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Research Article

Evaluating Technological Innovation of Media Companies from the Perspective of Technological Ecosystem

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The evaluating indicators on the benefits of innovative technology to media companies are preliminarily analyzed and evaluated, according to the research review and evaluating criteria of self-organization and ecosystem selection. Factor analysis and structural equation modeling are used to further explore and select the indicators. According to the results, from the perspective of technology ecosystem, innovative technology performance of media companies can be measured through a two-factor structure—the input of innovative technology and its output. On this basis, ANP (analytic network process) is used to establish a weighted evaluation of indicators. At the end of the paper, a complete set of evaluation systems was created to measure the performance of technology innovation.

1. Introduction

Media technology is evolving faster than we could imagine. With the gradual entry into the era of rationality, the role of media technology has become increasingly prominent. Media technology has created a new entertainment environment and makes life more colorful, influencing the trend of social civilization and the social lifestyle, as well as people's aesthetic and spiritual pursuit. Nowadays, the construction of spiritual civilization is the top priority of China's development. As early as in the "Twelfth Five-Year Plan" period, the development of cultural industry was put forward as a pillar industry. After that, a series of measures were put forward to promote the development of the media industry, which further accelerated the change of people's lives by science and technology. The new technology represented by the Internet, new media, cloud technology, and big data has become new driving forces for the development of media companies.

2. Analysis of Technological Ecological Mechanism of Media Companies

To maintain a favorable position in market competition, companies often rely on dominant technologies for innovation [1]. In formulating a technological innovation strategy, it is particularly important to identify the law of technological evolution [2]. With the rapid growth of consumers' demand on the renewal of science and technology in the new era, an accurate understanding of technology development trends and ecological characteristics of technology will promote the sustainable development of a company's innovative ability. Therefore, the analysis of the technological ecosystem is helpful to further understand the relationship between media company technology and technology and the technology and environment of media companies and provide a theoretical basis for the study of innovation and development of media companies.

On the basis of the research on the technological ecological characteristics of companies [3], it is understood that the technological ecosystem of media companies has two mechanisms, namely, the self-organization mechanism of the technology system and the selection mechanism of the technological ecosystem.

2.1. Self-Organization Mechanism of Technology System. Firstly, technology is inclusive, which is best reflected in media technology. For example, science, optics, chemistry, and other technologies lead to the invention of video and audio. Meanwhile, the inclusiveness of its technology system guarantees that media products will always stay ahead of the time and keep up with time and meet the basic audio-visual needs of consumers. For example, the early phonograph recording technology replaced the musical instrument dubbing, and the emergence of 3D media in the new era is gradually replacing the traditional 2D media technology. Therefore, taking the opportunity of technology evolvement is key to the technological innovation and development of the media companies and will ensure the return of technology.

The technology system has the characteristics of nonlinear interaction, which is represented by the nonlinear characteristics of technology in the production and development stage and the interaction between technology and technology. It is mainly reflected in the synergy of technologies and the new functions and effects produced by the interaction between technologies. For example, optical lens recording technology and 3D stereo imaging technology form prototype of stereo film, creating a powerful combination beyond a single technology.

Finally, the evolution of technology system is an automatic process. Any technology of a media enterprise is composed of technical factors, which plays a major part, and technological environment. It is an automatic process in which the technology is able to come into being, adapt to the surrounding system, and become stabilized without external instructions. Therefore, media technology is affected by both the internal and external factors. The innovation of media companies also depends on the quality of innovators and the application rate of innovative resources.

2.2. Selection Mechanism of Technological Ecosystem. Under the organization of media technology, companies could obtain premium benefits through innovation that subverts the existing technology. However, consumers and the market may not favor all technological innovations during this process. For example, a magic movie with an investment of 200 million yuan used full-scale 3D live shooting and the state-of-art technology of dynamic capture in its making, but its audience score was poor. When a disruptive technology is created, the selection mechanism of the technological ecosystem plays a leading role in market efficiency, and it is a significant other-organizational process. For example, Chinese consumers did not accept dynamic capture technology when it was first launched and so did European and American consumers when they first encountered the 3D technology. Thus, the application of innovative technology needs to adapt to the market. And technological innovation needs to constantly integrate with media products and make improvements. At this stage, the new technology of media needs to be dynamically adjusted to fit the market and meet the demand of consumers.

