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Proceedings of Business and Economic Studies

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Research Progress of High-Quality and Equilibrium Economic Development of Ethnic Regions in the Context of Digital Economy

Naxuan Hao*

Hongtao (Beijing) International Education & Technology Co., Ltd., Beijing 100163, China

Corresponding author: Naxuan Hao, haonaxuan@gmail.com

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Abstract: A new generation of information technology is driving the growth of digital economy across the world. In recent years, China has attached great importance to the development of digital economy and digital technology. With the support of a series of policies, the digital industry has been able to develop at an astounding rate, and at the same time the integration of other industries with digital technology has been strengthened. The profound changes in production factors, production methods, and production approaches have promoted high-quality regional economic development. Literature statistics have shown an increasing trend in digital economy research in recent years. In this paper, literature on digital economy development, digital economy and high-quality economic development, the current situation of economic development in ethnic regions, and digital economy and economic development in ethnic regions is recapitulated in an attempt to learn from existing studies.

Keywords: Digital economy; High-quality development; Regional economy; New era

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1. Introduction

With the continuous development and iteration of digital technologies, such as big data, artificial intelligence, and cloud computing, a new round of technological innovation with digitalization, networking, and intelligence as the core is providing a constant source of momentum for economic recovery across the world. The difference between the digital economy led by the new generation of information technology and the previous technological revolutions is that the new round of technological revolution is not the change of a single technology, but rather the integration of a series of technologies as well as the "digitalization of industry" and "digital industry" generated by the intersection of multiple technologies for development. The "digitalization of industry" and "digital industry" generated by the interplay of multiple technologies will definitely have a profound impact on human production and life.

For a long time, China has attached great importance to the development of digital economy and digital technology and stressed the need to continuously strengthen and expand its own digital economy. In 2016, China stressed the need to expand and strengthen digital economy as well as expand the space for economic development. In the same year, an initiative to develop digital economy was put forward in the G20 Summit. In 2017, the acceleration of building a digital China and a digital economy with data at its core as well as promoting the integrated development of real economy and digital economy was stressed. In 2018, at the Central Economic Work Conference, emphasis was placed on the construction of 5G, artificial intelligence,

industrial internet, and other new infrastructures; it was then that the "new infrastructure construction" was proposed for the first time. In 2020, the strengthening of the "new infrastructure" was included in the government work report. In a congratulatory letter to the Wuzhen Summit of the World Internet Conference in 2021, it was pointed out that it is necessary to stimulate the vitality of digital economy, enhance the effectiveness of the digital government, optimize the digital social environment, build a pattern of digital cooperation, build a digital security barrier, and allow the digital civilization to benefit people around the world [1]. In the president's keynote speech at the opening ceremony of the Boao Forum for Asia Annual Conference 2022, he stated that China will actively promote its accession to the Digital Economy Partnership Agreement [2]. The Chinese government has rolled out a series of policies to promote the development of China's digital economy and achieve its digital development goals. With the development of digital technology and its infrastructures in addition to the continuous integration of digital technology with the economic industries of each region, the production factors and production methods that drive the economic development in each region will change dramatically. The digital economy is still in its early stages of development, and its impact on the world's competitive landscape and economic development has been anticipated; however, the breadth and depth, content, and manner of its impact have yet to be established due to differences in regional folk culture, economic environment, and infrastructure. Therefore, in the context of digital economy, based on the construction and application of new digital infrastructures in ethnic regions and in consideration of the current economic level and development status of each ethnic region, ethnic society, and culture, sorting out literature on the high-quality and equilibrium economic development of ethnic regions will provide important insights and ideas for subsequent research.

2. Outlines of the development of digital economy

Modern computing technology did not begin with the internet; instead, it emerged in 1945 from the commercialization of technologies developed during World War II [3]. Computing technology in its initial stages focused on the speed of computation, and its ability to store and retrieve information was limited. By the early 1950s, magnetic core memory enabled efficient digital information storage. Over time, improvements in storage technology, software, and hardware allowed information processing and retrieval to become a commonplace. Software and hardware industries began to grow rapidly [3,4]. In the early 1990s, the privatization of computing technology in the United States led to the emergence and rapid spread of commercial internet. 1995 saw the publication of Tapscott's book "The Digital Economy" and the introduction of the concept of "digital economy," which argued that future economic activities would be widely represented in digital form and that digital management will greatly improve productivity. Castells, a professor at the School of Communication at the University of Southern California in Los Angeles, published a trilogy titled "The Information Age: Economy, Society, and Culture," while Negroponte, a professor at the Massachusetts Institute of Technology, published a monograph titled "Digital Survival," which offered the world an initial understanding of digital economy.

From 2004 to 2007, the world economy achieved rapid and steady growth, and the world's gross domestic product (GDP) grew at an average annual rate of about 5%, with the highest in the past 30 years. The 2008 global financial crisis hit the traditional financial industry hard but had little impact on digital enterprises, such as Apple and Google; following that, digital enterprises such as Baidu and Tencent emerged in China. In 2016, a new interpretation of digital economy was introduced in the G20 Summit, defining it as "a series of economic activities that use digital knowledge and information as key factors of production, modern information networks as important carriers, and information and communication technology (ICT) as an impetus for efficiency improvement and economic structure optimization [5]."

In academia, research on digital economy significantly increased in 2021, jumping into the top 10 research hotspots [6]. In 2022, the National Committee of the Chinese People's Political Consultative

Conference (CPPCC) held a special consultation on "promoting the sustainable and healthy development of the digital economy," advocating new economic forms in which the digital economy would undoubtedly play a significant role.

3. Digital economy and high-quality economic development

Changes in key factors of production are the primary variables driving economic growth [7]. The data factor rapidly decreases production cost, large-scale and unlimited supply, and universal application prospect, thus making it a typical key factor of production in the digital economy. The digital economy affects the factor input structure of industries through substitution and penetration effects and promotes economic growth by improving total factor productivity [8]. The digital economy has become a new impetus and source of economic development for all countries, bringing profound changes to the economic and social development of countries around the world. Goldfarb *et al*. [9] expressed that the intervention of information technology greatly reduces the search cost, replication cost, transportation cost, tracking cost, and authentication cost of data and information and has an impact on international economy, regional economy, and personal consumption habits.

In China, the digital economy has expanded the scope of social connectivity, promoted innovation and entrepreneurship, as well as created an environment for high-quality human capital performance. According to the National Bureau of Statistics, the network economy index, which represents the digital economy, grew the fastest from 2015 to 2020, contributing 81.70% to the total index growth in 2020, thus showing that the digital economy has become an impetus for China's high-quality economic development.

In China Journal Full Text Database (CNKI) "advanced search," the search criteria were set as "digital economy" and "high-quality economic development." A total number of 265 articles were obtained from 2018 to 2022, and the number of articles per year was observed to be on the rise, as shown in **Table 1** below. With "digital economy" as the subject matter, 235 articles were found, and there were 153 articles on "high-quality economic development."

Table 1. Number of articles with keywords "digital economy" and "high-quality economic development" in 2018–2022

Year	Number of literature (articles)
2018	14
2019	33
2020	60
2021	104
2022	127 (predicted volume)

A review of the above-mentioned literature revealed that most researchers affirm the positive effects of digital economy on high-quality economic development. These studies cover both theoretical studies on the theoretical logic, mechanism of action, and development path of digital economy that can drive high-quality development as well as empirical studies that have proven the original hypothesis that digital economy drives high-quality economic development and on the various characteristics of digital economy that have an impact on high-quality development.

In terms of constructing an indicator system of digital economy and its development, Wang *et al*. [10] constructed an indicator system of development level from five dimensions: innovation, coordination, green, openness, and sharing. According to Tian *et al*. [11], the high-quality economic development of each region is mainly reflected in the improvement of production efficiency and the coordinated development of urban

economy; thus, total factor productivity is taken as an important indicator to measure the level of high-quality development. Zhang *et al*. [12] constructed an evaluation index system of the development level of digital economy from two dimensions (industrial digitization and digital industrialization) using 22 three-level indicators.

In terms of the impact and mechanism of digital economy on high-quality economic development, Li [13] found that digital economy possesses certain characteristics, such as disruptive innovation and hyper-speed growth. According to Ren [14], the development of digital economy cultivates the mechanism and path of a new dynamic energy for China's high-quality economic development. Wang [15] pointed out that the digital economy has a significant role in enhancing the level of high-quality economic development. The digital economy contributes to China's economic development through the combined effects of digital infrastructure construction, digital industry development, and digital financial inclusion. Cui [16] proposed that digitalization can help accelerate the cultivation of the new dynamics of agricultural and rural growth as well as promote power change. Promoting digital industrialization and digitization of industries, growing digital economy and building digital countryside, as well as deeply integrating rural economy with digital economy are the core drivers of rural agricultural development and the key to high-quality agricultural and rural development. Using relevant data from 222 prefecture-level and above (including prefecture-level) cities in China from 2011 to 2016, Zhao *et al*. [17] constructed an indicator system of digital economy, high-quality development level, and enterprise entrepreneurial activity; their empirical analysis concluded that digital economy significantly promotes high-quality economic development.

From the above, it is clear that academics generally affirm the role of digital economy in fueling high-quality economic development, but it remains uncertain how long this impetus will give China's economy an edge.

