

OVERCOMING HIGH MORTALITY OF INNOVATIVE IDEAS ('VALLEY OF DEATH') FOR SCIENTIFIC AND EDUCATIONAL ENVIRONMENT: A BIBLIOMETRIC ANALYSIS

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Abstract: The study focuses on the problem of the gap between innovative ideas and scientific discoveries and their practical implementation and commercialization. The purpose of the article is to analyse the scientific basis and main tendencies of the issue of high mortality of innovative ideas in scientific and educational environment ('Valley of Death'). Therefore, the bibliographic analysis of published scientific articles on the mortality of innovative ideas is conducted. The methodology is based on data analysis from the Scopus scientometric database and R-Studio software. At the first stage of the study, a research infrastructure was created using the scientometric database Scopus and an analysis of literary sources was carried out. The second stage of the study focused on bibliographic analysis of the scientific documents indexed by Scopus over a 20-year period (2003-2023). This period was chosen to capture developments in the field, identify evolving trends, and trace how different aspects of the Valley of Death have been studied and addressed over time. The chosen keyword was "Valley of Death in innovation" (172 documents). This analysis also covered the study of the network of collaboration between authors, the publication trends of scientific papers, the estimation of the average number of citations of papers and the discovery of a thematic map. The resulting visual information was a valuable tool for studying current patterns. The results of the analysis indicated an interest in the mortality of innovation processes and a growing number of scientific literatures on this topic. It was found that this research problem started a long time ago but gained significant interest after 2010. The largest number of published works belongs to the USA. Research on international cooperation also shows that many countries are well integrated into scientific activities. A global science collaboration between the USA, Germany, Canada and the UK facilitates the sharing of knowledge and resources to advance innovation. The obtained results highlight the importance of developing sustainable strategies (the key strategies were proposed and described) and building networks between academic institutions, businesses and governments to overcome the "Valley of Death". This study can be used as a basis for further scientific research in this field.

Keywords: R&D, startup, science, higher education, university, business, collaboration, coopetition, commercialization, gap.

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1. Introduction. Scientific and technological progress in the modern world plays an important role in the development of society, and innovative ideas stimulate changes in various sectors of the economy. But not all innovative ideas reach the stage of successful implementation, because the process of their implementation constantly faces numerous challenges, especially at the initial stages of their development, which are often called the "Valley of Death".

The so-called "Valley of Death" is the period between the end of scientific research and its implementation in industry or business. Such a critical stage for ideas that have the potential to create new technologies, but do not receive adequate support for commercial success (insufficient support from investors, lack of funding, etc.) and are not implemented on the market, significantly hinders the development of innovation ecosystems in many countries. Special attention should be paid to the scientific and educational environment, where developments and research often remain in the field of academic research and do not reach the stage of implementation in industrial or commercial projects. Due to the lack of mechanisms for support, financing and management of the innovation process at the early stages, many promising ideas do not live to be implemented.

Moving from laboratory-based research (basic science) to scalable, marketable products (applied science) often requires considerable investment and a supportive ecosystem for startups, investors, and businesses. One other key challenge is the effectively transferring knowledge from academia to industry, which requires clear communication, knowledge sharing, and sometimes, alignment of incentives between researchers and commercial entities. The regulatory frameworks for new technologies often slow the application of scientific advancements, especially in fields like biotechnology, medicine, and energy.

So, achieving sustainable and innovative growth requires closing the gap that exists between scientific achievements and technological progress at the international level. And the "disappearance" of a significant part of promising projects causes a serious challenge for the economy, scientific and educational institutions in the face of global competition.

Solving the problem of the high mortality rate of innovative ideas is relevant for modern global development, where innovation plays a decisive role in competitiveness. New markets, job creation and economic stability can be achieved through effective implementation of innovative ideas. Thus, finding a solution to overcome the "Valley of Death" is an important step in creating a sustainable innovation system that will ensure business development through the use of the latest technologies. It is a significant challenge in transforming research outcomes into tangible innovations that benefit society that requires a multifaceted approach, incorporating effective strategies for knowledge transfer, technology commercialization, and fostering collaboration between academia, industry, and policymakers.

The need to overcome the gap between scientific discoveries and their practical application determines the relevance of the selected issues and detailed scientific research, which includes, among other things, bibliometric analysis of various scientific publications to determine the key tendencies in scientific background of this problem and accordingly methods of overcoming the "Valley of Death" of innovations in the scientific and educational environment, as well as the analysis of modern approaches and points of view of famous scientists on this issue.

The purpose of this study is to analyse the scientific basis and main tendencies of the issue of high mortality of innovative ideas in the scientific and educational environment.