The environment of technological innovation is the major player in the ecosystem selection. Media companies need to cater to the demand of the consumer market, which is the major player, and the innovation, which creates market impact, serves as the manifestation. When the media technology first enters the market, it will be influenced by many factors, among which the market is the most crucial one. The technological innovation of media is constantly evolving to meet the market demand. Therefore, the success of innovation and its return are the direct results of market selection. Meanwhile, the market choice can be divided into rational and emotional choices of consumers, so the media technology innovation is influenced by multiple factors.

In conclusion, the self-organization mechanism of technology system and the selection mechanism of the technical ecosystem can fully demonstrate the performance of the technological innovation in the media enterprise. Therefore, in this paper, the technological performance evaluation of media companies is carried out on this basis.

3. Research Review and Hypotheses

3.1. Research Review. As there is no research on technology evaluation of benefits to media companies, based on the technological ecological mechanism of the media companies and its features, this study will review and summarize the existing research and make relevant hypotheses.

For the understanding of technological innovation in companies, previous studies have put emphasis on the effect of technology innovation input. In Nelson's view [4], the investment in technological innovation in early days will promote the sustainability of innovation, thus conducive to the allocation of innovative resources. Scherer [5] held that the content of enterprise technology innovation input is broad and innovative activities are constantly changing and have different forms. Therefore, researches on enterprise technological innovation should adopt multiple evaluation indicators. Innovative indicators proposed by Scherer include R&D investment, the number of major technological innovations, and the number of new products. Hagedoorn [6] believed that R&D investment is crucial for accelerating the application of innovative technologies and the effective output of new products. With further research on R&D investment, Acs and Audretsch [7] discovered that patents represent the most significant new technical knowledge, processes, and new industrial products of a firm. Griliches and Mairesse [8] argued and found that R&D investment is directly related to the output of technological innovations and could increase the innovative abilities and performance of a firm.

As research goes on, scholars proposed more direct measures of returns on innovative technologies for firms. Many scholars use the commercialization of new product as a measure for innovative performances [9]. Meanwhile, scholars found that using patent data as an innovation indicator has

some limitations. However, high-tech companies can use patent propensity rates to measure innovation performance to some extent [10]. In this regard, scholars put forward a number of relevant indicators: Fischerchose to use the sales revenue of new products, product innovation degree, and the percentage of innovative process as indicators of innovation returns [11]. Hagedoorn included R&D inputs, patent counts, and patent citations to new product announcements into the indicators of innovative performance of companies summarize the existing research [12]. Laursen and Foss argued that the technical returns in the innovative performance of companies should be measured from the number of patent filed and licensed [13]. In the measurement research, Beneito added the indicators such as the growth of innovative performance, the number of new products and patents, R&D input, and investment return as indicators [14]. Kesidou and Romijn thought that patent counts and R&D input can reflect the technological returns from innovative activities [15].

