Digital Product Passport: Global Research Trends and Future Orientation

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SUMMARY

This paper employs bibliographic analysis of the Scopus database from 2003 to 2026, combined with PRISMA filtering, to construct a dataset of 445 publications on Digital Product Passports (DPP). The results show that DPPs are emerging as an interdisciplinary research direction, characterized by significant collaboration (1,314 authors; an average of 3.85 authors/article; international collaboration: 20.9%), with a concentration in publishing channels such as *Procedia CIRP*, *IFAC-PapersOnLine*, *Sustainability (Switzerland)*, and European research centers. Network analysis of authors and keywords reveals key themes, including the circular economy, product data digitization and governance, supply chain transparency, and technological trends (such as interoperability, data sharing, digital twin, Industry 4.0, and blockchain), while highlighting barriers to data standardization and information sharing mechanisms within the value chain.

Keywords: Digital passport, Circular economy, Product lifecycle

INTRODUCTION

In recent years, sustainable business has shifted from a voluntary trend to an essential requirement for companies to use resources responsibly and minimize negative environmental impacts. In the context of the transition toward a circular economy and increasing supply chain transparency, the Digital Product Passport (DPP) is emerging as a crucial policy and technological tool for storing, sharing, and retrieving data throughout the product life cycle, from design and production to use, reuse, and recycling (European Commission, 2022). The DPP is regarded as a platform that supports traceability, sustainability assessment, and the promotion of circular business models through the standardization and digitization of product information within the framework of the European Union's ecodesign policy (European Commission, 2022; European Parliament and Council of the European Union, 2024). In recent years, this topic has attracted increasing attention from researchers because of the role of product data in optimizing resource management, reducing emissions, and strengthening producers' extended responsibility (Bressanelli et al., 2022). Particularly within the framework of the European Union's Eco-Design for Sustainable Products Regulation, DPP is identified as a core tool for realizing the requirement to disclose information on product durability, repairability, recyclability, and environmental performance (European Parliament & Council of the European Union, 2024). The development of DPP not only presents opportunities for data integration and system interaction but also raises numerous research issues related to data governance, standardization, digital interoperability, and information security in multi-stakeholder value chains (CIRPASS, 2023). Furthermore, recent studies show that the implementation of DPP can facilitate strategies for extending product lifespan, improving material recovery, and supporting data-driven decision-making in sustainable manufacturing (Kristoffersen et al., 2020). However, academic knowledge on DPP is still in its

formative stages and fragmented across many fields. Therefore, synthesizing global research trends and identifying future development directions of DPP is necessary to clarify the knowledge structure, prominent topics, and current research gaps. Based on this, this study aims to analyze the development process of the DPP field and discuss potential research directions related to digital transformation, circular economy, and sustainable data governance. This approach has both academic and practical significance for policymakers, businesses, and stakeholders in the digital product ecosystem.

Therefore, this study aims to provide a comprehensive examination of the scientific knowledge produced in the literature on Digital Passports, while also clarifying the key contributions and emerging research trends in this field. Given the growing number of scientific publications on Digital Passports indexed in the Scopus database, the study reviews publications published between 2003 and 2026 in order to develop an overall understanding of the knowledge generated in this area. Accordingly, the study addresses the following research questions:

Question 1. What are the key bibliographic metrics for publications related to the Digital Product Passport, specifically the number of publications over time, and which journals, organizations, and countries have the highest publication productivity and greatest influence?

Question 2. Who are the influential authors and research networks behind the Digital Product Passport ?

Question 3. What are the main research topics and development trends identified in the scientific literature on Digital Product Passports?

RESEARCH METHODOLOGY

This study uses bibliometric analysis to examine global research trends on digital product passports. Bibliographic data were processed and analyzed using R. This approach both systematizes and clarifies the overall picture of a topic that is attracting significant attention from the academic community.

Identify data sources and collect data.

In this study, bibliographic data were collected from the Scopus database, one of the largest and most comprehensive academic data sources for international publications across various fields. Scopus was chosen because it provides relatively complete bibliographic information, including author names, publication year, source names, abstracts, keywords, citation numbers, and citation link information, thus meeting the requirements of bibliographic analysis. Besides its wide coverage, Scopus also supports exporting data in a format compatible with R software, facilitating data cleaning, normalization, and analysis.