2. Literature Review.

Several scientists, thought leaders, and innovation theorists have proposed approaches to address the Valley of Death. Chesbrough's concept of "open innovation" stresses the importance of collaborating across organizational boundaries and sharing intellectual property in order to accelerate the commercialization of new discoveries (Chesbrough, 2006).

The concept of open innovation, as discussed by Ioana Stefan (Stefan, 2022), represents a powerful approach to overcoming the gap between scientific discovery and practical implementation. By encouraging collaboration between scientific institutions, companies, and a range of external partners (such as other research labs, venture investors, and different enterprises), open innovation allows for the acceleration of innovation processes – especially in industries where time-to-market and technological advances are critical.

In industries such as biotechnology, AI, or quantum computing, where scientific breakthroughs can take years to mature into practical products, open innovation facilitates the rapid exchange of information and ideas. This can shorten development cycles, leading to faster time-to-market and improved product offerings (Torkkeli et al., 2009; Ryszko & Szafraniec, 2022; Artyukhov et al., 2023b; Efe, 2023; Kuzior et al., 2023; How & Cheah, 2024).

Triple Helix Model proposed by Henry Etzkowitz and Loet Leydesdorff relates to the collaboration between universities, industries, and governments. It is often seen as a powerful mechanism for overcoming barriers to innovation. This model highlights the synergy between research institutions, industry, and government in fostering innovation (Etzkowitz & Leydesdorff, 1995; Leydesdorff, 2020).

Collaborating with external partners, companies and research institutions gains access to new ideas, technologies, and scientific knowledge that they might not have internally. This external input can dramatically

speed up the process of product development, as it helps overcome the bottlenecks often associated with the limited scope of in-house research teams (Brette & Cleven, 2011; Corvello et al., 2023).

Many universities and research institutions have set up TTOs (Technology Transfer Offices) to bridge the gap between academic research and industry applications. These offices are focused on patenting, licensing, and facilitating startup creation based on university research (Rogers et al., 2000; Hulsbeck et al., 2013).

The study by Fanny Pruvot, Laurent Dupont and Laure Morel (Pruvot et al., 2022) highlights the importance of creating effective collaborative networks between various innovation spaces, such as technology parks, universities, and startup incubators, to significantly enhance the commercialization potential of new technologies and help overcome the so-called Valley of Death. These collaborative networks serve as vital ecosystems that can provide the necessary resources, expertise, and connections to help innovative ideas transition from research to market.

Ries' approach to "lean startups" and rapid iteration in technology development encourages startups to test hypotheses and prototypes quickly to identify feasible, marketable solutions before making large-scale investments (Reis, 2011).

The deep-tech venture builder model proposed by A. Georges L. Romme, John Bell and Guus Frericks (Romme et al., 2023) presents a promising solution to address the critical stage between scientific research and commercialization. This model is designed to help bridge the "Valley of Death" by providing a comprehensive, collaborative, and structured approach to the development of deep-tech innovations, those involving advanced and complex technologies like artificial intelligence (AI), biotechnology, and quantum computing. The venture builder model focuses on providing end-to-end support for innovation. This approach moves beyond the initial discovery phase and offers structured assistance through the entire innovation lifecycle.

Artem Artyukhov, Svitlana Bilan, Iurii Volk, Serhiy Lyeonov and Desislava Serafimova (Artyukhov et al., 2023a) presents a model for innovation transfer that bridges the gap between science, production, and business. The model aims to assess and enhance the process of moving scientific research outcomes into practical applications and marketable innovations and focuses on evaluating both the external environment (market analysis and external factors) and the internal environment (institutional readiness, internal capabilities, and innovation potential) of organizations. A key focus of the study is the role of entrepreneurial universities in facilitating the commercialization of scientific research and driving technology transfer.

Ulrich A. K. Betz, Loukik Arora, Reem A. Assal, Yatyas Azevedo, Jeremy Baldwin, Michael S. Becker, ... & Guoping Zhao (Betz et al., 2023) emphasizes the importance of an interdisciplinary dialogue between scientists from various fields, entrepreneurs, industry leaders, and the public. Such collaboration is essential to generating breakthrough ideas, many of which emerge at the intersections of different disciplines. This paper aims to provide insights into recent game-changing leaps in science and technology, with a focus on innovations that have the potential to radically transform both the scientific landscape and everyday life.

However, despite significant scientific work, bibliometric analysis on the issue of the mortality of innovative ideas was practically not conducted or was carried out using different database, time period, search queries, tools that determine the relevance of the research topic.

3. Methodology and research methods. The first stage involved creating a research infrastructure by leveraging the Scopus scientometric database. Scopus is one of the most widely used databases for indexing scientific articles and provides rich metadata that can be used to track the development of research across various fields. It was chosen because of its comprehensive coverage of peer-reviewed journals, conference proceedings, and academic papers across disciplines. This makes it an excellent tool for obtaining a broad view of the scholarly activity around the Valley of Death in innovation.