4. Economic development of ethnic regions

According to the data of the Sixth National Population Census in 2010, the total population in China is 1.37 billion, of which 113 million are ethnic minorities, accounting for 8.49% of the total number of people in the country; the total land area of China is 9.6 million square kilometers, of which the area of autonomous regions of ethnic minorities accounts for 63.9% [18]. The ethnic regions in China have rich natural resources, unique geographical locations, and profound ethnic cultures. In China, ethnic development has always had a role in the stable development of its society, while economic development has been an important cornerstone to social stability in ethnic regions. In recent years, our government has analyzed the new problems, new situations, and new challenges encountered in the economic development of ethnic regions in China and deployed to solve the economic problems of ethnic regions by holding both central and local ethnic work conferences. The economic development of ethnic regions in China has grown at a remarkable rate.

Existing studies generally agree that the harsh natural environment is the most fundamental shackle of economic and social development in ethnic regions and that it interacts with demographic, economic, and social development, entailing poverty in ethnic regions. Zhang [19] pointed out that the overlap of physical capital, human capital, and social capital in poor regions weakens their ability to develop themselves. According to Zhang *et al*. [20], with the deepening of poverty alleviation and development in ethnic areas as well as the western region, the development of natural areas has entered a bottleneck, indicating that the advancement of poverty alleviation strategies is increasingly constrained by the natural space. According to Wan [21], one of the important factors of the emergence of persistent poverty, the return to poverty after poverty eradication, and the intergenerational transmission of poverty is the superficiality and short-term state of the anti-poverty strategy, which does not solve the problem of endogenous sustainable development in ethnic poor areas. He [22] pointed out that it is necessary to ensure that ethnic minorities are aware of their

own benefits in the process of economic development and complete the initial distribution and multiple distribution for ethnic minorities especially when the regional economic development has achieved significant results in order to balance the distribution of economic development benefits and stimulate their vision for development and initiative to participate. Wang [23] indicated that a series of unbalanced and inadequate development problems, such as insufficient endogenous development momentum, difficulty in increasing rural residents' income, insufficient labor force skill training, high resistance to urbanization, and the lack of environmental protection effect, have restricted the realization of people's growing needs for a better life in ethnic regions and fundamentally led to the lack of sustainable development in ethnic regions. In the new era, ethnic regions must adhere to anti-poverty strategies and ecological environmental protection, strive to achieve the "double carbon" goal, rely on local resource endowment, vigorously develop digital economy, clean energy, specialty agriculture, cultural tourism, and other green low-carbon advantageous industries, adhere to green revitalization, and support green low-carbon industries to promote high-quality economic development [24].

From the combing of literature, it is clear that the focus of research on the economy of ethnic regions in the new era has shifted from the survival of poor people in ethnic regions to how ethnic regions can achieve high-quality development through digital economy and how the fruits of development can be shared.

5. Digital economy and economic development of ethnic regions

In recent years, several studies on digital economy and regional economic development have shown that the intervention of digital technologies can redistribute income within regions, especially between urban and rural areas. Gaspar and Glaeser [25] showed that network interoperability can complement and substitute for urban effects and the intervention of the internet can increase labor mobility by making information about jobs outside the region more accessible to people in relatively disadvantaged areas. Forman *et al.* [26] pointed out that basic network connectivity can benefit remote and rural groups. However, they also argued that the dividends of digital economy are more likely to be accentuated in large urban areas, where the quality and quantity of online content are better and higher, respectively, and urban residents are more willing and likely to access the internet. At the same time, urban areas are more prone to agglomeration effects. Forman *et al.* [27] demonstrated in their study that businesses in large cities and large corporations use internet commerce to a greater extent. Aggregation effects can benefit cities, yet low-cost internet interventions can benefit remote groups. These two arguments are inconclusive.

Domestic studies on digital economy and regional economic development have demonstrated that the digital economy represented by information technologies, such as big data, cloud computing, and artificial intelligence, has become a new impetus for regional innovation development. Deng *et al.* [28] showed that geographical segmentation, industrial segmentation, cultural knowledge segmentation, and other factors inhibit the spillover of regional innovation efficiency and regional innovation effect. Ai *et al.* [29], on the other hand, used provincial panel data from 2011 to 2018 to analyze the direct and indirect poverty reduction effects of digital economy through channels of economic growth and income distribution. Chen *et al.* [30] analyzed the provincial and city-level data of Yangtze River Delta region and concluded that digital economy positively contributes to regional economic resilience in the long run at the provincial level, while the development of urban digital economy significantly strengthens urban economic resilience at the city level and indirectly strengthens urban economic resilience through spatial spillover and urban innovation capacity improvement.

Focusing on the ethnic areas in China, the inauguration of the National Rural Revitalization Administration in 2021 represented the starting point of the rural revitalization strategy implementation in China [31]. As the focus and challenge of rural revitalization in China, ethnic regions should strengthen their economic development and raise farmers' income [32]. According to Young [33], digital economy, through

the virtual space that bridges the "physical world" and the "digital world," is a tool that supports the realization of agricultural production, rural circulation, social governance, lifestyle, and cultural concepts as well as a new means to support the comprehensive revitalization of rural areas. In the context of the digital era, Cui and Feng [34] argued that the mode and dynamics of economic growth have seen transformation, the promotion of rural revitalization combines cutting-edge digital technologies and rural digital economy to transform the growth dynamics and make up for the shortcomings of development in rural areas, and digital economy empowerment is required for the revitalization of ethnic areas. According to Sun [35], the economic development of ethnic minority regions can be promoted by building "digital platform" carriers to create a first-class science and innovation environment, developing ecological tourism to integrate special regional resources, and creating a special agricultural economy to meet market demands. Using 12 cases and the panel data of 30 provinces (autonomous regions and municipalities directly under the central government) from 2012 to 2019, Zhang *et al*. [36] found that digital economy, which includes digital infrastructure, agricultural digitization, and agricultural digital industrialization, and rural revitalization, which includes industrial prosperity, ecological livability, rural style, effective governance, and affluent living, are cross-coupled through key activities in both internal and external environments. In conclusion, although the degree of development of digital economy is generally weaker than that of rural revitalization, the former grows significantly faster than the latter, the gap between them is gradually narrowing, and a strong correlation exists between digital economy and rural revitalization.

Disclosure statement

The author declares no conflict of interest.

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A Review of Domestic and Foreign Research on Real Estate Financial Management

Xiuzhi Yuan*

Beijing Zhongchang Heyuan Enterprise Management Co., Ltd., Beijing 100072, China

Corresponding author: Xiuzhi Yuan, 1058620984@qq.com

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Abstract: With the tightening of house purchase policies in recent years, the introduction of financial and land restriction policies, as well as the impact of the COVID-19 pandemic, real estate bombshells are common. Real estate is in the critical stage of transformation and upgrading, and industrial development is facing dire challenges and pressure for survival. As an important part of enterprise management, financial management is directly related to the success or failure of enterprise development. Facing the financial risks emerging in the financial management of the real estate industry at this stage, this review begins from financial management personnel training, investment calculation management, budget management, and asset management in the effort of optimizing the real estate financial management operating mechanism under the new situation and ensuring the healthy and stable development of real estate enterprises, while maintaining core competitiveness.

Keywords: Real estate; Financial management; Investment calculation; Budget

Online publication: April 14, 2023

1. Research background and significance

Financial management has garnered widespread interest from real estate companies in recent years. However, the current financial management still has certain problems and deficiencies, such as flawed institutional systems, lack of informatization dynamic management, and long-term planning. Enterprises need to speed up innovation, reform financial management models, and improve the financial comprehensive management level, truly and ideally reflect the company's financial status, operating status, and future feasibility forecast analysis, effectively avoid blind investment, reduce the probability of financial risks, maximize the company's economic and social benefits, and assist real estate companies gain a greater advantage in the fierce competitive environment.

2. Literature search

The main sources of English literature were Web of Science, Chinese Social Sciences Citation Index (CSSCI), and Engineering Index (EI) databases; the keywords used included "real estate financing," "real estate budget management," "real estate financial management," "real estate tax planning," "real estate taxation system," "investment in real estate," "real estate sales payment," and "real estate supervision funds," with priority given to highly cited papers; the main source of Chinese literature was China National Knowledge Infrastructure (CNKI), and the keywords used were "房地产财务管理" (real estate financial management), "房地产税务筹划," (real estate tax planning), "房地产预算管理," (real estate budget management), "房地产测算," (real estate calculation), "房地产土地增值税" (real estate land appreciation tax), and "房地产投资管理" (real estate investment management). The articles were all carefully reviewed,

studied, and taken into consideration with work experience to focus on screening. Major key points were extracted and recorded.

3. Research status at home and abroad

3.1. Financial management personnel training

At present, the skill level of financial personnel in the real estate industry is uneven; most of them are occupational personnel with rigid working methods and little management awareness [1]. Judging from the status quo of China's real estate business operations, the sales, cost, and engineering departments are more valued by enterprises because they directly affect project sales, costs, and progress. Most enterprises do not see the value of financial management [2] as well as the significance and requirement of financial departments, thereby greatly limiting enterprise construction and development and dampening the enthusiasm of financial personnel.