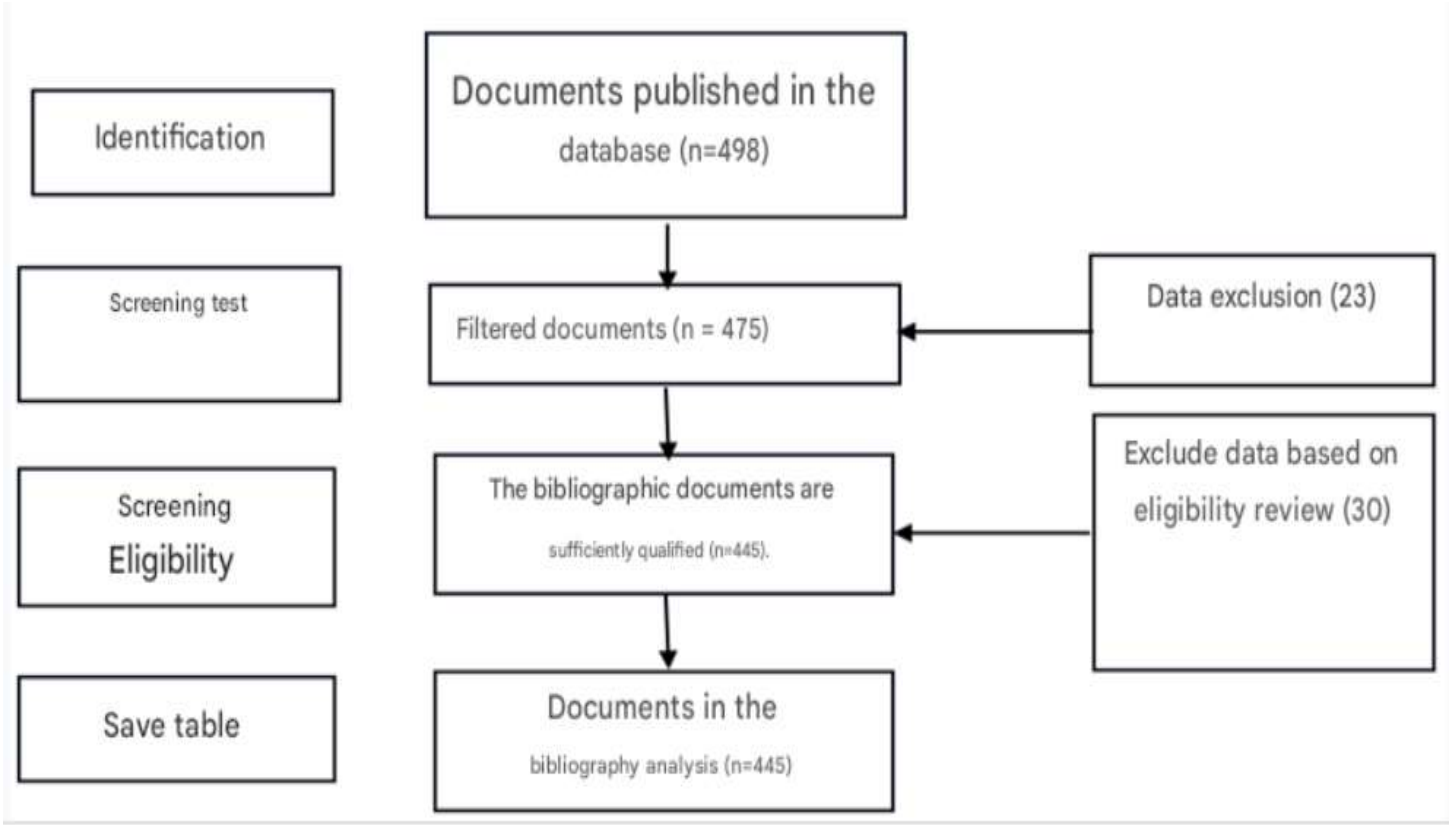
Search criteria

The search process was performed on the title, summary, and keyword fields, with the keyword phrase “Digital Product Passport” used as the central element for filtering information. The initial search on Scopus yielded 498 documents as of 10 PM on March 1, 2026. The documents were limited to academic publications in English, including scientific articles, books, book chapters, and conference papers. Through a filtering and selection process based on research objectives, the number of publications was reduced to 475, creating a more streamlined database that ensures the necessary focus and depth for bibliographic analysis. The final query used in the Scopus tool was constructed as follows:

TITLE-ABS-KEY (“Digital Product Passport”) AND (LIMIT-TO (DOCTYPE, “Ar”) OR LIMIT-TO (DOCTYPE, “Cp”) OR LIMIT-TO (DOCTYPE, “Ch”) OR LIMIT-TO (DOCTYPE, “Bk”)) AND LIMIT-TO (SUBJAREA, “SOCI”) AND LIMIT-TO (LANGUAGE, “English”)

PRISMA screening:

The document search and screening process was conducted in accordance with the PRISMA guidelines. The initial search in the Scopus database yielded 498 documents. After a preliminary screening based on the defined search criteria, 23 documents were excluded because they did not meet the inclusion requirements. Subsequently, the remaining 475 documents were reviewed based on their titles and abstracts to assess their relevance to the research topic. The results showed that 31 documents were not directly related to the topic of Digital Product Passports and were therefore excluded from the dataset. Thus, the final dataset comprised 445 documents indexed in Scopus and used for further analysis (Figure 1).



(Source: Compiled by the author)

Figure 1. Data processing procedure for PRISMA screening.

Data analysis

The dataset comprised 445 documents on Digital Product Passports retrieved from Scopus and exported to a master Excel file for descriptive statistical analysis. This step enabled the examination of publication growth patterns and the geographical distribution of research output. The data were subsequently processed in R software to identify influential authors and documents and to examine citation relationships. To address the research questions outlined in the introduction, bibliographic coupling analysis was conducted for the period 2003–2026, as the number of cited documents changes over time and this time frame better reflects the current structure of the field (Glänzel & Thijs, 2012). The colored clusters on the map represent conceptual groupings, indicating thematic similarities among keywords and documents.

RESULTS AND DISCUSSION

Overview of the documents

This section helps answer question 1. What are the basic bibliographic metrics for publications related to the Digital Product Passport, specifically the number of publications over time, the journals, and the organizations with the highest publication productivity and greatest influence?