The second stage was a bibliographic analysis of scientific documents indexed by the scientometric database Scopus on the keyword "Valley of Death in innovation" for the period 2003-2023. This period was chosen to capture developments in the field, identify evolving trends, and trace how different aspects of the Valley of Death have been studied and addressed over time. The specific keyword "Valley of Death in innovation" was used to filter relevant articles. This term encapsulates the challenges faced by innovative technologies as they move from academic research to practical applications, making it the central theme for the bibliometric analysis.

The BibTeX format was used to export and store the data, which were then processed using the R-Studio software for statistical data processing. This standard citation format is particularly useful for organizing bibliographic data and references and it is compatible with various data processing tools, making it easier to perform quantitative analysis. In turn, R-Studio is a powerful software environment for statistical computing and is commonly used for performing data manipulation, visualization, and analysis.

Bibliometric analysis helped identify key trends in scientific publications, highlighting research priorities, emerging fields, and interdisciplinary approaches that could contribute to overcoming the Valley of Death. By analysing citation patterns, publication frequency, and authorship networks, it was identified which areas of research are gaining momentum and which are underdeveloped. Also, it was shown how scientists, institutions, and industries are collaborating to transfer research into practical applications, and it was

assessed how often scientific works are cited by other researchers and industries, indicating the relevance and potential for commercialization, etc.

4. Results. On the basis of bibliographic analysis research was conducted to analyse in detail the impact of the "Death Valley" phenomenon on innovative ideas in scientific and educational environments using R-Studio software.

In this context, 172 scientific documents indexed in the scientometric database Scopus between 2003 and 2023 with the keyword "Valley of Death in innovation" were selected. Figure 1 shows the number of scientific publications and dynamics of changes in the publication activity of scientists.

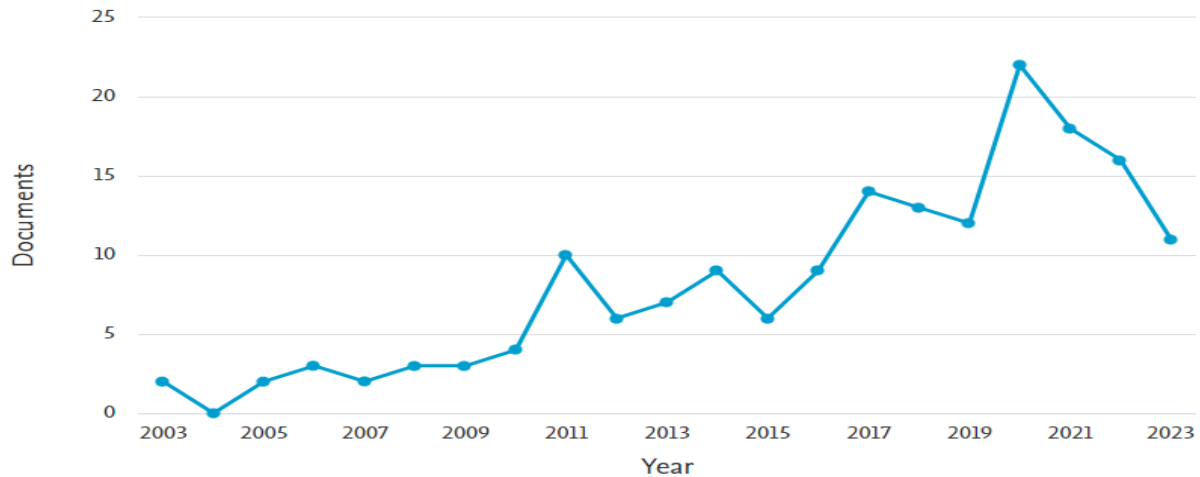


Figure 1. Analysis of the dynamics of changes in the publication activity of scientists who participated in the study of issue on "Valley of Death in innovation"

Sources: built by the author

Throughout the analysed period, the results of the analysis of changes in the publication activity of scientists who participated in the study of issue on "Valley of Death in innovation" show an unstable growth trend. A gradual increase is observed until 2010, which indicates an increased interest in the topic of the mortality of innovative ideas. Significant growth after 2010 may be related to an increase in global investments in innovative projects and a growing desire to solve the problems of commercialization of innovations.

The distribution of scientific documents by country is shown in Figure 2.