Under the new situation of the real estate market, enterprises must improve their awareness of financial management and strengthen the construction of financial teams. Finance, as the core of enterprise management, plays a very important role in improving enterprise operation and improving enterprise economic efficiency. According to Smith *et al.* [3], a good overall management practice effect can be achieved through the optimal configuration of corporate financial management teams [3]. Enterprises should introduce financial management professionals through multiple channels, strengthen benchmarking learning with high-quality enterprises, increase financial management system training, ensure that everyone has solid financial management understanding and financial knowledge, as well as improve their overall financial management level. On the other hand, financial management personnel should cultivate the concept of "lifelong learning" [4], actively communicate with their colleagues, and obtain qualification certificates to enhance their professional quality. Other than that, it is necessary to optimize the financial information management and control system, strengthen the construction of financial information, provide clear instructions on the content, management process, and management methods of financial management and control, establish important institutional standards for financial management and control, and ensure that financial management and control develop in the direction of normalization, standardization, and systematization.

3.2. Investment calculation management

With the rapid development of the real estate market, the operating environment of real estate development companies has undergone tremendous changes, and the average profit margin of the industry has seen a gradual decline. The characteristics of the real estate industry include large investment quota, long development and construction cycle, as well as wide coverage and poor liquidity, indicating that there are not only market risks, such as business risks and financial risks, in the development process, but also policy risks, caused by changes in national macroeconomic policies and real estate control policies that highlight the importance of investment calculations in the decision-making period of development projects. For development companies to avoid the risk of unprofitability or even loss as much as possible, it is necessary to analyze the feasibility of projects under various risk conditions through investment calculations [5]. Arnold *et al.* [6] proposed that companies, in real estate investment management, should supervise their own strategic risk management from the perspective of strategic management and improve their ability to resist risks in order to cope with new regulatory requirements. An essential part of financial management is accurate investment estimation. Finance should understand the real situation of each business sector, boldly question and present the estimated data, as well as constantly verify the estimated data to help enterprises make correct decisions. For example, in order to obtain land plots and achieve short-term sustainable operations, if business departments perform blind calculations in their financial reports, artificially increase

the value of goods, reduce their costs and expenses, and cause subsequent inversions, such as higher costs and lower prices, data distortion may occur [7] and their businesses may be at risk of loss. Armstrong *et al*. suggested that financial and taxation management should strategically avoid uncertainties or factors that are unfavorable to the enterprise before business activities are carried out [8]. Johannesen *et al*. pointed out that tax planning is helpful to the future development of enterprises. Only by rationally arranging financial management activities can enterprises achieve the goal of maximizing corporate profits. At the same time, they recommended that enterprises should formulate suitable planning plans based on different development stages as well as analyze and solve planning problems at different stages one by one [9]. Financial management should be fully incorporated into investment calculations, conduct comprehensive, in-depth, and systematic calculations and analysis of real estate investment, provide risk warning and control for enterprises, look for high-quality investment projects, and maximize corporate income.

3.2.1. Sales plan and land value-added tax planning

The real estate industry business is complex, involving many different types of taxes, with heavy tax burden. Among them, the three most important taxes are value-added tax, corporate income tax, and land value-added tax. From the perspective of enterprise development, Brys *et al*. assert that real estate enterprises should pay attention to tax planning issues, *i.e*., to achieve the goal of maximizing corporate profits to the greatest extent through scientific and standardized financial management activities [10]. The amount of corporate income tax and land value-added tax payment is inversely proportional to the overall profit of the real estate company. Therefore, in the case of a certain planned sales floor area, it is not true that the profit will be higher with higher sales price and greater overall value of goods. Sales plan, taxes, and profits are all closely related. Marques *et al*. pointed out that tax planning space is positively correlated with corporate income tax rate, in which the higher the corporate income tax rate, the greater the tax planning space [11]. Cummings proposed the combination of real estate financial investment and price forecasting [12]. Francois *et al*. linked the tax burden level of real estate companies with the sales price of houses, indicating that attention should be paid to the impact of housing prices [13]. Finance and taxation personnel should actively participate in the sales pricing of real estate projects and determine the selling price with the aid of the critical point of value-added rate planning. If ordinary houses are involved, they should also make full use of the 20% critical point tax preferential policy to avoid paying land value-added tax [14,15] and convert the enterprise tax burden into customer income; real estate enterprises should change their framework of planning first and then formulating planning objectives, carry out various tax planning work based on prior planning, give full play to the guiding role of planning objectives, and effectively standardize their tax planning model.

Finance should take into consideration of the current situation of enterprise projects to compare product positioning and sales strategies with multiple plans, such as choosing hardcover delivery or rough delivery, bundled sales or discounted sales, *etc*.; reasonably and scientifically plan sales revenue, analyze its impact on taxation, and determine the impact on the overall performance of the project. Attention should also be paid to the impact of the overall payment collection cycle of the project on the full-cycle cash flow, while fully considering the time of investment project fund recovery and effectively controlling the change in the time value of money to reduce financial risks.

3.2.2. Development cost and land value-added tax planning

In order to maximize profit efficiency, many real estate development companies are now advocating the idea of reducing costs and increasing efficiency in addition to proposing several effective measures that can save operating costs [16]. However, this brings negative impact on the economic benefits of the land value-added tax. Therefore, high benefits cannot be achieved simply by reducing costs. Enterprises should make

full use of the land value-added tax cost deduction policy, *i.e.*, enterprises engaged in real estate development are allowed to deduct the sum of the amount paid when acquiring the land use right and the real estate development cost multiplied by 20%; by reasonably increasing the cost and the deduction amount and reducing the value-added amount, the amount of land value-added tax payable is reduced. This provision leaves room for real estate companies to plan for land value-added tax. Since enterprises mainly acquire land through bidding, auction, and listing, without room for manual manipulation, the same goes for land cost; hence, the only other way is from the development cost of the project. From the assumption of building an equilibrium model of housing price and quality in a balanced competitive space, Maydew *et al*. asserted that local fiscal policies will affect the construction of public facilities. If real estate companies improve and optimize tax planning, they will promote the construction of public facilities and the development of the region [17]. For example, enterprises can increase costs by improving the overall standard of landscape and infrastructure facilities. On the one hand, they can optimize the community environment, improve the infrastructure and market competitiveness, as well as actively accumulate brand reputation. On the other hand, it is beneficial to cost-plus deduction, which lowers taxes.

The collection of development costs also plays a vital role in the planning of land value-added tax. For example, among multiple liquidation units, if the amount of the deducted items can be collected directly according to different liquidation units, it should be collected directly; if it cannot be collected directly, it should be reasonably apportioned according to the area occupied by each liquidation unit, the salable building area, *etc*. For the apportionment of the amount of different types of real estate or sold and unsold deduction items in the same liquidation unit, if it can be collected directly according to different types of real estate, it should be collected directly; the amount that cannot be collected directly shall be apportioned according to the construction area of different types of real estate first and then apportioned according to the sold and unsold areas of different types of real estate. In the calculation of real estate investment, finance should comprehensively compare and analyze whether the development cost should be collected directly or apportioned reasonably, which would be beneficial to the planning of land tax increase. For those that can be directly attributed to the cost, the contract should be signed separately. However, if the contract cannot be signed separately, the amount should be indicated separately when the contract is settled and the invoice is issued so as to facilitate the direct collection and allocation of costs and expenses later. In short, within the scope allowed by the legal system, the relationship between cost and land tax increase planning should be carefully considered through legal actions so that the enterprise's product reputation and profits can be achieved.

Karayan *et al*. pointed out that tax planning should not only be discussed from the financial point of view, but also be considered and implemented at the overall strategic level of an enterprise. The previous concept of only paying attention to the current tax payment should be transformed from the perspective of continuous operation. The taxation issue should be considered from a different perspective and matched with the dynamic process of actual enterprise operation [18]. Hondroyiannis *et al*. proposed that an enterprise's life cycle should be fully considered in tax planning and different tax planning strategies should be adopted according to different cycles [19]. Cárdenas *et al*. studied the correlation between tax planning and enterprise location selection and found that there is a continuous interaction between the location selection of the company and the tax planning activities within the company [20]. For example, the urban maintenance and construction tax implements a three-level proportional tax rate with regional differences, there are also large regional differences in land value-added tax, and the standards are not uniform, such as the "dichotomy" and "three-division method" in the settlement of land value-added tax [21]; whether the underground parking space is within the scope of liquidation, the regional restrictions need to be taken into account when planning the land value-added tax, and tax planning should be reasonably carried out.

Accounting issues should be taken into consideration. For example, the reduced output tax due to the land price deducted from sales can be recorded in three different ways: "principal business cost," "principal business income," and "other income" [22]. It is necessary to compare and analyze its impact on major tax types, such as value-added tax and land value-added tax; select the most reasonable accounting treatment method; and straighten out the accounting treatment of this business in advance. This would aid the settlement of land value-added tax for "new real estate projects."

In terms of design schemes, construction progress, *etc*., finance should conduct comprehensive analyses and calculation of real estate projects in all aspects, from multiple dimensions, and at all stages. At the same time, it is necessary to conduct an in-depth investigation of the local government's planning, policies, market, and other factors related to the real estate industry so as to identify the degree of risk of investment projects. At present, there is a general trend of informatization and intelligent application. Enterprises should make full use of network information technology to obtain accurate information and materials about investment projects and carry out in-depth research on the implementation stages of project construction through diversification from various angles and in consideration of multiple factors. In order to obtain the correct project selection, carrying out systematic research and analysis scientifically and rationally through various methods, such as internal rate of return, cost profit rate, investment payback period, break-even point, *etc*., to evaluate its feasibility and risk plays a very forward-looking and guiding role.