Based upon data and papers from foreign studies or databases, Chinese scholars gradually deepened their understanding of innovation measurement. Chen and Wang took product innovation as the first-level indicator and established a performance evaluation system for technology innovation, which was divided into innovation output and performance dimensions during innovation [16]. He also put forward a series of indicators including the number of new products, improved products, new standards, patent applications, technical know-how, technical documents, scientific papers, technical innovation proposals and competitive intelligence analysis reports, frequency of communication between the R&D department and customers, between R&D departments in companies, between R&D department and manufacturing department, between R&D departments and universities and research institutes, R&D/sales ratio, proportion of R&D staff, number of technical leaders, number of rewarded technicians, average training cost for each technician, and number of technicians attending conferences at home and abroad, as well as industrial technical forums. Yin and Yang used the Balanced Scorecard (BSC) to study the technological innovation performance of enterprises [17]. In their design, the effects of technological innovation, innovation management, innovation input, finance, and social benefit are the second-level indicators of the evaluation system. They continued to divide the abovementioned dimensions, such as technological innovation effects, innovation management, and technology innovation input, into subcategories such as the number of new products, sales rate and profit margin of new products, the number of new standards, patent counts, productivity rate, number of scientific papers, proportion of R&D personnel, number of technical leaders and rewarded technicians, number of technical personnel attending conferences at home and abroad, exchanges between R&D departments and other institutions, market penetration rate of a new technology, the rate of innovative products and their success rate, product life cycle, proportion of R&D investment to sales revenue, expenses of acquiring external technologies, expenses on human capital development and training, input on university-industry collaboration on innovation, and the quality of equipment compared with peers. Cao et al. took the number of patent applications, the number of patents, implementation level of technological innovation, and the sales of new products as the indicators of enterprise innovation in their research on assessment model and evaluation index for the effect of tacit knowledge conversion on tech-transfer [18]. Wang and Deng set up an innovation evaluation system for Jiangxi companies based on innovation process, in which knowledge output and economic performance are regarded as the first-level indicators, input factor, and output factor as the third-level indicators [19]. Items including number of scientific and technical personnel, R&D personnel, funds for scientific and technological activities, and R&D expenditure are the input factors under the indicator of knowledge output; patent licenses, application rate of innovative resources, scientific and technical publications, and scientific and technological achievements and awards are output factors under the indicator of economic performance. In the research on the coupling indicator system of enterprise patent management and innovation performance, Cao and Su believed that the following factors could be taken as second-level indicators for technological innovation performance, and they are the number of staff in R&D and training activities, R&D expenditure, the amount of sophisticated equipment, patent information utilization, market penetration of the product, frequency of communication between patent R&D departments, number of patent applications and licenses, number of corporate patent regulations, patent risk assessment, the number and volume of patent disputes, the term of patents, the number of participating standards, core patents, technical files and scientific papers, and improvement of R&D personnel skills, as well as external networking [20]. Wei and Liang proposed to use the performance of organization and management skills as well as technical ability as the second-level indicator to evaluate innovation [21]. Each second-level indicator will further extend to third-level indicators. There are nine third-level items in total, including innovative management skills on company strategies, methods and institutions, improvement of new product, cleanliness of production process, the input-output ratio of exploring new market and introducing new resources, the conversion rate of new techniques, and the input-output ratio of environmental technological achievements.

3.2. Research Hypotheses. This study has carried out an expert review of indicators (a total of 6 experts, including 4 academic experts (all of whom are professors of management) and 2 industrial experts (a CCTV program director and a president assistant from a media company)), which has mentioned above, based on the feature of technological ecosystem in media companies (as shown in Table 1). The chosen indicators must meet the following criteria: (1) suitable to the mechanism of technological ecosystem, (2) relevant to returns generated by innovative activities by media companies, (3) with concise and easy-to-understand language, (4) clear in meaning, and (5) related to innovation. The expert review has selected 14 indicators that fit the media companies from existing ones, and they are the number of technically improved media products, the application

Table 1: Preliminary establishment of technological innovation indicators for media companies.

Dimensions	Proposed indicators	Features of related technical ecosystem
Technological innovation	The application rate of a new media technology	Openness
	The number of major technological innovations	
	The output rate of innovative technologies by media companies	
	The conversion rate of new techniques	
	The frequency of new product announcements	
	R&D inputs of media companies	
	The implementation of innovative media technology	Nonlinear interaction
	The application rate of new media technology	
	The number of staff in technological innovation	Self-organization
	The application rate of innovative resources	
	The number of technically improved media products	Ecosystem selection
	The life cycle of media products	
	The market penetration rate of a new media technology	
	The success rate of innovative products	

rate of innovative resources, the number of staff in technological innovation, the frequency of new product announcements, the conversion rate of new techniques, the output rate of innovative technologies by media companies, the application rate of a new technology, the number of major technological innovations, R&D inputs of media companies, the life cycle of media products, the implementation of innovative media technology, the success rate of innovative media products, the application rate of new media technology, and the market penetration rate of a new media technology.

Technological performance usually refers to the margin of economic results, and labor inputs after technological policies and measures are implemented and applied. Technological performance of media firms reflects the return of input during the creation of film and television products. The technological performance of media innovation is to explore such relation from the perspective of innovation, in order to help media companies, achieve rapid and sound development with low cost. On this basis, this study also takes into account the ecosystem selection of media companies and uses academic classification methods, the evaluation indicators of innovative technology of media companies to divide the indicators of technological innovation performance of media companies into two dimensions: the performances of technology input and output.

Firstly, the performance of technology output generally refers to higher returns brought about by technological innovation and improvements to media companies. As the media companies belong to strategic emerging industries, the application of innovative technologies will greatly affect the revenue of companies.

Secondly, the performance of technology input generally refers to the returns of technological innovation and improvements to media companies, which reflects the revenues generated by innovation in production process by media companies.