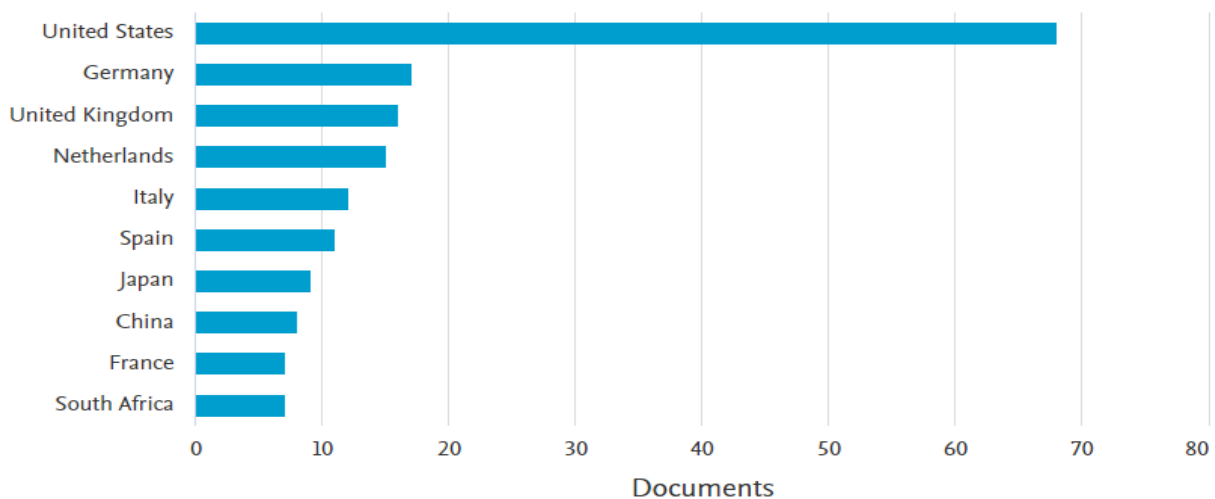


Figure 2. Cross-country analysis of publishing activity for 2003-2023.

Sources: built by the author

The United States ranks first with the largest number of published works, indicating that it plays a dominant role in research on the mechanisms that support innovation due to the active involvement of public and private investments in scientific research. And thanks to the actively researched issues of commercialization and integration of scientific ideas into the economy, Germany takes second place. Other countries, such as the United Kingdom and the Netherlands, have also contributed to the industry, showing the international interest of the Valley of Death.

Looking at the data on the average number of article citations per year (Figure 3), the number of citations on average was relatively stable throughout the year, with only minor fluctuations, except for a significant increase in 2021, which may indicate that a particular important article is recognized, but the general tendency is that new scientific articles at the initial stages of existence are less in demand (difficulties arise with the recognition of the results of new research by the scientific community).

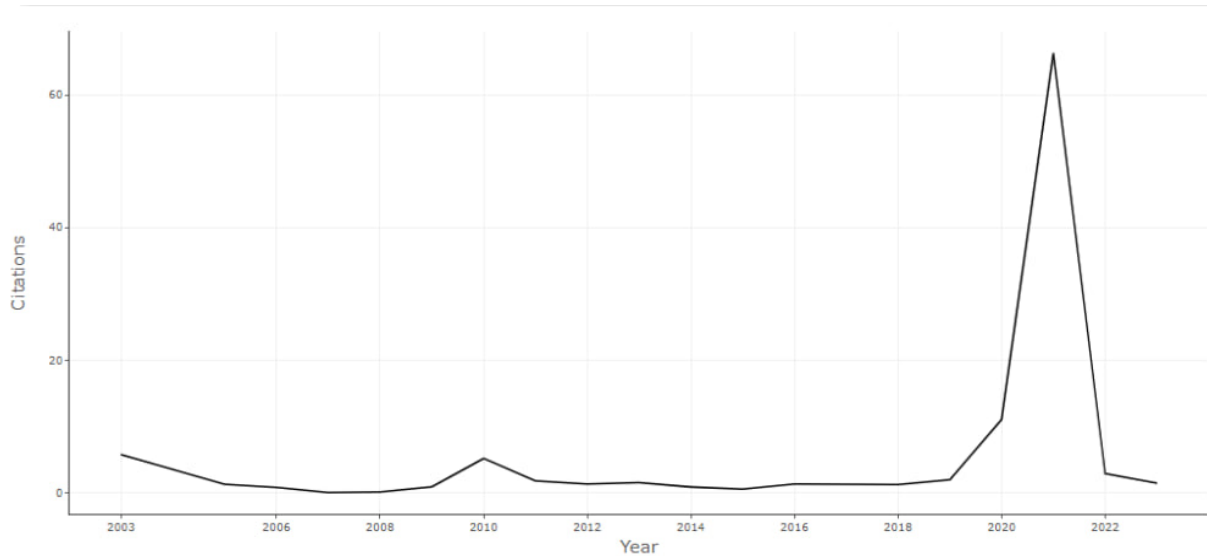


Figure 3. Results of determining the average number of article citations per year.
Sources: built by the author

This trend emphasizes the challenge of supporting and incorporating new research into the scientific debate to encourage greater acceptance of innovative ideas.