Bibliometric indicators suggest that research on Digital Product Passports (DPP) is gradually developing into an interdisciplinary academic field characterized by a high degree of collaboration and an expanding knowledge base. The analyzed dataset includes 445 scientific publications produced between 2003 and 2026 across 223 different publication sources, reflecting a relatively diverse distribution of publication outlets and indicating that this topic has been approached from multiple disciplines, including the circular economy, supply chain management, and information systems.

The research community comprises 1,314 authors, while the number of single-authored articles is only 35 publications, with an average of 3.85 authors per document. Simultaneously, the international collaboration rate reaches 20.9%, indicating a significant level of transnational academic collaboration. The field's knowledge base is also relatively rich with 31,578 references and 1,064 author keywords, reflecting the diversity of research directions.

The literature has an average age of 6.32 years and an average citation impact of 8.196 citations per document, suggesting that research on DDP is still relatively new but is steadily gaining academic influence. In the context of the growing global emphasis on circular economy and digital transformation policies, DPP are expected to emerge as a significant research area at the intersection of digital technology, supply chain management, and sustainable development.

Table 1. Description of the research document

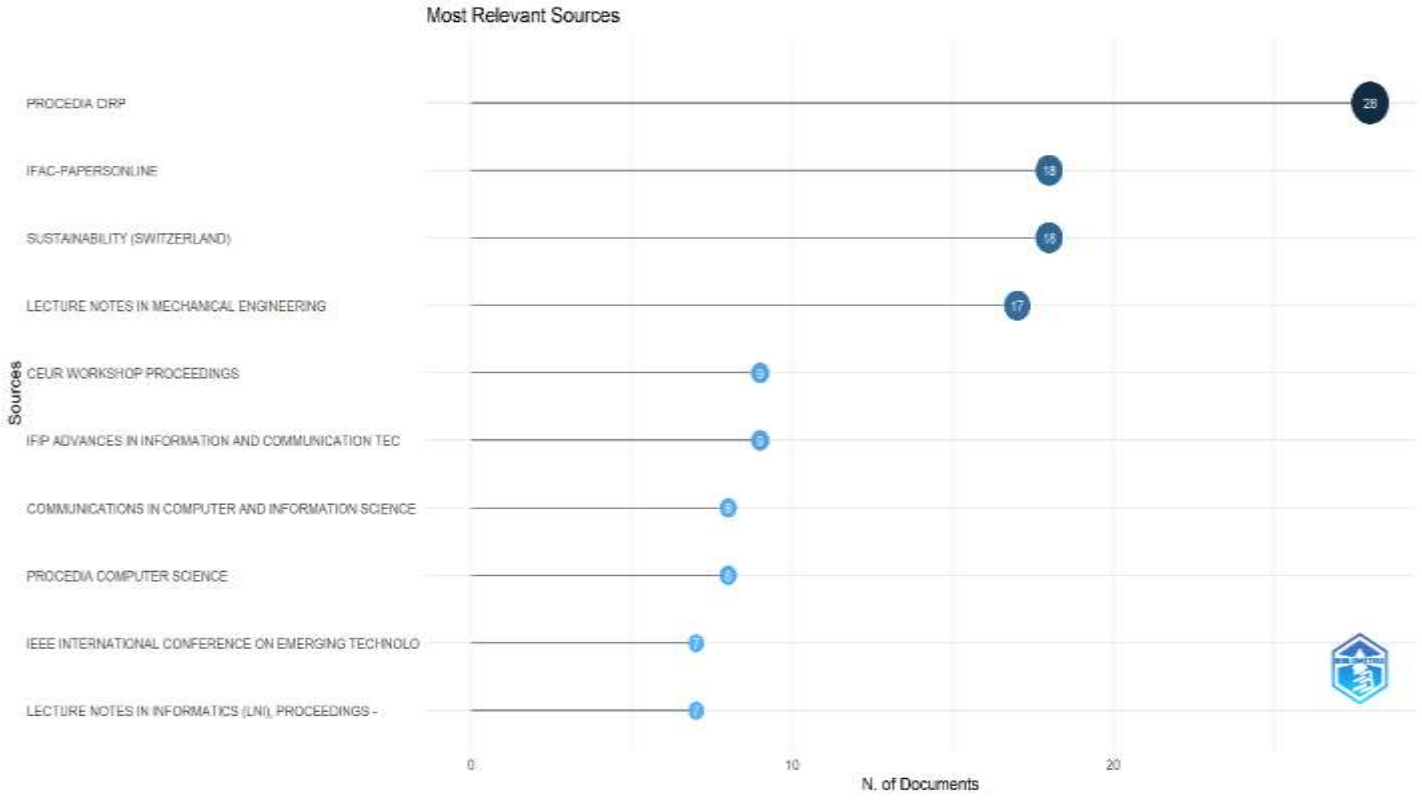
Timespan: 73:2026	Sources: 223	Documents: 445	Annual Growth Rate: 0.2 %
Authors: 1314	Authors of single-authored docs: 35	International Co-Authorship: 20.9 %	Co-Authors per Doc: 3.85
Author's Keywords (DE): 1064	References: 31578	Document Average Age: 6.32	Average citations per doc: 8.196