3.3. Financial budget management

Budget is a systematic way for an enterprise to allocate various resources. By carrying out budgeting work, the established strategic goals of the enterprise can be achieved, and the completion progress of the strategic goals can also be monitored and controlled. The specific amount of expenditure, forecast profit, and cash flow can be monitored throughout the process.

The application of budget management in Chinese enterprises is still in its infancy [23]. At present, many enterprises are making financial budgets, but the participation of financial personnel in the budget work is limited to data collection, summary, and result presentation, without substantial participation in budget review, analysis, and control. Since financial management cannot comprehend budgets and treats budget management as a fund plan, it cannot fulfil the role of a staff.

For real estate companies, budget management is a very important tool, which can be used to control various costs, maximize the utilization rate of corporate funds, and increase profit margins. According to Chrisman *et al*. [24], the comprehensive implementation of budget management is the result of years of accumulated management experience of many foreign companies. It is a reasonable upgrade for modern companies and represents a management ability or level that fully integrates the company's operations, organizational strategies, and culture [24]. Budget is by no means as simple as it appears on the surface. Lindquis *et al*. divided budget management into four stages: budget goal setting, budget preparation, budget adjustment, and budget incentives [25]. Budget management runs through all aspects of business operations and requires participation from various departments. Based on the future planning of enterprises and the financial indicators of projects, professional financial judgments are put forward, analyses and judgements are made from multiple perspectives, such as cash flow, rate of return, and taxation, and a decision-making basis is provided for the strategic deployment of enterprises.

3.3.1. Standardize budgeting

Budget preparation is an important basis for budget management work. Only when the budget preparation data are real and feasible can budget management be carried out effectively. The budget management in real estate development enterprises is highlighted by the lack of scientificity in preparation, the use of

historical data, poor accuracy, the dissociation from the strategic goals of enterprises, the actual development situation, and the economic environment, as well as the lack of support. At present, the management does not pay enough attention to budget preparation, and enterprises do not have systematic and instrumental budget management. Excel remains the main tool for budget preparation. The logic report verification of basic data relies on manual work; thus, the inspection of huge data volumes is time-consuming and inefficient [26]. Some real estate development companies still uphold the principle that the general budget is managed by financial departments, thereby neglecting the synergy of various departments. When enterprises carry out budget management, they must first strengthen the scientific nature of budget preparation. The most important thing is to organize and implement it based on the business objectives and strategic goals of real estate development enterprises and change the conventional "short-term" behavior into long-term strategic and forward-looking budget preparation. In the specific implementation process, it is necessary to focus on the overall development strategy of real estate development enterprises, refine and decompose the strategic goals, and form a phased or annual business plan to facilitate later comparisons and assessments. In addition, the enthusiasm and initiative of various departments to participate in budget preparation should be strengthened, and corresponding coordination mechanisms, coordination models, and collaborative relationships should be established, with each department undertaking the corresponding responsibilities and tasks, *i.e.*, dividing labor without separating it [27]. At the same time, the financial management department should also strengthen communication with the sales department, cost department, design department, and engineering department; explore the substantive business of each department; gauge the accuracy of various data; summarize income and expenditure data; as well as analyze, process, and obtain real and reliable financial data in time. All these play an important role in the relevant business decision-making of enterprises. In order to ensure a more scientific budget management, there is a need to extensively solicit opinions from various departments and comprehensively design the budget preparation work, while constantly revising and improving it [28].

3.3.2. Strengthen budget execution

In the process of budget management, there is a lack of sufficient analysis, monitoring, and control mechanisms. The budget system is a mere formality; therefore, it is unable to fulfill its mission. Budget execution cannot be effectively coordinated and controlled, nor can it be accurately assessed and monitored in real time. There is poor awareness of operating cash flow management and control in corporate financial management [29], and companies often assume building first-class real estate brands and services as their overall development goal and are prone to overemphasize on market development, while neglecting cash flow. Budget overruns are common since budget preparation is not only poorly executed, but also frequently adjusted. Therefore, ensuring good budget control is a major issue that real estate development companies need to examine carefully; otherwise, it would lead to budget management failures and even major risks.

Hope *et al*. pointed out that in the process of reviewing the budget development process, budget criticism will not affect the budget itself fundamentally, but rather resolve the various problems in the business management process [30]. Enterprises need to continuously strengthen budget execution, increase training and guidance for various departments and relevant personnel so that they can develop a sense of responsibility, as well as assume the implementation of various goals, tasks, and requirements of budget management as one of the key tasks. Financial management should be guided by the budget, the rolling budget should be used as the starting point, and the sales revenue and expenditure of the enterprise should be reversed to achieve a reasonable balance of capital inflow and outflow. In addition, it is imperative to continue to decompose and refine the annual budget indicators on a monthly basis, give early warning of problems by exposing them as quickly as possible, analyze and solve problems on a monthly basis, coordinate with various departments to ensure efficiency, identify the risk factors in a timely manner based

on operational analysis, and strengthen the construction of budget adjustment mechanisms. In order to establish a dynamic adjustment model [31], it is necessary for the finance management to effectively strengthen the analysis of various budget data, use big data technology to organize the implementation, establish a big data budget analysis platform, identify the deviations, make timely, comprehensive adjustments, formulate safeguard measures and plans, assign responsibilities to individuals, form a dual-line mechanism for promotion and reporting, condense budget goals, direct enterprises to move forward on the set track, and improve the ability of enterprises to resist risks.

Enterprises should pay more attention to the income and expenditure deviations of operating cash flow, which would directly affect the enterprise's interest-bearing liabilities, financial expenses, and fund balances. Andreas *et al*. used a model to analyze the investment and use of funds; combined with the evaluation indicators related to the development project, they adjusted the cash flow dynamically, laying a solid foundation for future development project financial evaluation and cash flow statement management [32]. The research results of Francis *et al*. [33] on cash flow management and risk control measures are also worthy of reference. Finance should always remind the enterprise to pay attention and make immediate adjustments and guarantee plans if there are deviations. For example, the inflow of real estate funds mainly involves sales receivables. Sales should fully investigate the surrounding conditions of the project, design a feasible repayment plan for the project, make changes in a timely manner, and formulate safeguard measures; the finance department should actively communicate with financial institutions and the project department, promote the standardization of the mortgage payment process, improve the efficiency of mortgage approval, ensure that the process is controllable, and ascertain that the mortgage payment is returned. Moreover, finance should also actively strengthen communication and relationship maintenance with the tax bureau and make full use of policies, such as incremental tax refunds, to reduce the burden on the company's working capital. In terms of capital outflow, various payment methods should be explored, such as supply chain financing, house arrival, and financial company bills, to enhance the concept of time value of funds and accelerate the efficiency of capital turnover; capital payment should also be guaranteed and stressed, and the key points involved in development should be inflated. The key funds of the nodes are invested to improve the efficiency of fund payment approval, ensure that the overall development progress is controlled, reduce all unnecessary expenditures, and strictly manage project expenditure budgets.

3.3.3. Strengthen the budget review mechanism

Brownell *et al*. proposed budget participation as a means to improve organizational and individual performance. With the development of the principal-agent mechanism, the problem of asymmetric information between superiors and subordinates as well as various parallel departments is aggravated. This problem can be alleviated to a certain extent by the participation of each member in the budget [34]. An appropriate assessment mechanism is a prerequisite to support the budget system. However, the current budget assessment mechanism of real estate enterprises is flawed; the main reason is that the corresponding assessment indicators are not clear enough and the assessment process is not strictly followed. Hence, there is a need to improve the budget execution system and optimize the reward and punishment measures for budget execution [29]. Good budget management outcomes can only be attained by implementing budget management earnestly.

3.4. Asset management

In the case of such fierce competition in the market economy, strengthening enterprise asset management can reduce enterprise investment risks and maintenance costs as well as provide protection for the healthy development of enterprises. Fundraising has a significant impact on the life cycle of projects. Real estate projects require large amounts of funds, and companies often opt for bank loans. Okafor *et al*. investigated

whether commercial banks can be used as a financing source for real estate enterprises through questionnaire survey and interviews. Through an in-depth analysis of their financing difficulties, the results indicated that commercial banks are not the best choice as short-term commercial bank deposits do not match with the long-term real estate development cycle [35]. Squires *et al*. conducted a study on issues related to the innovation and development of financing models of real estate companies. The results showed that the degree of diversification of corporate financing models directly affects the decline in corporate financing costs, indicating that enterprises must diversify their financing models in order to increase their value [36]. Therefore, in the process of fundraising, finance should ensure good preliminary research; conduct comprehensive comparative analyses of loan conditions, time, interest rates, and other factors for different financial institutions and different financing modes [37]; obtain loans with long periods, low interest rates, and favorable conditions to reduce financial risks; improve the development and operation efficiency; and provide assistance to enterprises to obtain more economic benefits. At the same time, the credit management of enterprises should be strengthened so that enterprises with good credit will have more abundant cooperation resources and cooperation conditions. Second, there must be a plan for fundraising. According to project investment calculations and budgeted cash flow conditions, the loan amount should be strictly controlled, and repayment should be made in a timely manner according to the repayment situation.