4. Quantitative Analysis and Discussion

Descriptive statistics, exploratory factor analysis, and confirmatory factor analysis were used in the statistical research, and a questionnaire was distributed. A total of 656 questionnaires were collected during one month, and 626 questionnaires were screened out with an effective rate of 95.42%. The questionnaires were randomly divided into two parts, each of which consisted of 313 questionnaires, to ensure the validity and randomness of sample selection. They were used, respectively, for exploratory factor analysis and confirmatory factor analysis. Factors of the sample are as shown in Table 2.

4.1. Exploratory Factor Analysis. Through the analysis and research review of technological ecosystem, it can be concluded that the technological performance of Chinese media companies includes 14 measurements. The KMO value and Bartlett spherical test of 313 effective samples were carried out. The results showed that the KMO's test had a high value of 0.921. The Bartlett value of the spherical test was 1,904.697 and a level of significance of less than 0.001. Secondly, the reliability analysis was carried out. The result showed that the correlation coefficient of the single item to the total item in all items was greater than 0.5. Finally, a consistency analysis was performed, and the results showed an Alpha value of 0.902. In summary, the reliability of the scale is very good, in line with the exploratory factor analysis standard.

The screening of items was carried out with principles that were agreed upon by scholars. The analysis principles are as follows: (1) the common factor load should be greater than 0.50; (2) the common factor load can only be one and more than 0.50; (3) the common factor load should have a large difference.

Based on the principles, factor analysis was operated as follows: constructing covariance matrix, extracting factors with principal component analysis, rotating with the maximum variance method, and converging after 3 rotations. The technological benefit indicator shows a clear two-factor structure.

Conclusions are as follows: items T1, T4, T8, and T13 with a common degree of less than 0.50 were deleted; T7

Table 2: Demographic variables for questionnaires.

Exploratory analysis phase ($n = 313$)				Confirmatory analysis phase ($n = 313$)			
Gender	Male	99	31.6%	Gender	Male	113	31.6%
	Female	214	68.4%		Female	200	68.4%
Education background	Graduate	4	1.3%	Education background	Graduate	6	1.3%
	Undergraduate	288	92%		Undergraduate	268	92%
	Junior college student	20	6.4%		Junior college student	38	6.4%
	Below junior college	1	0.3%		Below junior college	1	0.3%
Age	20-30	121	38.7%	Age	20-30	100	38.7%
	30-40	190	60.7%		30-40	210	60.7%
	40-50	2	0.6%		40-50	3	0.6%
	Above 50	0	0		Above 50	0	0
Identity	Technician	109	34.8%	Identity	Technician	101	32.3%
	Management	71	22.7%		Management	92	29.4%
	Consumer	133	42.5%		Consumer	120	38.3%
Employment duration	1-2 yrs	51	16.3%	Employment duration	1-2 yrs	73	16.3%
	3-5 yrs	170	54.3%		3-5 yrs	164	54.3%
	6-10 yrs	91	29.1%		6-10 yrs	72	29.1%
	Over 10 yrs	1	0.3%		Over 10 yrs	4	0.3%

Table 3: Results of exploratory factor analysis of innovative technology for efficiency scale of media companies ($N = 313$).

Items/name of factors	Technology output performance	Technology input performance
T6: the output rate of innovative technologies by media companies	0.748	
T10: life cycle of media products	0.737	
T11: the implementation of innovative media technology	0.760	
T12: success rate of innovative products	0.791	
T14: the market penetration rate of a new media technology	0.677	
T2: the application rate of innovative resources		0.754
T3: the number of staff in technological innovation		0.785
T5: the conversion rate of new techniques		0.689
T9: R&D inputs of media companies		0.797
Characteristic value	6.198	1.566
Variance contribution ratio (%)	30.249	25.203
Cumulative variance contribution ratio (%)	30.249	55.452

was deleted because it has 2 common factors with loads exceeding 0.50. The total explained variance ratio is 55.452%, and the results are shown in Table 3.

In view of the meaning of the abovementioned items and combining with the review and classification criteria of the characteristics of innovation technological ecological mechanism and innovative technology performance characteristics of media companies, the above 2 factors are named.

Factor 1 is named as technology output performance with variance contribution ratio of 30.249%, consisting 5 items: T6, T10, T11, T12, and T14.

Factor 2 is named as technology input performance with variance contribution ratio of 25.203%, consisting 4 items: T2, T3, T5, and T9.