(Source: Results of running data on R software)

The most published sources

Analysis of the most relevant publications reveals that research on DPP is distributed across numerous prestigious international journals and conference proceedings, reflecting the interdisciplinary nature of the field. Among these, as shown in Figure 2, Procedia CIRP leads with 28 publications, highlighting the prominent role of research related to smart manufacturing and product lifecycle management. Other sources, such as IFAC -Papers On Line and Sustainability (Switzerland), each have 18 publications, demonstrating the connection between research on industrial systems, automation, and sustainable development. Furthermore,

publications from Springer and Elsevier, such as *Lecture Notes in Mechanical Engineering* (17 papers), *Communications in Computer and Information Science* (8 papers), and *Procedia Computer Science* (8 papers), also contribute significantly, demonstrating the important role of information technology and manufacturing engineering in the development of the DPP concept. Furthermore, several international conference proceedings, such as IFIP Advances in Information and Communication Technology and CEUR Workshop Proceedings (9 papers each) continue to expand academic discussions on data infrastructure and digital transformation. The concentration of publications in widely indexed sources within Scopus and international academic systems demonstrates the high reliability and prestige of the research data, and confirms that DPP is becoming a crucial topic at the intersection of digital technology, supply chain management, and sustainable development.



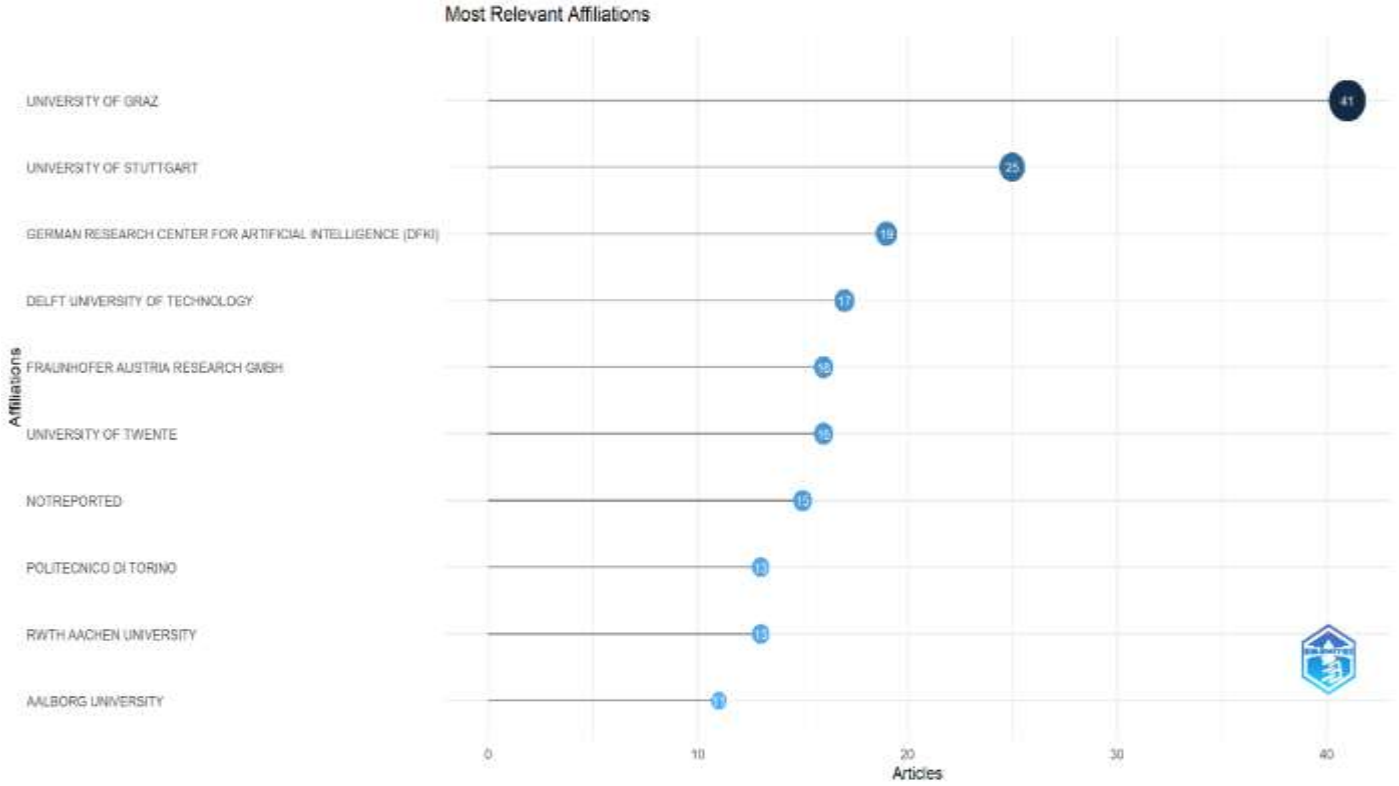
(Source: Results of running data on R software)

Figure 2. Top 10 publications with the most articles on DPP.