For assets such as accounts receivable, finance should cooperate with other relevant departments to carry out regular asset inventory and collection of accounts receivable [38], make calm analysis of the market according to the current situation of the real estate market, grasp the relevant trend in time, and speed up fund recovery.

For pre-sale supervision funds, we should learn from the successful experience of western countries. In foreign commercial housing pre-sale fund supervision models, supervision through third-party agencies, such as agencies in the United Kingdom, real estate notarization companies in Belgium, and the real estate transaction guarantee system in the United States, is more common. In addition to the above, finance should emphasize on the significance of communication with government departments, obtain as much government financial support as possible, and appropriately reduce the amount of key regulatory funds; focus on the release of regulatory funds [39] and rationally reverse the sales online signing work arrangement according to the deposit and withdrawal progress of regulatory funds to increase the capital turnover rate; reduce capital occupation by communicating with financial institutions to issue letters of guarantee and use these letters of guarantee to replace pre-sale regulatory funds; speed up project management progress to meet the supervision fund withdrawal conditions as soon as possible, while ensuring project quality.

4. Research dearth and prospects

4.1. Research dearth

The real estate industry is a high-risk and -profit industry. The risks and benefits of financial management coexist. Especially in the current economic environment, it is necessary to analyze the risks of real estate financial management and address them. A good corresponding management and control work is also important. This paper focuses on four aspects: financial management personnel training, investment calculation management, budget management, and asset management. There are certain problems and deficiencies in the extensiveness and comprehensiveness of research. In addition, system construction, tax management, risk management, cost management, supervision and management, *etc*. are also crucial aspects of financial management that should be studied and analyzed.

4.2. Prospects

The estimated range of cash inflow and cash outflow of a development project has a significant impact on

the risk and the income of the project; hence, the estimated range should be as accurate as possible. In future research, the accuracy of the estimated range should be strengthened. The real option theory can be used to reduce the risks of development projects and make correct investment decision-making analyses. There is a need to continue to study the applicability of different financial evaluation models and the sensitivity of risk warnings corresponding to different real estate companies in order to avoid corporate financial risks and prevent crises.

With the continuous innovation and development of corporate financial management systems and by standardizing the management system and using rationalized management methods, in-depth research on corporate financial management risks will significantly improve, thereby strengthening pre-prevention and post-event management and supervision as well as the construction of an ideal overall financial management system for real estate enterprises.

5. Conclusion

Under the new situation, whether in the operation or development process, real estate is facing significant challenges. The operating mechanism of financial management is directly related to the development and growth of enterprises. Financial management is the core link in the management of real estate enterprises. The current level of financial management still requires improvement; hence, enterprises should pay more attention to it, provide training for financial management personnel, improve the financial investment calculation and management capabilities, introduce new budget management concepts at home and abroad, establish an asset management and control system, and carry out good risk management. Early warning and countermeasures can help ensure the compliance and professionalization of financial management, improve the internal management capabilities of real estate companies, and promote the long-term and stable development of real estate industries in China.

Disclosure statement

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Analysis of Enterprise Cost Management from the Perspective of Management Economics

Bin Chen*

Zibo Hi-tech Industry Investment Co., Ltd., Zibo 255086, Shandong Province, China

Corresponding author: Bin Chen, gph111@163.com

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Abstract: In view of economic globalization, China's economy has entered a stage of normalized development. In the post pandemic era, the costs of raw materials, production, sales, and labor in Chinese enterprises continue to increase, leading to severe competitive pressure among the enterprises. Therefore, it is of great theoretical and practical significance to actively apply the relevant theories of management economics to guide the cost management of Chinese enterprises, improve their economic benefits, and promote healthy and sustainable development. Currently, there are still many problems in terms of cost management in Chinese enterprises. Therefore, it is crucial to address these problems and further improve the effectiveness of cost management. This paper presents an overview of cost management and an analysis of the specific problems and provide corresponding countermeasures, in hopes of to providing a reference for cost management in enterprises and achieve the goal of stable and sustainable development of China's economy.

Keywords: Management economics; Enterprise cost management; Problems; Strategies

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1. Introduction

In a socialist market economy with Chinese characteristics, for an enterprise to stand out in the highly competitive market and achieve rapid economic growth, various measures should be taken to continuously expand its market share, reduce enterprise costs, and achieve stable growth. Currently, the management economics theory is commonly used among enterprises to reduce operating costs to achieve "cost reduction while increasing efficiency" in production and business [1]. The theory of management economics mainly focuses on three aspects: market demand, production and operation of the enterprise, and the social market economic environment. This theory deeply analyzes and summarizes the internal and external environment of production and operation, helping enterprises further understand the market environment and problems in cost management and how to solve them. In this way, the economic development of enterprises can be accelerated, and their competitiveness can be improved.

2. Overview

2.1. Concept of enterprise cost management

Enterprise cost management refers to the analysis and management of the costs consumed in each link of the production and operation process of an enterprise through a series of scientific management methods, with the purpose of reducing production costs and improving economic benefits. All actions taken to manage enterprise costs are called enterprise cost management. In view of the socio-economic development, the expenditure of enterprises on production and operation is also increasing, especially in the purchase of

raw materials, wages, and product marketing, which are important factors affecting the development of enterprises. Enterprise cost management revolves around all links and processes in the production and operation of an enterprise, specifically manifested in the scientific and reasonable evaluation, prediction, and control of production costs. In this highly competitive market, the competitive pressure faced by enterprises is not only reflected in the sales volume and price of products, but also involves other factors. Therefore, with the appropriate application of management economics theories, enterprises can adopt various scientific and effective methods to manage their costs, thereby improving their profitability, and achieving a healthy and sustainable development [2].

2.2. The importance of enterprise cost management

Enterprise cost management is an important manifestation of the overall management level of an enterprise and is an important factor in determining the quality of enterprise management. Enterprise cost management mainly includes four aspects: budget, control, analysis, and assessment of cost items in the production and operation process of an enterprise. Effective enterprise cost management can not only further improve the cost control of the enterprise, but also enhance the competitiveness of the company's products, and promote a healthy and sustainable development of the enterprise. Secondly, the application of information technology and relevant theories of management economics in cost management can effectively improve the financial accuracy and efficiency of enterprise, while also significantly standardizing the accounting of enterprise costs, which in turn ensures the quality and security of the enterprise's financial information. Moreover, good cost management helps national government departments in supervising and managing enterprises in terms of taxes and product quality. Finally, using management economics in cost management can effectively enhance the core competitiveness of enterprises in the highly competitive market environment. Scientific and effective cost management methods can drive the modernization of enterprises, thereby meeting the needs and requirements of modern social market development [2].

3. Problems in enterprise cost management from the perspective of management economics

In recent years, Chinese enterprises have applied the relevant theories and methods of management economics to their cost management and achieved good development. However, there are still some problems, leading to a large gap between the cost management of most Chinese enterprises and other world-class enterprises. A detailed analysis of the problems in cost management in Chinese enterprises from the perspective of management economics are explained below [3].

3.1. Lack of correct awareness of enterprise cost management

China's economic development market has been severely affected due to the COVID-19 pandemic and the international trade environment, and enterprises, no matter big or small, are facing strict competitive pressure. In order to survive and develop during an economic downturn, some enterprises choose to expand production on a large scale, hoping to get rid of the shackles of the economic market downturn by further expanding market share. However, expanding production or seizing market share require a large amount of production input and marketing expenses, leading to a further increase in costs, and even breaking the capital chain, which will severely affect the long-term development of the enterprise [4]. The reason for this phenomenon is that some enterprise leaders lack the awareness of enterprise cost management, leading to the inability to apply the theoretical knowledge of management economics in the production and operation process, resulting in low production efficiency and even losses, making them lose their competitive advantages in the highly competitive market, and this is not conducive to long-term development of enterprises. Some enterprises in China, especially small and medium-sized enterprises, have a relatively backward understanding of cost management. They generally believe that the main body of enterprise costs

is the financial department, and that they should further strengthen the functional value of the financial department to achieve cost management by reducing expenditure. However, this approach is very one-sided and ineffective. Cost management refers to the implementation of cost management in all aspects, ranging from raw material procurement to product sales to ensure effective cost management. Relying solely on the financial department to implement cost management will inevitably lead to ineffective cost management, and it is not conducive to the long-term development of the enterprise [5].

3.2. Lack of professional talents

Management economics is a highly specialized and comprehensive discipline, in which it requires managers to have a high level of knowledge in management, and large amount of practical experience in cost management. However, managers in many enterprises do not have these qualifications. Some managers understand the theory of management economics but lack experience in enterprise production and cost management, resulting in ineffective cost management. In addition, many enterprise managers in China only focus on the management of production costs, while ignoring cost management in other operations, resulting in the inability to maximize cost management, thereby affecting the long-term development of enterprises [6]. Besides, the effective implementation of enterprise cost management cannot be separated from effective guidance and training for managers and staff. Although in recent years, Chinese enterprises have placed more emphasis on cost management and applied management economics in cost management and have also strengthened special training for managers and employees, but the training content is more focused on the skills and methods of cost management. Professional knowledge training in economic management and cost management has been largely neglected, which led to the lack of awareness of cost management among employees in Chinese enterprises, and a failure to effectively grasp the significance and value of cost management, resulting in a large amount of unnecessary expenditures on the production and operation processes of many enterprises [4].