Analysing the graph of the most relevant sources (Figure 4), it becomes obvious that certain publications are more involved in the creation of documents on this research topic.

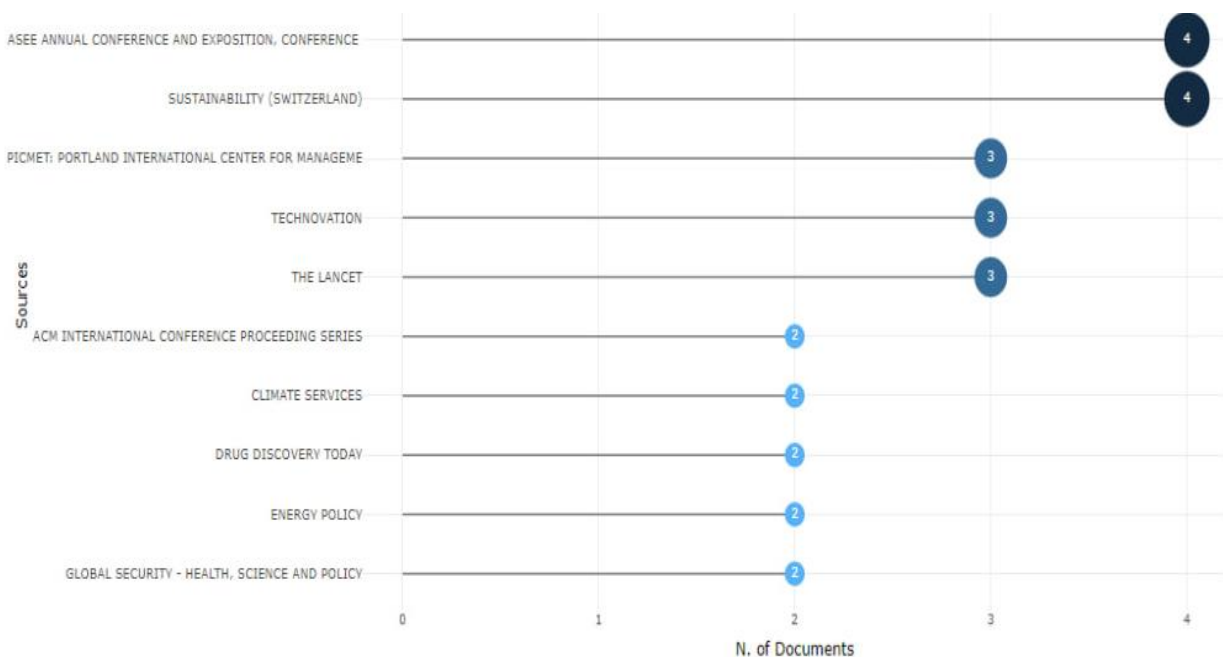


Figure 4. The most relevant sources in the field of the studied issues.
Sources: selected by the author

For example, the ASSE Annual Conference and the ACM International Conference Proceeding series are major sources of information, indicating their high importance to the scientific community. These conferences are crucial for the promotion of research and exchange of ideas.

The graph of the most relevant connections (Figure 5) indicates that certain institutions dominate in the number of publications on the research topic.

Affiliation	Articles
UNIVERSITY OF OXFORD	14
GEORGE MASON UNIVERSITY	7
UNIVERSITY OF THE WITWATERSRAND	7
BOISE STATE UNIVERSITY	6
STANFORD UNIVERSITY	6
UNIVERSITY COLLEGE LONDON	6
MAASTRICHT UNIVERSITY	5
NOTREPORTED	5
UNIVERSITY OF COLORADO	5
EINDHOVEN UNIVERSITY OF TECHNOLOGY	4

Figure 5. The results of finding the most relevant connections.
Sources: identified by the author

The University of Oxford and George Mason University show themselves as leading research institutions due to the largest number of works (have good research groups and resources). And fields of research that are not so well-known are most often offered by institutions with a small number of publications.

By analysing the problems of key positions, it is possible to determine which aspects should be paid attention to in order to overcome the "high mortality" of innovative ideas. Based on keywords (Figure 6), the most often used items from a sample of 172 publications were determined.



Figure 6. A tree graph of the keywords in the sample.
Sources: built by the author

Such categories as "technology transfer" and "financing" make up a significant share, which indicates their importance for the success of innovative ideas. Also, themes related to "investment" are strongly expressed, emphasizing the need for financial support to overcome the "Valley of Death".

Examining the collaboration network (Figure 7), one can see a visualization of the network with nodes representing authors and their connections to each other – collaboration in publications.



Figure 7. Analysis of the authors' collaboration network.

Sources: built by the author

The solid red box shown in the image shows close and strong connections between scientists, indicating active collaboration in innovative research. This trend indicates that overcoming the "Valley of Death" and ensuring that innovative ideas are properly supported requires researchers to work together, which is especially important in the transition from idea to implementation.