The most relevant affiliated organizations

According to the data presented in Figure 3, the University of Graz is the institution with the highest level of contribution, with 41 publications on DPP, highlighting its central role in the research network related to product life cycle management and data-driven solutions for sustainable manufacturing. It is followed by the University of Stuttgart with 25 publications, reflecting its strong research position as one of Germany's leading technical universities, particularly in the fields of Industry 4.0, smart manufacturing systems, and digital transformation in supply chains. In addition, the German Research Center for Artificial Intelligence (DFKI) recorded 19 publications, reflecting the increasingly important role of artificial intelligence and data infrastructure in the development of DPP systems. Several other prestigious technical universities in Europe, such as Delft University of Technology (17 publications), University of Twente (16 publications), Politecnico di Torino (13 publications), and RWTH Aachen University (13 publications), also demonstrate significant participation in this research network. In addition, applied research institutions like Fraunhofer Austria Research GmbH, with 16 publications, contribute to promoting research with practical applications in industry. The simultaneous presence of many leading European technical universities and research institutes indicates that research on the DPP is being

strongly promoted within the context of the European Union's digital transformation and circular economy strategies, and reflects the high level of academic linkage between centers of technology, data, and smart manufacturing research.



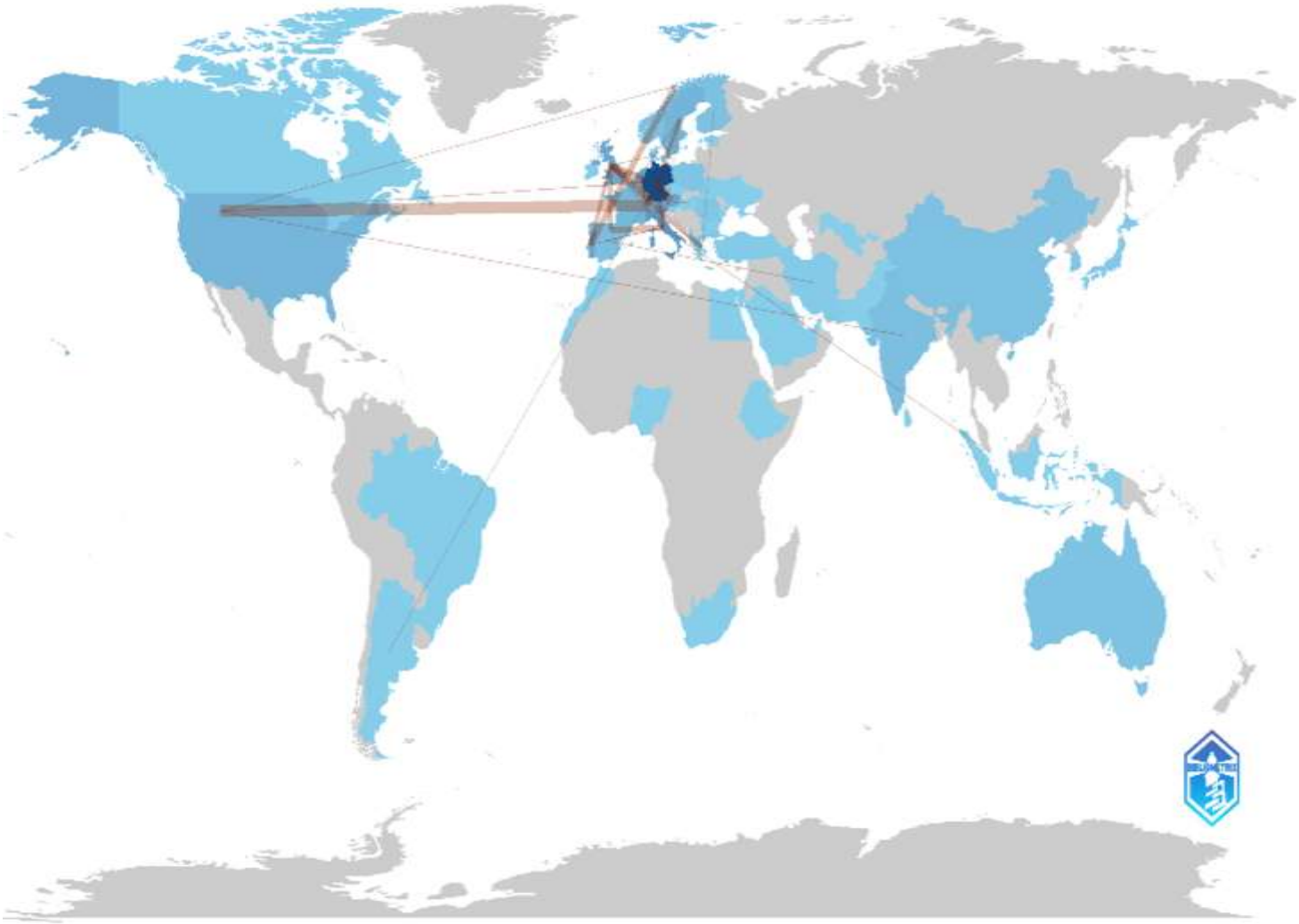
(Source: Results of running data on R software)

Figure 3. Top 10 organizations with the most publications on DPP.

Cooperation between countries

Figure 4 reveals that DPP research is supported by an increasingly global collaboration network, with European countries occupying the core of the structure. Germany emerges as the principal hub, maintaining extensive links with Austria, Italy, Sweden, the United Kingdom, and the United States, which underscores its strategic position in European industrial digitalization and circular economy initiatives. Switzerland and the Netherlands also display strong international connectivity, acting as bridging countries within a broader knowledge network focused on data infrastructure and digital supply chains.