3.3. Lack of scientific and effective cost management methods

With the continuous development of the Internet and information technology, substantial benefits have been brought to the development of enterprises. More and more enterprises are beginning to use modern information technology to guide production and operation, further improving production efficiency and quality. However, there is still a lack of scientific and effective cost management methods, especially in cost accounting. Many enterprises still use manual accounting, which greatly increases the cost of accounting, and it is also difficult to guarantee the accuracy and scientificity of the accounting data. In addition, most enterprises in China focus on strict cost management during the production stages, including purchase of raw materials and equipment, labor remuneration, and other aspects. In order to save cost, some employees may even purchase low-priced and subpar raw materials or reduce their "Five Insurances and One Fund." As a result, the product quality is affected, which affects the competitiveness of the enterprise, causing serious impact and harm to its survival and sustainable development. Therefore, enterprises should formulate their own scientific and effective management methods and attributes of their products, so as to minimize production costs and enhance the core competitiveness of their products without affecting the product quality.

4. Effective approaches of enterprise cost management from the perspective of management economics

4.1. Improving awareness of cost management

Cost management directly affects the economic benefits of enterprises. In order to improve the competitiveness of enterprises, it is necessary to improve their awareness of cost management. Firstly, it is

necessary to establish a correct understanding of cost management. Cost refers to the expenses incurred in the production and operation of an enterprise and is a series of measures taken to evaluate and control the relationship between input and output of related activities. Various industries are facing fierce competition in the market economy. In this situation, only by continuously improving their competitiveness can they survive and develop. Moreover, it is also important to know the differences between cost management and traditional management methods. Many traditional cost management models are no longer applicable in the current market economy, and corresponding changes must be made to meet the needs of modern economic development [7]. Finally, it is necessary to continuously enhance the awareness of the importance of cost management throughout society. To carry out cost management under the market economy, it is necessary to use the laws of market economy as the foundation and prerequisite for corresponding improvement and innovation. Under the socialist market economy, in order to enhance the comprehensive competitiveness of enterprises and maximize economic benefits, it is necessary to change traditional concepts, establish a correct awareness, and actively participate in cost management. Only then can society better understand the importance and necessity of enterprise cost management, thereby enhancing the participation of the entire society in cost management of enterprises.

4.2. Strengthen the cultivation of enterprise cost management talents

The development of enterprise cost management cannot be separated from professional management personnel. In fact, the comprehensive ability of enterprise management personnel is the core factor that determines the efficiency and quality of cost management of an enterprise. From the perspective of management economics, having high-quality management personnel is crucial to achieving the goal of reducing enterprise costs. Therefore, to further improve the quality of enterprise cost management and enhance economic efficiency, enterprises should strengthen the training of professional cost management personnel. Firstly, enterprises can invite well-known experts and scholars from the industry to carry out seminars to train their management and financial personnel in terms of theoretical knowledge of management economics and cost management skills, to ensure that their employees not only master the knowledge of management economics, but also have a deep understanding of cost management. Secondly, when recruiting talents, enterprises should prioritize outstanding talents with rich management experience in the field of cost management and require candidates to have certain qualifications in management and economics to ensure that the recruited talents can be engaged in cost management as soon as possible. Finally, enterprises should establish a targeted cost management reward and punishment mechanism with the achievements of employees as an important standard for reward and punishment. Enterprises should also actively guide and encourage their employees to innovate cost management methods, expand cost management achievements, so that the concept and awareness of cost-saving can be spread throughout the company, through contributing to the healthy development of the enterprise [7].

4.3. Innovating cost management methods and building a sustainable cost management system

The development of science and technology has brought positive impacts on people's lives, work, and other aspects. Therefore, the Internet and information technology should be utilized in the cost management of an enterprise. For example, an information-based cost management system can be built. In this the effectiveness and quality of cost management can be improved. When applying management economics theory in enterprise cost management, the current internal and external environment of the enterprise should be analyzed objectively and impartially. Besides, the social environment and specific requirements for enterprise financial management should be well understood. Moreover, it is necessary to select effective cost management methods based on the actual situation within the enterprise and formulate a scientific and reasonable cost management plan from the perspective of sustainable development of the enterprise, in

order to respond to the increasingly fierce competition in the social market economy. Secondly, enterprises should mediate the cost investment of products, invest as much as possible in product innovation and research and development, minimize the expenses in production and marketing, improve the economic profit margin of their products, and reduce production costs, and prevent problems such as loss of market competitiveness due to reduced product quality.

5. Conclusion

In short, cost management is an important part of enterprise management and an effective way to enhance the core competitiveness of enterprises. Cost management based on the perspective of management economics involves making targeted adjustments to the products of an enterprise according to the market demand to ensure that products will be favored by the market to expand economic benefits and achieve sustainable development. However, there still exist a lack of correct enterprise cost management awareness, professional talents, and scientific and effective cost management methods among enterprises in China. Therefore, targeted adjustments should be made from these aspects, such as establishing a correct awareness of cost management, strengthening the training of cost management personnel, innovating cost management methods, and constructing a sustainable cost management system, in order to effectively improve the level of cost management in enterprises [7].

Disclosure statement

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Research Progress and Prospect of Tourism Carbon Emissions and Its Uncertainty Analysis Under the Goal of Low-Carbon Scenic Spots

Aihong Wang[1,2]*, Qiguang Lyu[1]

[1]Chongqing University of Science and Technology, Chongqing 401331, China

[2]Chongqing Energy College, Chongqing 402260, China

Corresponding author: Aihong Wang, 573390550@qq.com

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Abstract: Under the dual carbon goal, China Certified Emissions Reductions (CCER) and the national carbon market have become important means of emission reduction and control. The tourism industry is a strategic pillar industry of China's national economy, and scenic spots are the main sites of tourism activities. Research on carbon emissions in scenic spots is of great significance for the construction of low-carbon scenic spots and the realization of the dual carbon goal. In this paper, the research on carbon emissions in tourism is reviewed, the current research progress is discussed, and further prospects are made. The research on tourism carbon emissions in China has a good foundation and achieved certain results. However, there are few studies on micro-scales such as scenic spots. The statistical data caliber and measurement methods of carbon emissions are not uniform, and there is a general lack of uncertainty analysis. Future research should focus on building a multi-spatial dimension research system, unifying the statistical caliber and measurement methods of carbon emission data, increasing uncertainty analysis, and ensuring the robustness of research results.

Keywords: Low-carbon scenic spot; Carbon emissions; Uncertainty analysis

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1. Introduction

Under the background of global warming and increasingly prominent ecological environment problems, the impact of tourism, as the pillar industry of the tertiary industry, on the environment has attracted the attention of scholars, government departments, and relevant organizations at home and abroad. In the 2014 China-US Joint Statement on Climate Change, China proposed to achieve "carbon peak" in 2030 and "carbon neutrality" in 2060. In order to achieve the dual carbon goal, every industry in China is facing new challenges of energy conservation and emission reduction. At the 20th National Congress of the Communist Party of China in 2022, propositions to promote green development, build a beautiful China, and actively and steadily promote carbon peak and carbon neutralization were made. In order to coordinate the two strategic objectives of tourism development and both energy conservation and emission reduction, there is a need to vigorously promote low-carbon transformation and development in tourism [1].

Carbon emissions trading is an important means of emission control. In July 2021, the national carbon market started trading. By the end of 2022, the cumulative trading volume of carbon emission allowance (CEA) in the national carbon market was 2.233 tons, with a cumulative trading volume of 10.121 billion yuan [2]. The range of the national carbon market trading price is 44–60 yuan per ton, and carbon emission

rights have become the fifth asset of enterprises carbon assets. The emission reduction potential of tourist attractions is huge and promising in the carbon market. As a market unit, scenic spots have a large number of carbon sink resources, such as wetlands, forests, and lakes, while bringing a large amount of carbon emissions from tourism activities. The potential for emission reduction is huge. They should actively participate in the carbon trading market and play a catalytic role in achieving national and local carbon neutrality goals. Carbon market transactions require high data quality, as data quality is the lifeline of the national carbon market. Therefore, it is of practical significance to carry out research on carbon emissions in tourist attractions.

2. Research status of carbon emissions in tourist attractions

At present, there are few low-carbon policies related to tourism. The China Environmental Protection Federation and the China Tourist Attractions Association selected 19 National Low-Carbon Tourism Demonstration Zones in 2011, and the Sustainable Development Guide for Tourist Attractions approved by the Ministry of Culture and Tourism in 2021 only provides directional guidance for low-carbon construction and sustainable development of scenic spots. With the advent of the era of mass tourism, there will be significant carbon emissions from tourism-related activities. Scenic spots are the main sites of tourism activities, and the construction of low-carbon scenic spots is of great significance. The construction of low-carbon scenic spots requires low-carbon evaluation standards and relevant emission reduction measures. Therefore, calculating the carbon emissions of scenic spots, finding key carbon emission factors, and exploring targeted emission reduction paths will help promote the construction of low-carbon scenic spots in China.

