Technology Topic Evolution from the Perspective of Patent Validity[1]*

Jinzhu Zhang, Runze Chen

Department of Information Management, School of Economics and Management, Nanjing University of Science and Technology, Xiaolinwei Str 200, 210094, Nanjing, China

Abstract

In technology topic evolution analysis, current research primarily uses datasets that include both valid and invalid patents, which can affect the accuracy of assessing technology development trends. This paper categorizes patents by legal status into valid and invalid groups for separate evolution. A two-dimensional evolution trajectory based on patent validity is constructed for common technology topics, providing a clearer view of which technologies are becoming more mature, and which are saturated or lagging. Experimental validation in the field of 3D printing has demonstrated the effectiveness of this approach.

Keywords

topic evolution, patent validity, invalid patents, LDA model, 3D printing

1. Introduction

Exploring the evolution of technology topics in depth not only aids in advancing the technology itself but also provides crucial support for sustained societal progress[1], [2]. A substantial number of studies use patent data sources such as Derwent Innovation and USPTO to conduct research on topic evolution [3], [4]. However, these studies primarily use datasets that include both valid and invalid patents, without considering their validity. As a result, outdated technologies may still influence the assessment of technological development trends. To more accurately identify technological trends, this study classifies patents in the field of 3D printing by legal status into valid and invalid categories [5]. Using an LDA model [6], it analyzes the evolution of technology topics separately for each category. A two-dimensional coordinate map [7] based on the validity of common technology topics is then constructed, with dynamic evolution trajectories plotted to reveal which technologies are becoming more mature and which are saturated or lagging.

2. Data and method

This paper utilizes patent validity information to classify and analyze the evolution of patents, distributing technologies into four regions from the perspective of patent validity and revealing the evolution trajectories of technology topics over time. First, patent data is divided by legal status into valid and invalid categories. Next, an LDA model is applied separately to each category within a shared vocabulary space to generate evolution trend charts of technology topic proportions and identify common topics. Finally, a two-dimensional coordinate map and evolution trajectory are constructed for the common technology topics of both categories, based on their valid and invalid proportions, to reflect their evolution trends.

2.1. Data division

We obtained 3D printing patent data from Google Patents because it clearly includes the legal status of patents, totaling 25,899 records from 2014 to 2020. Patents marked as "Active," "Granted,"

*[1]Joint Workshop of the 2th Innovation Measurement for Scientific Communication (IMSC) in the Era of Big Data (IMSC2024), Dec 20th, 2024, Hong Kong, China and Online

* Corresponding author.

zhangjinzhu@njust.edu.cn (Jinzhu Zhang); chenrunze0819@163.com (Runze Chen)

0000-0001-7581-1850 (Jinzhu Zhang); 0009-0002-2317-3898 (Runze Chen)

and "Active - Reinstated" were classified as valid (20,975 records), while those marked as "Abandoned," "Expired - Fee Related," "Expired - Lifetime," and "Ceased" were classified as invalid (4,924 records). We collected text information, including titles, abstracts, and claims.

2.2. Topic detection of valid and invalid Patents based on LDA model

To determine the optimal number of topics, we calculate both topic perplexity and topic coherence. Separate LDA models were then trained in valid and invalid Patents, using a shared vocabulary space. Identify common topics between valid and invalid patents by calculating keyword similarity.

2.3. Topic positioning and evolution based on patent validity

For common technology topics between valid and invalid patents, we create a two-dimensional coordinate map based on their proportions in valid

2.4. and invalid patents. We distribute technology topics into four quadrants, as shown in figure 1:

- First Quadrant: Innovation Intensive Zone (High Valid Proportion, High Invalid Proportion): These technology topics are core competencies with high innovation potential and commercial value[8].

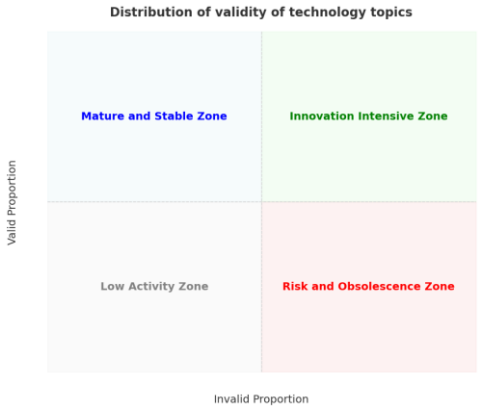

Figure 1: Distribution of validity of technology topics.

- Second Quadrant: Mature & Stable Zone (High Valid Proportion, Low Invalid Proportion): High and stable technical maturity, representing current mainstream technologies[9].
- Third Quadrant: Low Activity Zone (Low Valid Proportion, Low Invalid Proportion): Emerging or niche markets with low attention.
- Fourth Quadrant: Risk Obsolescence Zone (Low Valid Proportion, High Invalid Proportion): High patent risk, potentially outdated or low-value technologies.

Then, plot the dynamic evolution trajectory of each common technology topic over time.

3. Results

3.1. Topic positioning based on patent validity

In topic detection, we identified 12 valid patent topics and 7 invalid patent topics based on the highest coherence and lower perplexity, finding 7 common topics between them. For two categories, we separately plotted the evolution trends of technology topics based on topic proportions (Figure 2, using invalid patent as an example). Additionally, we positioned the 7 common topics on a two-dimensional coordinate map based on their valid proportions and invalid proportions (Figure 3, using 2014 as an example).