At the regional level, collaboration among the United Kingdom, France, Italy, and the Nordic countries forms dense research clusters, indicating a shared commitment to the development of traceability systems and product life cycle management. Beyond Europe, the presence of the United States, China, India, Japan, and Australia demonstrates the growing global reach of DPP research. The links shown in the map capture the intensity of academic collaboration and reflect the convergence of research ecosystems around the use of digital technologies to strengthen transparency, traceability, and sustainability in product value chains. Taken together, these patterns suggest that DPP research is increasingly driven by international academic alliances, particularly among countries prioritizing circular economy strategies and industrial digital transformation.



(Source: Results of running data on R software)

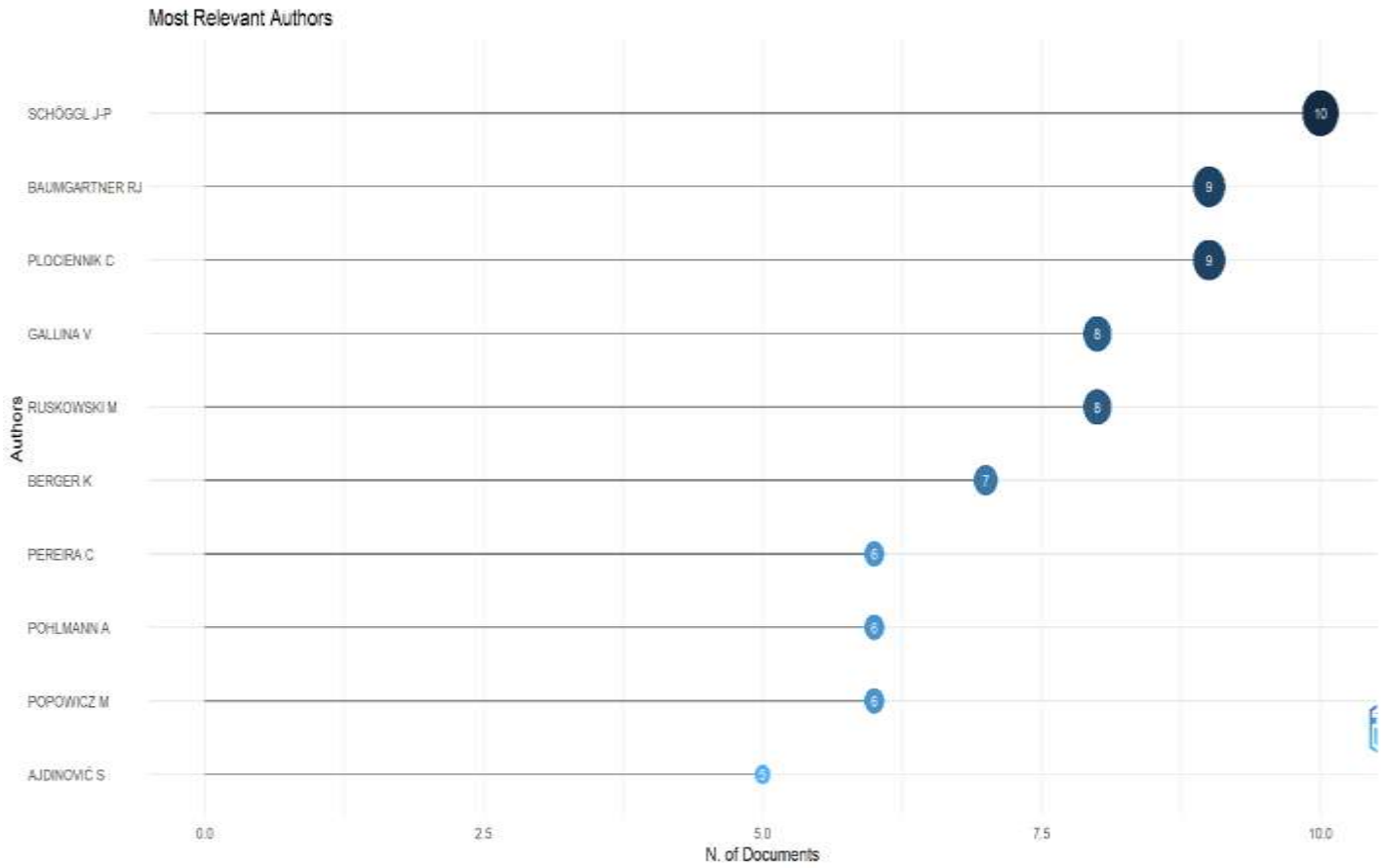
Figure 4. World map showing cooperation among countries on DPP.

Analysis of the main authors

This section helps answer question 2: Who are the influential authors and research networks behind the DPP ?

Among the most influential authors in DPP research, Schöggl J.P. is the most prolific, with 10 publications. This output underscores his central role in shaping research frameworks related to the circular economy and product life cycle management. Baumgartner R.J. and Plociennik C. follow closely, with 9 publications each, reflecting their important contributions to the intersection of sustainable development, supply chain governance, and digital transformation within the product ecosystem.