The two-factor structure shows that the investment by media companies will affect innovation activities, which can increase the output of the companies, thus enhancing the technological performance of media companies in all aspects.

4.2. Confirmatory Factor Analysis. During the exploratory factor analysis, it was found that the innovative technology performance of media companies was composed of two factors. Therefore, the second-order confirmatory factor analysis was carried out (shown in Figure 1 and Table 4). The results show that all factors of indicators for the innovative technology performance had significant levels.

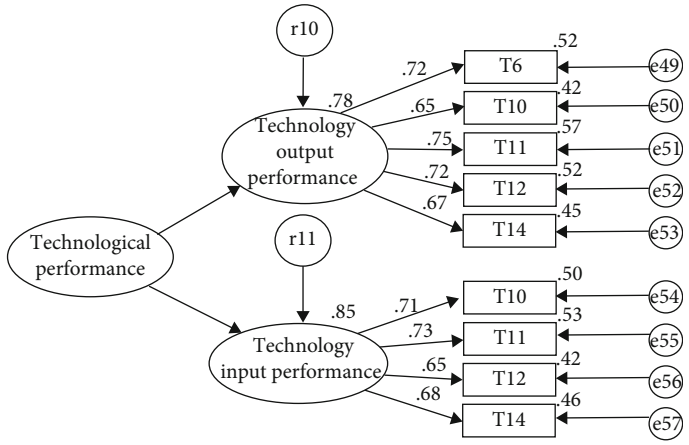

Figure 1: Confirmatory factor analysis model.

Table 4: Factor load coefficient of the indicators model for innovative and social performances for media companies ($N = 313$).

Items/factors	Technology output performance	Technology input performance	
T6: the output rate of innovative technologies by media companies	0.722		
T10: the life cycle of media products	0.650		
T11: the implementation of innovative media technology	0.753		
T12: the success rate of innovative products	0.723		First-order factor load coefficient
T14: the market penetration rate of a new media technology	0.673		
T2: the application rate of innovative resources		0.709	
T3: the number of staff in technological innovation		0.726	
T5: the conversion rate of new techniques		0.651	
T9: R&D inputs of media companies		0.680	
Second-order factor load coefficient	0.885	0.924	

Table 5: Overall fitness of the indicator system of innovative technology efficiency of media companies ($N = 313$).

Model fitness	Fitted value	Fitting standard
X^2/df	1.996	Less than 3, good fit
GFI	0.964	Greater than 0.9, good fit
AGFI	0.938	Greater than 0.9, good fit
CFI	0.975	Greater than 0.9, good fit
RFI	0.934	Greater than 0.9, good fit
IFI	0.976	Greater than 0.9, good fit
NFI	0.952	Greater than 0.9, good fit
NNFI (TLI)	0.966	Greater than 0.9, good fit
ECVI	0.228	The smaller the better
RMSEA	0.057	Less than 0.1, good fit
RMR	0.034	Less than 0.1, good fit

Table 5 shows that the overall fitness of the indicator model for innovative technology performance is very good, $x2$/df is 1.996 (<3), which is within the acceptable range of the test value. All indicators of CFI, NNFI, IFI, RFI, NFI, GFI, and AGFI are greater than 0.9, RMSEA and RMR are less than 0.1, and ECVI value is smaller, indicating a very good fit. Therefore, it is judged through confirmatory factor analysis on the verification model of indicators for innovative technology performance of media companies has a high degree of fit, and all the indices are valid.

4.2.1. Weight Establishment. To further improve the construction of the indicator system for innovative technology performance of Chinese media companies and scientifically evaluate the technological innovation activities of media companies, the Super Decisions software is used to analyze the weight of the indicator system on the basis of dimension empirical test. Firstly, a structural model of the indicator system of innovative technology performance of Chinese media companies is drawn, as shown in Figure 2. The model consists of two levels:

Control level: technological benefit (B_3).