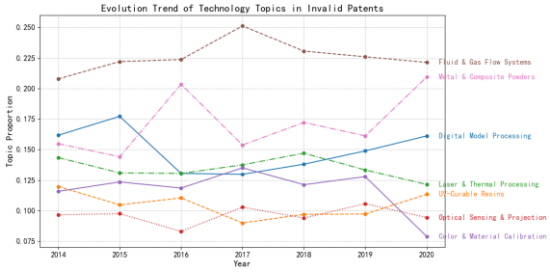

Figure 2: Evolution Trend of Topics in Invalid Patents

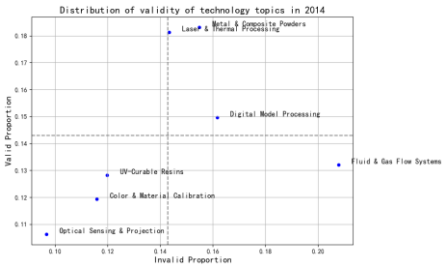

Figure 3: Distribution of validity of technology topics

It can be seen from figure 3 that " Metal & Composite Powders" and " Digital Model Processing" are in the first quadrant, indicating they have high innovative potential and commercial value, and are likely to occupy an important position in the market in the future.

"UV-Curable Resins," "Color & Material Calibration," and "Optical Sensing & Projection" are in the third quadrant, suggesting low attention and potential as emerging or niche market technologies.

3.2. Topic evolution based on patent validity

We recorded the positions of each common technology topic in 2014, 2017, and 2020, and plotted the dynamic evolution trajectories, as shown in figure 4.

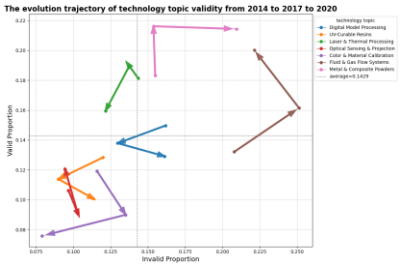

Figure 4: The evolution trajectory of technology topic validity from 2014 to 2017 to 2020

It can be observed that "Fluid & Gas Flow Systems" moved from the fourth quadrant to the first, indicating that its market competitiveness and technological activity have significantly increased, entering a phase of intense competition, and it may experience greater market opportunities.

In contrast, "Digital Model Processing" moved from the first quadrant to the third, and then to the fourth, reflecting a significant decline in its applications and innovation activities, suggesting a risk of obsolescence or replacement by other technologies.

4. Conclusion

This paper utilizes patent validity and invalidity information to reveal technology topic evolution trends in the 3D printing field through the perspective of patent validity.

Acknowledgements

This work is supported by National Natural Science Foundation of China (Grant No. 72374103, 71974095), China Society of Indexers (Grant No. CSI24C10), and Jiangsu Provincial Federation of Philosophy and Social Sciences (Grant No. 24SYC-023). The paper is presented at the second

Workshop on “Innovation Measurement for Scientific Communication (IMSC) in the Era of Big Data” at 2024 ACM/IEEE Joint Conference on Digital Libraries (JCDL).

Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT in order to: Improve writing style, Grammar and spelling check. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the publication’s content.

References

[1] Lin, Y.; Wang, X.; Yang, J.; Wang, S. Core Technology Topic Identification and Evolution Analysis Based on Patent Text Mining—A Case Study of Unmanned Ship. Appl. Sci. 2024, 14, 4661. https://doi.org/10.3390/app14114661

[2] Liu, P., Zhou, W., Feng, L. et al. Mapping and comparing the technology evolution paths of scientific papers and patents: an integrated approach for forecasting technology trends. Scientometrics (2024). https://doi.org/10.1007/s11192-024-04961-0

[3] Wu, H., Yi, H. & Li, C. An integrated approach for detecting and quantifying the topic evolutions of patent technology: a case study on graphene field. Scientometrics 126, 6301–6321 (2021). https://doi.org/10.1007/s11192-021-04000-2

[4] Zhang Xian, Zeng Rongqiang, Li Shuying, Li Jiahui. Patented Technology Evolution Path Identification Based on Multi-relation Data Fusion[J]. Library and Information Service, 2024, 68(3): 71-84. https://doi.org/10.13266/j.issn.0252-3116.2024.03.007

[5] Fu Ying. Strategy for Development and Utilization of Invalid Patent. R & D management. 2005, (03): 96-100.

[6] Blei, David M., Andrew Y. Ng, and Michael I. Jordan. "Latent Dirichlet Allocation." Journal of Machine Learning Research, vol. 3, 2003, pp. 993–1022.

[7] Xiaotong Han, Donghua Zhu, Ming Lei, Tugrul Daim, R&D trend analysis based on patent mining: An integrated use of patent applications and invalidation data, Technological Forecasting and Social Change, Volume 167, 2021, 120691, ISSN 0040-1625, https://doi.org/10.1016/j.techfore.2021.120691

[8] Hall, Bronwyn H. and Harhoff, Dietmar, Recent Research on the Economics of Patents (July 2012). Annual Review of Economics, Vol. 4, pp. 541-565, 2012, Available at SSRN: https://ssrn.com/abstract=2139260 or http://dx.doi.org/10.1146/annurev-economics-080511-111008

[9] Lerner, Josh. “The Importance of Patent Scope: An Empirical Analysis.” The RAND Journal of Economics 25 (1994): 319-333.