuer and Ariño, 2002; Todeva and Knoke, 2005). Strategic alliances are associated with many risks, especially in the biotechnology sector, which can lead to their failure.

The RBV is the second theory used to analyse strategic alliances. This theory is diametrically opposed to TCT, since the minimisation of transaction costs is no longer the central focus of corporate decision-making. According to the RBV, decision-making is based on the expansion of a firm's resources and capabilities (Almodóvar Martínez, 2007), and all firms are heterogeneous and unique, especially biotechnology firms, as their resources are different (Hernández, 2010; Teece, 1982). Therefore, each firm's knowledge base is also unique and determines the performance of the firm (Dadfar *et al.*, 2014; Grant, 1996). Sometimes, however, knowledge cannot be traded in the market and must be obtained by other means (Barney, 1986). Thus, the RBV suggests that an alliance is the ideal option when a firm needs resources and/or capabilities that are characterised by mobility, inevitability and/or imperfect substitutability, so that they cannot be acquired by other means (Barney, 1991) and, therefore, can neither be acquired through the market nor be timeously and cost-effectively developed internally.

Strategic alliances provide prime opportunities for an organisation to access the knowledge of partner firms (Das and Teng, 2000a, b). However, the RBV highlights that organisations form clusters with all their resources and capabilities (Yasuda, 2005). When organisations cannot acquire resources through market transactions or cannot develop them internally, they resort to strategic alliances, and their formation is justified by the creation of value through the resources and capabilities of the partners (Das and Teng, 2000a, b; Glaister and Buckley, 1996). The RBV conceives inter-organisational relationships as a way to acquire resources; these relationships, in turn, generate synergies, taking into account that resources should be complementary or similar, as all partners should offer surplus resources and seek complementary resources to transfer or pool, which is of great benefit to the biotechnology sector (Hoffmann *et al.*, 2010; Subramanian *et al.*, 2018, pp. 5–6).

4.2 Mature, emerging and unaddressed issues in the literature

According to the analysis of the strategy maps and the different clusters, the theme “innovation” received the most attention from researchers during the five periods. From Period 1 onwards, researchers' interest grew steadily. However, in Period 5, although the “innovation” cluster had the highest impact, its h-index decreased. This indicates that the theme reached its maturity and gave way to other themes, such as “governance”, “dynamic capabilities” and “value creation”, which are driving themes with a high degree of development.

On the one hand, themes such as “networks”, “competitive advantage”, “management”, “biotechnology industry”, “product development”, “technology”, “firm performance”, “patents” and “small firms” are basic and transversal themes that may be the next to be developed, depending on the research and the relationships that exist between their nodes, both internally and externally. On the other hand, “technology transfer”, “diversity networks”, “exploitation” and “initial public offerings” are emerging themes and may disappear, as their nodes have a low weight compared with the internal and external nodes of the other three quadrants, which could indicate that they are not of interest to researchers.

Some themes, such as “scientific human capital”, “marketing”, “complementary assets”, “R&D alliances”, “structural holes”, “venture capital”, “growth”, “investment” and “public sector research”, are highly developed internally, but they are isolated. These themes are not of interest to researchers.

We found that, in the biotechnology industry, some topics have received little to no attention and could be the subject of future lines of research. In particular, the following topics have been addressed globally in the analysis of strategic alliances but not specifically or in

depth in the biotechnology industry: contracts and types of contracts, formation of strategic alliances, barriers or variables that influence the formation of alliances, partner selection, success, failure, opportunism, internationalisation, entrepreneurship, resilience, alliance performance, reputation, spin-offs and knowledge transfer. These topics could be the focus of future research in the biotechnology industry.

Furthermore, we propose several pertinent research gaps that remain relatively unexplored or that are currently in their nascent stages. These include (1) an investigation into the aspects or variables associated with the value creation of biotechnology companies during Period 5, (2) an extensive inquiry into the internalisation of biotechnology companies via strategic alliances, (3) an in-depth exploration of the factors that exert influence over the success of strategic alliances within the biotechnology industry and (4) a comprehensive study of pre-alliance dynamics to determine the aspects or factors that impact contract formation and signing in biotechnology alliances (Carvajal-Camperos *et al.*, 2023).

5. Conclusions

In this research, we conducted a literature review of strategic alliances in the biotechnology industry, and we presented, over five different periods, the clusters that constitute the key topics for this sector. We used the SciMAT tool, which allowed us to analyse and depict the relationships among strategic alliances in the industry and other topics. The relevance of this line of research stems from the significant economic impact of the biotechnology industry in many countries. The industry has emerged as a crucial contributor to job creation and has demonstrated consistent growth over time (AseBio, 2020, 2021).

Our study indicates a robust association between topics that exhibit high centrality, situated in the right quadrants of the strategy diagrams, and the corresponding number of citations they receive, as depicted in Figures 6 through 10. Specifically, our findings underscore the significant impact of topics located in these quadrants on the realm of strategic alliances. Over the five periods under review, innovation was the predominant theme within the literature – a finding that aligns with the substantial number of authors who have dedicated their research to this subject. This body of scholarship has exerted a notable influence on the field, particularly regarding topics linked to innovation and associated nodes, such as industry, networks, patents, technology, absorptive capacity, alliance formation, product development, collaboration, opportunism and dynamic capabilities (Chung *et al.*, 2021; Hu *et al.*, 2021; Melnychuk *et al.*, 2021; Vedel, 2021). We also drew upon theories such as TCT and the RBV to assess the function of alliances in relation to various factors (Hu *et al.*, 2021; Lange and Wagner, 2021; Na *et al.*, 2021; Palomeras and Wehrheim, 2021; Vlasisavljevic *et al.*, 2021).

Finally, our research shows that strategic alliances in the biotechnology industry remain an area of interest for researchers. Notably, the topic of innovation has been studied for more than 30 years and continues to evolve. Issues such as the network structure of collaborative alliances continue to be investigated to observe their course and impact on the industry (Pammolli *et al.*, 2021). Likewise, ongoing research delves into the asymmetrical impacts of alliances on absorptive capacity (Do Prado Vicentin, Galina, Alves and Viana, 2021). Recent studies have shed light on the potential impact of cooperation on the development of in-house R&D human capital, particularly in the context of alliances with competitors (Vlasisavljevic *et al.*, 2021). The biotechnology industry has emerged as a subject of interest for research on radical innovations in small businesses through knowledge exchange and cooperation. Moreover, investigations have been conducted to discern the effects of partner collaboration on the advancement of in-house R&D human capital (Shkolnykova and Kudic, 2022). Additionally, researchers have sought to determine the relationships among partner collaboration, the degree of external competition and the probability of alliance dissolution

(Hu *et al.*, 2021). These studies demonstrate a growing interest in the role of cooperation and alliance formation in facilitating the development of human capital within the realm of R&D.

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Corresponding author

Marisol Carvajal-Camperos can be contacted at: marisol.carvajalc@urjc.es