The world map of international cooperation (Figure 8) clearly shows the connections within the framework of scientific research between different states.

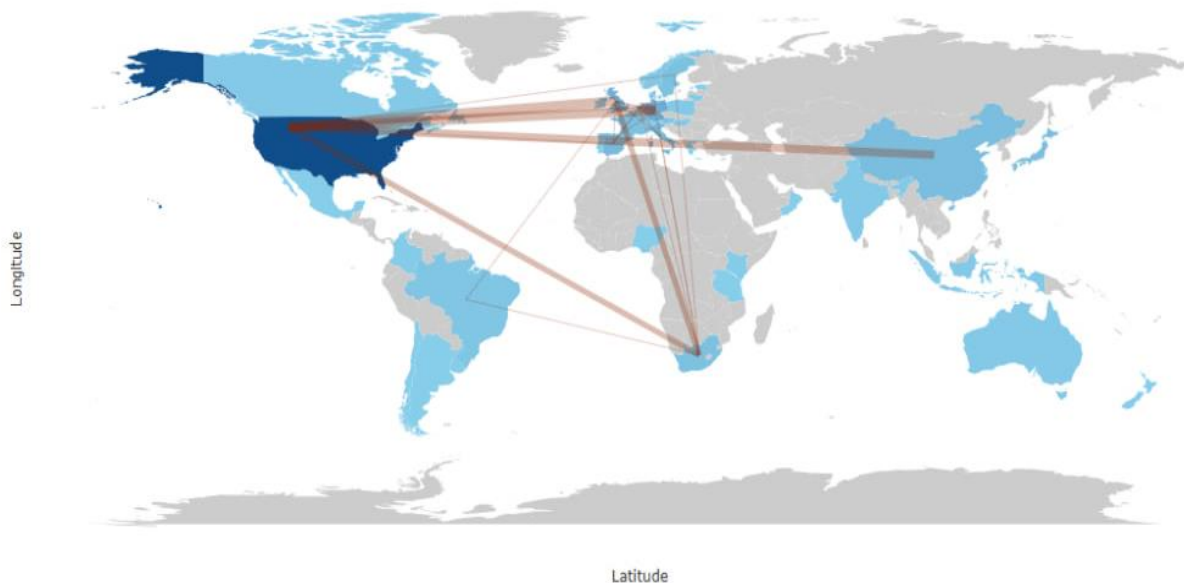


Figure 8. Map of international cooperation in scientific research.

Sources: built by the author

The USA certifies many connections with other countries (Canada, Great Britain, Germany). This demonstrates the active cooperation of American scientists with foreign partners, which stimulates the exchange of ideas and materials. To overcome the "Valley of Death", such interaction is crucial, because global cooperation provides access to financing and new technologies that can support innovative ideas at the stage of implementation.

The analysis of the thematic map (Figure 9) makes it clear that the central positions are occupied by topics such as "Innovation Management" (peak topic), "Technology Transfer" (basic topic) and "Education in Engineering" (niche topic), that represents their important contribution to overcoming the "Valley of Death". The above shows that in order for the implementation of innovative ideas to be successful, it is better to focus on combining knowledge with practical solutions. The high density of connections of these topics emphasizes their importance and interdependence for the innovation process.