Gallina V. and Ruskowski M., each with 8 publications, also play a significant role in advancing research on data infrastructure and technological applications in smart manufacturing. The repeated presence of these scholars within the publication network indicates their importance as core contributors to the DPP research community. From a bibliometric perspective, their contributions extend beyond publication volume, as they have also helped shape emerging research directions, particularly those related to product data integration, circular economy principles, and digital solutions for global value chains.



(Source: Results of running data on R software)

Figure 5. Top 10 authors with the most publications on DPP.

Main themes in research literature on DPP

This section helps answer question 3. What are the main research topics and development trends identified in the scientific literature on DPP?

The keyword map analysis in Figure 6 shows that the thematic structure of research on DPP is formed around several central concepts related to digital transformation and the circular economy. The keyword "circular economy" appears most frequently with 238 occurrences (14%), reflecting the strong link between DPP and strategies for resource optimization, reuse, and recycling in the product value chain. This is followed by " digital products" with 206 occurrences (12%), indicating the focus of research on the digitization of product information and data management throughout the product lifecycle. Additionally, "digital product passport" with 163 occurrences (10%) confirms its position as a core research topic attracting strong academic interest in the context of the digital transformation of the global supply chain.

In the medium frequency group, keywords such as "supply chains" with 51 occurrences (3%) and "information management" with 44 occurrences (3%) indicate that DPP is approached not only from a technological perspective but also linked to information management and enhanced transparency in the supply chain. These topics reflect the need to integrate product data among stakeholders to support traceability, lifecycle management, and logistics optimization.

Meanwhile, some keywords appear less frequently but still hold significant supporting importance for the research ecosystem. Terms such as "carbon footprint" (12 times), "digital devices" (12 times), and "product

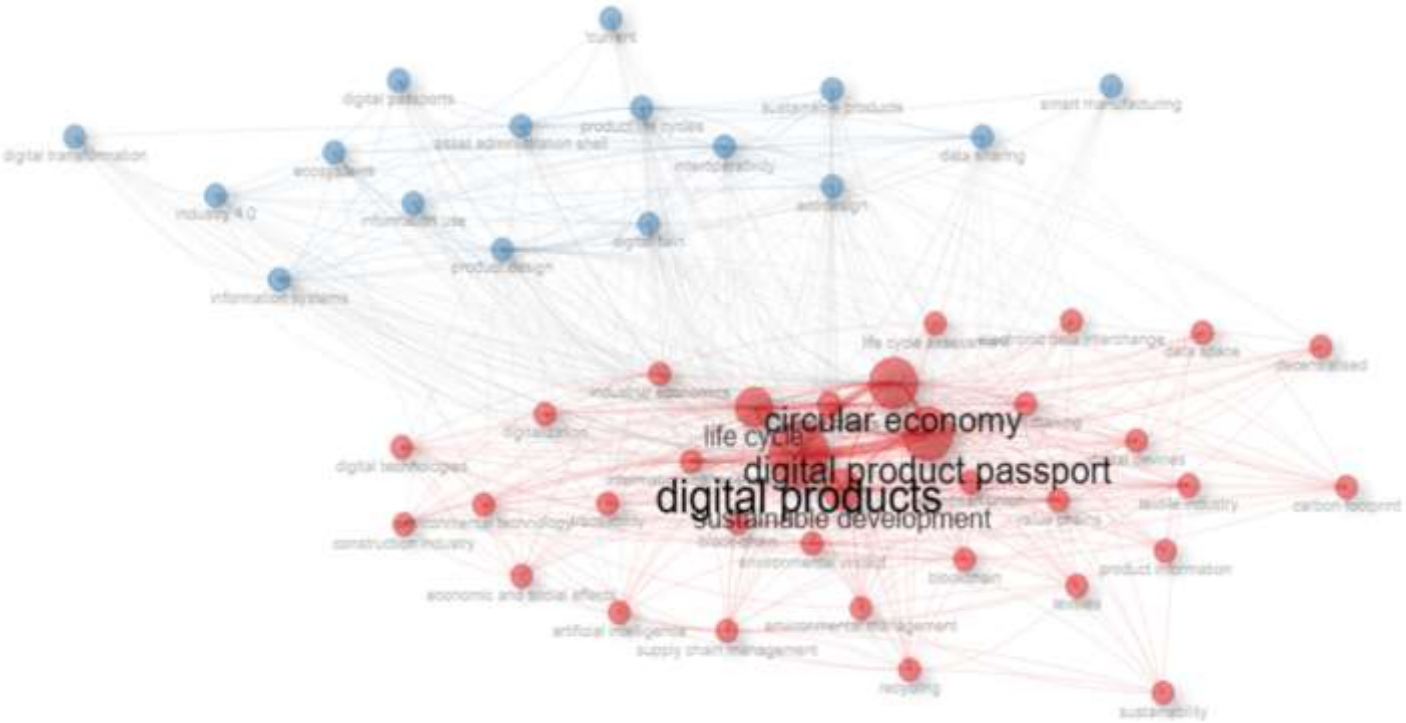
information" (12 times) indicate that research is beginning to expand into aspects of environmental impact assessment, digital device infrastructure, and product data standardization. Although their frequency of appearance is not high, these topics reflect emerging research directions, contributing to the refinement of the necessary technology and data foundation for the effective implementation of DPP systems in practice.