Greenhouse gases are considered to be one of the important culprits of global warming, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), among which CO_2 accounts for as high as 75.5 % [3]. Most scholars at home and abroad use CO_2 as the research subject to measure carbon emissions. At present, there are many studies on tourism carbon emissions. From the research scale, the focus mainly is on the estimation of tourism carbon emissions at the global scale [4], national scale [5-7], and provincial scale [8,9]. There are relatively few estimates of carbon emissions at micro-scales such as tourist attractions. From the perspective of research subjects, the focus is mainly on carbon emissions from tourism transportation [10,11], carbon emissions from tourists' consumption behavior [12,13], and low-carbon management of tourism enterprises [14], while there are relatively few studies focusing on tourist attractions.

2.1. Calculation method

The calculation method is the keypoint and focus of tourism carbon emissions research. Scholars mainly use two methods, namely the top-down method based on input-output theory and the bottom-up method based on life cycle theory. The main difference between the two is the data source. Top-down data are mainly derived from statistical yearbooks, tourism satellite accounts, and other statistical data, which are used for comparative research on tourism carbon emissions and carbon tax formulation at a larger spatial scale. Bottom-up data, on the other hand, are mainly derived from the measurement data of tourism industry and tourists, which are used to study the impact factors of tourism carbon emissions at a small spatial scale.

2.1.1. Top-down method

According to literature research, although the top-down method uses second-hand data, the statistical data selected by different scholars are different. Some scholars begin from tourism economic indicators to calculate the number of tourists, the per capita cost of tourists, the energy consumption of tourism economy, and its emission coefficient, so as to obtain the tourism carbon emissions [15,16]. Other scholars begin from

the tourism energy consumption index and use the ratio of the added value of a certain industry to the total added value of the corresponding industry to obtain the tourism consumption stripping coefficient, and then calculate the various types of energy consumed by the corresponding industry, the tourism consumption stripping coefficient, the corresponding energy standard coal conversion coefficient, the sum of the product of CO_2 emissions of standard coal, and the carbon emissions of the tourism industry. The advantage of this method is that it can directly use government statistical data; thus, it is convenient and fast, simplifies the research process, and is suitable for national and provincial spatial scale research. However, its shortcomings are also evident. First, due to the different selection of statistical data, it is difficult to compare the research in different regions horizontally, and the research results in the same region will also have a huge gap. Secondly, in view of the deep and extensive integration of tourism with other industries, separating and recognizing the energy consumption science related to tourism are the difficulties faced with this method.

2.1.2. Bottom-up method

According to literature research, the bottom-up rule is calculated by scholars according to the actual carbon emission sources of the research object, and the total carbon emission is then estimated. The calculation model of carbon emissions from different carbon sources is relatively uniform, that is, the product of carbon source activity data and carbon emission factors. The Intergovernmental Panel on Climate Change (IPCC) assumes that the carbon emission factor is fixed, and this practice is continued by scholars. Different scholars use different carbon emission factors. Some scholars selected energy (including mobile source fuel and electricity) and waste (including wastewater, solid waste, and manure) as carbon emission factors [13,17]. Some scholars selected tourism activities, such as eating, living, traveling, shopping, entertainment, *etc*., as carbon emission sources. Some scholars subdivided different traffic vehicles (including sightseeing vehicles, private cars, and working vehicles) and calculated the traffic carbon emissions of scenic spots by combining the number of passengers [18]. Some scholars selected transportation, scenic area management (including office, tourist facilities, and public facilities) and solid waste as carbon emission sources [19]. The advantage of this method is the accuracy of data, with fine analysis, and it is suitable for small spatial scale carbon emission research. On the other hand, the disadvantage is the complex and time-consuming data acquisition process, with many uncertainties.

The carbon emission coefficient is applicable to both the bottom-up method and the top-down method. For example, some scholars begin with tourism energy consumption, obtain the gross domestic product (GDP) energy consumption and various energy consumption of the research object through the statistical bulletin of the county where the research object is located, and then multiply the various energy carbon emission coefficients to obtain the total carbon emission of the research object [20]. For tourist attractions, their spatial scales are relatively small; thus, the bottom-up approach is more applicable.

2.2. Carbon emission coefficient of tourist attractions

Carbon emission coefficient refers to carbon dioxide emission coefficient, which is the key value in the calculation process. However, the carbon emission sources of different tourist attractions vary, along with the carbon emission factors. The carbon emission coefficient in common tourism carbon emission research mainly includes traffic carbon emission coefficient, power carbon emission coefficient, water supply carbon emission coefficient, waste carbon emission coefficient, and so on.

2.2.1. Intergovernmental Panel on Climate Change recommended calculation method

The calculation of carbon emission coefficient has not been uniformed across the many studies conducted. However, the calculation method most used is the one recommended by the IPCC. The 2006 IPCC

Guidelines for National Greenhouse Gas Inventories 2019 Revision covers greenhouse gases produced by the energy industry, agriculture, and waste. The IPCC recommended calculation method has been used in many studies [17,19,21,22]. The specific formula is as follows:

$$C = OC \times V$$

where C is the carbon dioxide emission coefficient of a certain type, OC is the original carbon dioxide emission coefficient recommended by IPCC 2006 (2019 revision), and V is the recommended calorific value of this type of energy in China.

2.2.2. Traffic carbon emission coefficient

Traffic carbon emissions are mainly caused by energy. Due to the questionable global or local applicability of the carbon emission coefficient obtained by the IPCC recommended calculation method [1], some scholars have adopted the equivalent standard coal coefficient method [19] to calculate the traffic carbon emission coefficient. The specific formula is as follows:

$$D = E \times I_c \times O_c \times R$$

where D is the carbon dioxide emission coefficient of a certain type of energy, E is the low calorific value of this type of energy, I_c is the carbon content per unit calorific value of this type of energy, O_c is the carbon oxidation rate of this type of energy, and R is the relative atomic mass ratio of carbon dioxide to carbon, in which the general value is 44/12. Among them, the low calorific value of energy, the carbon content per unit calorific value of energy, and the carbon oxidation rate of energy can be obtained in the General Principles for Comprehensive Energy Consumption Calculation and China Greenhouse Gas Emission Accounting Methods and Reporting Guidelines.

2.2.3. Electricity carbon emission coefficient

In order to accurately and conveniently develop Clean Development Mechanism (CDM) projects in China's key emission reduction areas in line with CDM rules and China's greenhouse gas voluntary emission reduction projects (CCER projects), the Department of Climate Change of the Ministry of Ecology and Environment of the People's Republic of China publishes the China Low-Carbon Technology Fossil Fuel Grid-Connected Voluntary Emission Reduction Project Regional Grid Baseline Emission Factors on a yearly basis. The national grid belongs to indirect carbon emissions. For tourist attractions, scholars generally directly refer to the power carbon emission coefficient in the document [17,19] for convenience of research and then multiply it with electricity consumption to obtain the power carbon emissions of the power grid. As for the direct carbon emissions caused by local power generation, it should be calculated by the power generation structure (thermal power generation, hydropower generation, wind power generation, photovoltaic power generation, *etc.*), and the carbon emissions of thermal power generation should be converted according to the emission factors of fuel. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories 2019 Revision does not provide emission factors for power generation; instead, it only provides emission factors for fuels used for power generation and greenhouse gas estimation methods for water injection in reservoir area.

2.2.4. Waste carbon emission coefficient

In the study of tourism carbon emissions, only solid waste is considered as "waste." Waste treatment in China includes landfill, composting, and incineration. The carbon emission coefficient of solid waste is

obtained by multiplying the amount of solid waste, unit energy consumption of waste treatment, standard coal conversion coefficient of electric energy, and standard coal coefficient [21].

Most tourism activities take place in major tourist attractions and have become an important area in low-carbon tourism research. The study of carbon emissions in scenic spots is an important part of low-carbon tourism. It can be seen from the above that the research method of carbon emissions in scenic spots has matured, that is, the bottom-up method is used to calculate the product of carbon source activity data and carbon emission factors, and the carbon emissions of scenic spots are then obtained. However, there are great differences in carbon source activity data between tourist attractions, carbon emission factors are complex and diverse, and there are many uncertainties that affect the accuracy of carbon emissions research results. In order to calculate the carbon emissions of scenic spots more accurately and clarify the carbon assets of scenic spots, it is necessary to improve the accuracy and stability of carbon emissions research results and identify the key factors of carbon emissions, so as to formulate more targeted emission reduction measures.

3. Uncertainty analysis

In the actual practice of carbon emission research in tourist attractions, due to conceptual errors such as the unrecognized emission mechanism or the non-existence of measurement methods, there are model errors such as simplification of calculation models and data errors such as limited data sample size, measurement errors, and classification errors, which directly affect the calculation and analysis of carbon emissions. Uncertainty analysis is needed to provide accurate information for emission reduction decisions. It includes quantitative uncertainty analysis and qualitative uncertainty analysis. Quantitative uncertainty analysis includes random errors, such as limited data samples and measurement errors, while qualitative uncertainty analysis includes systematic errors, such as conceptualization, mode, measurement technology, and data derivation. This paper focuses on quantitative uncertainty analysis.