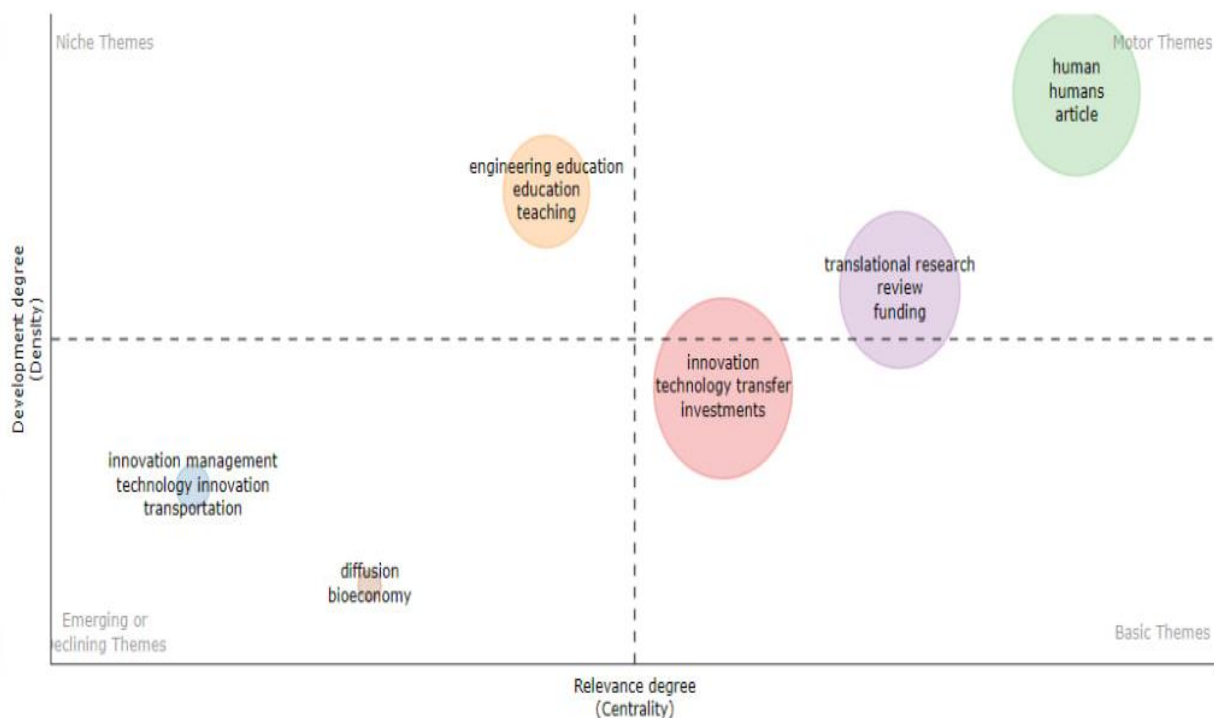


Figure 9. Thematic map in the context of “Valley of Death in Innovation”.

Sources: built by the author

It is proposed to introduce more active cooperation between interested parties, strengthen support for innovative projects in the early stages, optimize public and private investments.

5. Discussion

This study is limited to the analysis of the scientific basis (Scopus) and main trends in overcoming the high mortality of innovative ideas for the scientific and educational environment, based on bibliometric analysis. At the same time the obtained results can be used as a basis for further scientific research in this field.

The bibliometric analysis provided valuable insights into key trends in scientific publications related to the Valley of Death in innovation. Specifically, it helped to identify research priorities, which aspects of the Valley of Death are most actively researched (technological commercialization, the role of external funding, industry-academia collaborations, and the regulatory challenges in translating research into practice). By examining the frequency and context of specific terms in the publications, the analysis uncovered emerging fields or new technologies that are gaining attention in the context of overcoming the Valley of Death (artificial intelligence, biotechnology, quantum computing, or other advanced technologies). Bibliometric analysis also helped identify interdisciplinary research approaches, where different fields (e.g., engineering, economics, business, policy studies) intersect to address the commercial viability of new technologies. The integration of knowledge from these diverse fields can provide a more holistic approach to solving the problems that arise at the Valley of Death.

Wenyue Cui, Jie Tang, Zhipeng Zhang and Xin Dai (Cui et al., 2023) provided valuable insights into the development history and research trends of innovation convergence. They also used bibliometric methods and identified the key literature and scientific institutions that have significantly influenced the field, researchers interested in understanding the trajectory and collaborative dynamics of innovation convergence. with to offer an in-depth understanding of the field's development. However, the study relies on literature from the Web of Science database, covering the period from 1990 to 2021.

Edwin Paipa-Sanabria, Maria Belen Orozco-Lopez, Felope Escalante-Torres, Clara Paola Camargo-Diaz and Julian Andres Zapata-Cortes (Paipa-Sanabria et al., 2024) used the bibliometric analysis of concepts and trends connected with eco-Innovation but especially in the shipbuilding and manufacturing industries. A bibliometric analysis was conducted using comprehensive search engines such as Scopus and Web of Science (WoS). Articles published on eco-innovation in the manufacturing and shipbuilding industries were selected, covering a time span from the early 1990s to the most recent publications available. The data was processed and analyzed using several tools: Bibliometrix (R package), Microsoft Excel and Gephi.

The bibliometric analysis by Cong Cheng, Limin Wang, Hongming Xie and Lulu Yan (Cheng et al., 2023) was performed on a total of 647 articles published between 2000 and 2020. These articles were sourced from various academic databases, and the analysis focused on identifying the most influential concepts and

relationships in the digital innovation literature. The primary analytical techniques used in this study were co-occurrence and co-citation analyses, conducted using CiteSpace software.

6. Conclusions.

The purpose was to analyse the scientific basis and main tendencies of the issue of high mortality of innovative ideas in the scientific and educational environment. The combination of scientometric analysis using the Scopus database and R-Studio for statistical processing provides a powerful tool for uncovering important trends in the research landscape surrounding the Valley of Death in innovation. By conducting a bibliometric analysis of scientific publications from 2003 to 2023, the study helps to identify the emerging research priorities, key interdisciplinary approaches, and innovative strategies that can contribute to overcoming the commercialization challenges faced by new technologies.