(Source: Results of running data on R software)

Figure 6. Network of co-occurring keywords

Looking at Figure 7, we can see that the DPP field is formed through the close linkage of many research topics. At the heart of the network are the concepts of "circular economy", "digital product passport" and "digital products" playing a core role in connecting research related to the digitization of product information and lifecycle management in the context of a circular economy. The large size of the nodes and high density of connections reflect the frequency of appearance and strong interaction between topics such as sustainable development, life cycle, supply chain management, and environmental impact, showing that DPP is researched as a tool to support data transparency and promote sustainable production. In addition, the network also forms clusters of technology topics with terms such as digital twin, interoperability, data sharing, Industry 4.0, and blockchain, reflecting the trend of integrating digital technologies to build data infrastructure for digital product passports. The division into different color clusters within the network represents specialized research directions that are still linked by central concepts. From a bibliographic perspective, parameters such as keyword frequency,

link strength, and node centrality play a crucial role in forming a clear and compelling network structure, thereby highlighting key research trends and the intersection of digital technology, supply chains, and sustainable development in the DPP field.



(Source: Results of running data on R software)

Figure 7. Diagram showing the network of keywords appearing together by related keyword groups.

CONCLUSION

Based on the analysis of scientific publications indexed in Scopus during the period 2003–2026, the study shows that the Digital Product Passport (DPP) is rapidly emerging as an interdisciplinary research field, characterized by a high growth rate and a significant level of academic collaboration. The research dataset consists of 445 documents selected through the PRISMA process, reflecting a clear expansion of the knowledge base on DPP, with a primary focus on areas such as the circular economy, supply chain management, and information systems. Descriptive indicators provide an overview of a large research community comprising 1,314 authors, with a low proportion of single-authored publications, a high average number of authors per paper, and an international collaboration rate of 20.9%. This highlights the multidisciplinary nature of the field and its cross-border interconnectedness. In terms of publication outlets, journals and conference proceedings such as Procedia CIRP, IFAC-PapersOnLine, and Sustainability (Switzerland) play an important role, reflecting substantial interest from research communities specializing in manufacturing, automation, and sustainable development. At the institutional level, leading organizations such as the University of Graz, the University of Stuttgart, and several prominent European research institutes, including DFKI, Fraunhofer, RWTH Aachen, Delft, and Twente, have emerged as key centers driving this field forward.

This reflects the core role of the European research ecosystem in shaping strategies related to the circular economy and digital transformation. In addition, the national collaboration map highlights Germany's central role as a key hub, with an extensive network of linkages both within Europe and globally. An analysis of prominent authors reveals that several researchers, such as Schöggl J.P., Baumgartner R.J., Plociennik C., Gallina V., and Ruskowski M., have made significant contributions to the development of this field. From a thematic perspective, the results of the keyword co-occurrence network analysis emphasize the central role of

concepts such as “circular economy”, “digital products” and “digital product passport”. These concepts are closely connected with areas such as product lifecycle management, sustainable development, supply chain governance, and environmental impact assessment. Furthermore, the emergence of keywords such as “digital twin”, “interoperability”, “data sharing”, “Industry 4.0”, and “blockchain” indicates a trend toward integrating advanced digital technologies to build the data infrastructure supporting DPP. Although this field offers significant potential, the research also identifies several challenges that need to be addressed in order to realize the full value of DPP. The main issues include the lack of standardized data, difficulties in integrating diverse data sources, as well as barriers related to information sharing and intellectual property protection across the entire supply chain. This study, based on an analysis of Scopus-indexed publications from 2003 to 2026, shows that the DPP is rapidly developing into an interdisciplinary and internationally connected research field. The dataset of 445 documents, selected through the PRISMA process, reflects the growing knowledge base on DPP across areas such as the circular economy, supply chain management, and information systems. Descriptive indicators reveal a highly collaborative research community of 1,314 authors, with a low proportion of single-authored papers and an international collaboration rate of 20.9%, highlighting the field’s multidisciplinary and cross-border nature.

The findings also indicate that European institutions and countries play a central role in shaping this field. The University of Graz, the University of Stuttgart, DFKI, Fraunhofer, RWTH Aachen University, Delft University of Technology, and the University of Twente emerge as major contributors, while Germany acts as a key hub in the international collaboration network. Prominent authors such as Schöggl J.P., Baumgartner R.J., Plociennik C., Gallina V., and Ruskowski M. have made substantial contributions to the intellectual development of DPP research.

The keyword analysis identifies “circular economy”, “digital product”, and “digital product passport” as central themes, closely associated with product life cycle management, sustainable development, supply chain management, and environmental impact assessment. At the same time, the increasing presence of terms such as “digital twin”, “interoperability”, “data sharing”, “Industry 4.0”, and “blockchain” points to a growing emphasis on advanced digital infrastructures supporting DPP implementation. Despite its strong potential, the field continues to face challenges related to data standardization, data integration, information sharing, and intellectual property protection across supply chains.

Therefore, the findings underscore that the DPP has considerable potential to serve as a strategic instrument for improving transparency, ensuring regulatory compliance, and enhancing market trust in sustainable products. Nevertheless, its effective implementation will depend to a large extent on the establishment of technical standards, robust data governance mechanisms, and effective coordination among stakeholders throughout the value chain.

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