Network level: technology output performance (C_1), technology input performance (C_2), the output rate of

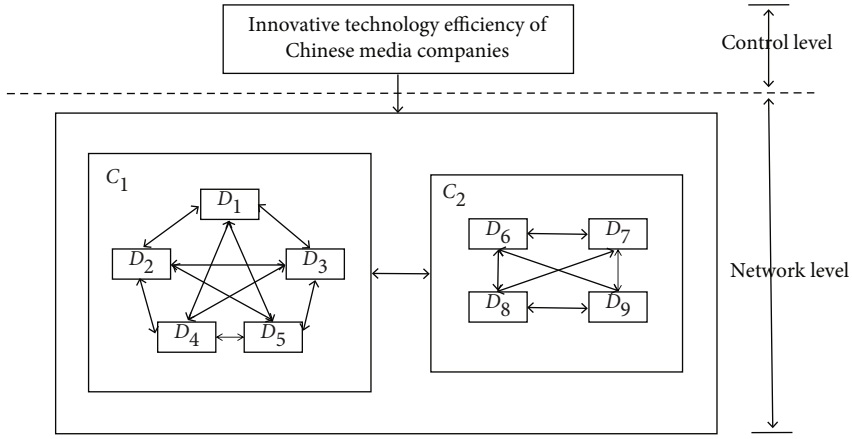

Figure 2: Network level structure model of innovative technology efficiency indicator system for Chinese media companies.

Table 6: Weight system of innovative technology efficiency evaluation indicators for Chinese media companies.

First-level indicators	Second-level indicators	Third-level indicator element		Actual rating
		Indicators	The weight of the element to the overall system (retaining 3 decimal places)	
Technological benefit	Technology output performance	Technology innovation output rate of media companies	0.063	
		Life cycle of media products	0.257	
		Implementation of innovative media technology	0.084	
		The success rate of innovative products	0.111	
		The market penetration rate of a new media technology	0.152	
	Technology input performance	The application rate of innovative resources	0.088	
		The number of staff in technological innovation	0.058	
		The conversion rate of new techniques	0.118	
		R& D investment by companies	0.069	

innovative technologies by media companies (D_1), the life cycle of media products (D_2), the implementation of innovative media technology (D_3), the success rate of innovative products (D_4), the market penetration rate of a new media technology (D_5), the application rate of innovative resources (D_6), the number of staff in technological innovation (D_7), the conversion rate of new techniques (D_8), and investment in R& D by companies (D_9).

This study explicit the innovative technology efficiency of media company, the process includes innovations on inner sensational experiences, in terms of input and output to abstract the words of implantation and expression, which explains the innovating process of media companies; the words of output and input contain a more general conation.

In this study, the analytic network process (ANP) was used comprehensively, and the one-time test was used to calculate and form a complete weight system for indicators of innovative technology performances of Chinese media companies, as shown in Table 6.

5. Conclusions and Suggestions

5.1. Conclusions. The application of the technological ecosystem can well explain the overall characteristics of technological innovation in media companies. The self-organized technology system is the driving force of innovation in media companies and is crucial for companies to generate returns. The market selection in the technological ecosystem determines whether a newly applied media technology can adapt to the consumer market and whether a disruptive technology could dominate the market.

The ecosystem of technology tends to follow a fixed path of accumulation and time evolution. Such a path for media technologies is especially unique. Transitions from black and white to color, silent to sound, 2D to 3D, fully reflect the interaction and fierce competition among old and new media technologies. Upon achieving self-organization and selection by technological ecosystem, new media technologies will always replace the old ones and realize a

technological leap. In market competition, new disruptive media technology needs to compete with dominant technologies for advantageous positions in the consumer market. A new disruptive media technology will not only meet the blockade from the old but also the selection and feedback from the market. After continuous evolving, new media technology will finally trump the old by leapfrogging to a new level and making paradigm changes.

Therefore, in this paper, evaluation forms for innovative technology performance of media companies are designed based on the characteristics of the technological ecosystem, to provide a methodological guide for innovation and the improvement of technical performance for media companies. The forms follow a two-factor structure: technology output performance and technology input performance.

5.2. Suggestions. Through the research, it concluded that the utilization of innovative resources and the number of staff in technical innovation would significantly affect the performance of media technology. Therefore, innovative talents and resources are still the key to the success in innovation competition of media companies in the new era. The output rate of innovative technology, implementation of innovative technology, and the success rate of technological innovation are more significant in the output performance of media technology. Therefore, media companies should pay more attention to details in innovation and understand the characteristics of the ecosystem.

Generally speaking, from the perspective of the technological ecosystem, the technological innovation of media companies' progresses in stages. Media companies or media-related departments should better identify each stage during the application of new technology, take targeted measures in different stages, to promote the application of the new technology and the paradigm transformation of media technology.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest

It is declared by the authors that this article is free of conflict of interest.

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