Analysing the issue of the mortality of innovative ideas, it became known that the research on this topic began a long time ago but gained significant interest after 2010. The largest number of published works belongs to the USA. Research on international cooperation also shows that many countries are well integrated into scientific activities. A global science collaboration between the US, Germany, Canada and the UK facilitates the sharing of knowledge and resources to advance innovation.

The results highlight the importance of developing sustainable strategies and building networks between academic institutions, businesses and governments to overcome the "Valley of Death". The proposed strategies for overcoming the "Valley of Death" are the following:

1) strengthening university-industry partnerships (creating stronger links between academia and industry; developing programs such as research consortia, industry-sponsored research projects, and joint ventures to help align academic research with real-world needs);

2) early-stage funding (securing sufficient funding for early-stage innovation that includes public and private investments, venture capital, and government grants aimed at bridging the funding gap between basic research and commercialization);

3) integrated innovation ecosystems (various stakeholders as entrepreneurs, researchers, government bodies, investors work together to drive research into practical application that requires creating conducive environments for innovation, such as tech parks, incubators, and accelerators);

4) training for commercialization (researchers and scientists must be equipped with skills in entrepreneurship, intellectual property management, and commercialization strategies through targeted training programs, entrepreneurship courses, and networking events where scientists can connect with potential investors, customers, and commercial partners);

5) public policy and regulation (creating supportive policies for innovation, offering tax incentives, and streamlining regulatory processes that help bring new technologies to market faster).

The above shows that overcoming the Valley of Death in innovations requires a comprehensive, multi-stakeholder approach that integrates scientific discovery with practical application through funding, collaboration, knowledge transfer, and a supportive innovation ecosystem. This will contribute to the elimination of the technological gap and the transfer of innovations from laboratory discoveries to real solutions.

This study can be used as a basis for further scientific research in this field.

Conflicts of Interest: Author declare no conflict of interest.

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ПОДОЛАННЯ ВИСОКОЇ СМЕРТНОСТІ ІННОВАЦІЙНИХ ІДЕЙ («VALLEY OF DEATH») ДЛЯ НАУКОВОГО ТА ОСВІТНЬОГО СЕРЕДОВИЩА: БІБЛІОМЕТРИЧНИЙ АНАЛІЗ

Карина Рикова, студентка, кафедра економічної кібернетики, Сумський державний університет, Суми, Україна. Дослідження фокусується на проблематиці розриву між інноваційними ідеями та науковими відкриттями і їх практичною реалізацією й комерціалізацією. Метою статті є аналіз наукового підґрунтя та основних тенденцій щодо питання високої смертності інноваційних ідей у науково-освітньому середовищі (так звана «Долина смерті»). Для цього було проведено бібліографічний аналіз опублікованих наукових статей про смертність інноваційних ідей. Методика базується на аналізі даних наукометричної бази даних Scopus за допомогою програмного забезпечення R-Studio. На першому етапі дослідження було створено дослідницьку інфраструктуру з використанням наукометричної бази даних Scopus та проведено аналіз літературних джерел. Другий етап дослідження стосувався бібліографічного аналізу наукових публікацій, проіндексованих наукометричною базою даних Scopus за 20-річний період (2003-2023 рр.). Цей період було обрано, щоб відобразити розвиток подій у цій галузі, визначити тенденції, що розвиваються, і простежити, як різні аспекти «Долини Смерті» щодо інноваційних ідей вивчалися та розглядалися з часом. За вибраним ключовим словом «Долина смерті в інноваціях» було відібрано 172 документи. Цей аналіз також охоплював вивчення мережі співпраці між авторами, тенденції публікацій наукових робіт, оцінку середньої кількості цитувань робіт та побудови тематичної карти. Отримана візуальна інформація стала цінним інструментом для вивчення поточних паттернів. Результати аналізу свідчать про інтерес до питання смертності інноваційних процесів та зростання кількості наукової літератури на цю тему. Встановлено, що дана дослідницька проблема виникла давно, але значного інтересу набула лише після 2010 року. Найбільша кількість опублікованих робіт за афіліацією відноситься до США. Дослідження міжнародного співробітництва також показують, що багато країн добре інтегровані в наукову діяльність. Глобальна наукова співпраця між США, Німеччиною, Канадою та Великобританією сприяє обміну знаннями та ресурсами для просування інновацій. Отримані результати підкреслюють важливість розробки стійких стратегій (запропоновано та описано ключові з них) та побудови мереж між науковими установами, бізнесом та урядом для подолання «Долини смерті» інноваційних ідей в науковому та освітньому середовищі. Це дослідження може бути використане як основа для подальших наукових досліджень у цій галузі.

Ключові слова: R&D, стартап, наука, вища освіта, університет, бізнес, співробітництво, комерціалізація, розрив.