According to literature, uncertainty analysis has been maturely applied in the analysis and prediction of carbon emissions in line with businesses such as industry [23], agriculture [24], and transportation [25]. In the tourism industry, Liu *et al*. analyzed the uncertainty of capital strategy of tourism supply chain enterprises and simulated it with MATLAB software [26]. Han *et al*. summarized the uncoordinated factors that caused the uncertainty of ecotourism planning and proposed several improvement measures [27]. Yang *et al*. summarized the causes of the uncertainty of greenhouse gas emission estimation in China's natural wetlands [28]. With regard to the research direction of tourism carbon emissions, at present, it stops at the calculation of carbon emissions and generally lacks verification and the uncertainty analysis of carbon emission measurement data.

When conducting uncertainty analysis, the description tools that are commonly used are box uncertainty sets [23], and Monte Carlo model [24,25], SimaPro 9.0 [24], and MATLAB [26] are among the commonly used analysis tools. Generally, sensitivity analysis is carried out at the same time as uncertainty analysis. According to the data of different carbon source activities, the high-sensitivity input parameters of carbon emission are identified to provide reference for formulating emission reduction measures.

In short, it is imperative to analyze the uncertainty in the study of carbon emissions, and the essential methods and tools necessary for this are mature. The study of carbon emissions in tourist attractions generally lacks uncertainty analysis, which needs to be paid attention to [29].

4. Summary and prospect

While China's research on tourism carbon emissions generally has a solid foundation and yielded some results, there are still some problems that require further research and discussion.

4.1. Constructing a multi-spatial dimension research system

At present, the spatial scale of tourism carbon emissions research is mainly based on national, provincial, and municipal regions, and there are only a few micro-scale studies such as tourist attractions. According to the national conditions and people's conditions, we should construct a multi-spatial dimension of tourism carbon emissions research, so as to build a more perfect research system and further explore the spatial distribution of tourism carbon emissions. At the same time, with the rapid development of CCER and the national carbon market, the establishment and improvement of carbon asset accounts based on scenic spots are conducive to mobilizing the enthusiasm of scenic spots for emission reduction and to giving full play to the role of tourism in the carbon neutrality strategy.

4.2. Unified carbon emission data statistical indicators and carbon emission coefficient

Whether it is "top-down" or "bottom-up," there are inconsistent statistical indicators and inconsistent calculation methods of carbon emission coefficients. In terms of statistical indicators, some use economic income indicators, while others use energy consumption indicators as data accounting standards; in terms of carbon emission coefficient, some adopt the IPCC carbon emission coefficient method, while others adopt the standard coal coefficient method, resulting in large differences in the research results of different scholars based on the same research object and the inability to compare different research objects horizontally. We should unify the index caliber and establish a unified foundation and platform, such as the unified use of tourism satellite account research framework and data; carbon sources should be classified according to the actual situation in China, and a carbon emission coefficient calculation method should be used for the same carbon source.

4.3. Increase uncertainty analysis

At present, there is a general lack of uncertainty analysis in tourism carbon emission research, rendering inaccurate and inconclusive research results. Uncertainty analysis should be increased. Through Monte Carlo and other simulation software, the probability density function of total emissions is constructed by repeating random values of different parameters to ensure the accuracy and robustness of the research results. At the same time, the impact of different emission reduction measures on carbon emissions in scenic spots should be predicted by simulation, so as to formulate more targeted and effective emission reduction measures.

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Marketing Path of Enterprise Brand Management Under the New Economic Situation

Tongfei Lin[1]*, Qiansha Zhang[2]*

[1]Faculty of Business, City University of Macau, Macao Special Administrative Region 999078, China

[2]School of Business Administration, Guangxi University of Finance and Economics, Nanning 530003, Guangxi Zhuang Autonomous Region, China

Corresponding authors: Tongfei Lin, 332339586@qq.com; Qiansha Zhang, 2018210034@gxufe.edu.cn

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Abstract: Under the new economic situation, the previous marketing concept of "good wine needs no bush" is now applicable to the operation and development of modern enterprises. Therefore, enterprises must actively innovate marketing concepts and pay adequate attention to brand management. Only in this way can enterprises develop sustainably in a highly competitive market environment. We explore and analyze the significance and existing problems of enterprise brand management marketing under the new economic situation and put forward a marketing path in hope that this research will contribute to the development of enterprises.

Keywords: New economic situation; Enterprise; Brand management; Marketing

Online publication: April 25, 2023

1. Introduction

All enterprises need to pay adequate attention to marketing in their operation and development. In order for enterprises to implement marketing more effectively, they need to integrate marketing with brand management. Through this integration, further breakthroughs in marketing can be achieved. Under the new economic situation, enterprises must recognize the significance of brand management marketing, pay attention to the development of this work, and continuously optimize brand management through various strategic paths.

2. Significance of enterprise brand management marketing under the new economic situation

2.1. Contribute to the enhancement of enterprise competitiveness

Under the new economic situation, if an enterprise wants to occupy a certain development advantage in the industry market and gain more market share, the enterprise must pay attention not only to products, but also to brand management marketing. The naming of a corporate brand not only allows consumers to quickly recognize the brand, but also marks the product and endows it with unique value. The successful development of brand management can greatly improve the popularity of the corporate brand and contribute to the enhancement of corporate competitiveness. Therefore, it is necessary for enterprises to strengthen their brand management, so as to continuously promote the development of enterprises. In that way, enterprises can gain a firm foothold in the highly competitive market environment and expand their market share.

2.2. Contribute to the improvement of enterprise profit margin

Under the new economic situation, successful corporate brand management marketing can create more intangible assets. The intangible value of corporate brand itself far exceeds the value of products. The market sales volume of brand products with high popularity is always at the forefront, and their market pricing is relatively high, while their profit margin is naturally high. It can be seen that brand management marketing can bring more profit to an enterprise. Compared with products with relatively low brand awareness, there is a large disparity in the profit margin. For example, a certain company did not implement brand management marketing in 2017, but it paid more attention to this work in 2018. Under the influence of brand benefits, the company's sales revenue and total profit significantly improved. See **Figure 1** for details.

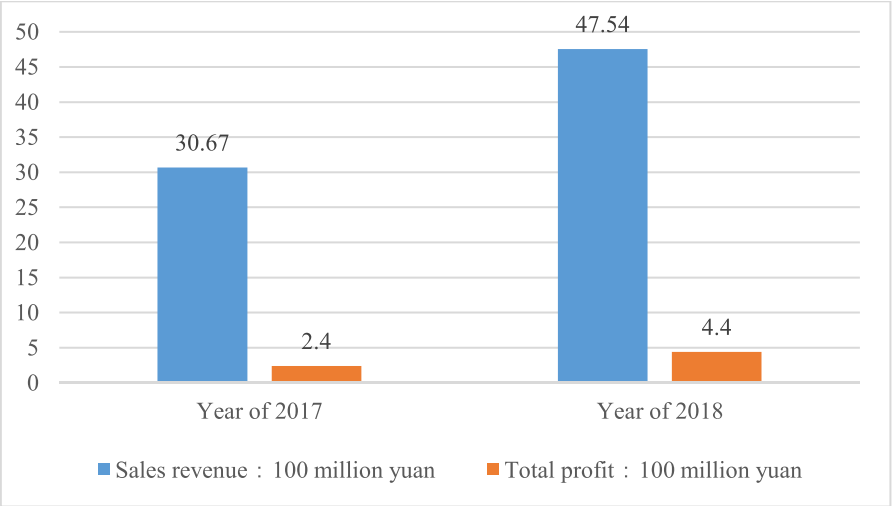

Figure 1. 2017–2018 sales and profits of a company

2.3. Contribute to the establishment of a good corporate image

Under the new economic situation, brand management marketing is implemented not only to bring more profits and intangible assets to enterprises, but also to establish a good corporate image. For an enterprise, a good image is a powerful weapon to gain advantage in market development. When a company establishes a good image, it will attract more consumers, and the company's popularity will also improve significantly, thus attracting more partners and investors.

3. Problems existing in enterprise brand management marketing under the new economic situation

3.1. Lack of attention to brand management marketing

Under the new economic situation, the market environment in which enterprises operate has become more complex, and there are many uncertain factors in it. The marketing plan originally adopted by enterprises faced issues meeting the current economic development situation. At this stage, there are still some enterprises that are unaware of the importance of brand management marketing and have a relatively one-sided understanding of brand management marketing; they are still implementing previous marketing strategies, which limit their development to a large extent.

3.2. Lack of an ideal marketing system

Under the new economic situation, in order to implement brand management marketing, it is important to focus on improving the marketing system. However, according to relevant surveys, there are still many companies that do not possess a sound marketing system, resulting in the lack of coordination and

cooperation among various departments within the company and the lack of attention to the role of brand management marketing among some staff and departments. There are also some companies that simply "mirror" the successful marketing experience of other companies when carrying out brand management marketing. In order to achieve stable development in the market environment of "gold and sand," there is a need for an ideal marketing system as support.

4. Marketing path of enterprise brand management under the new economic situation

4.1. Strengthening the innovation of marketing ideas

Under the new economic situation, the importance of effective marketing work under brand management has been gradually highlighted, and enterprises are also paying more attention to the development of the work. Many companies have begun to organically integrate brand management with marketing and innovate marketing to improve the depth of marketing work [1]. Based on this understanding of marketing, enterprises should actively innovate marketing concepts and focus on improving the strategy and sustainability of brand management marketing. To this end, it is necessary to clarify the short-term, medium-term, and long-term development goals of enterprises, as shown in **Figure 2**, and make reasonable brand management marketing strategies on this basis.

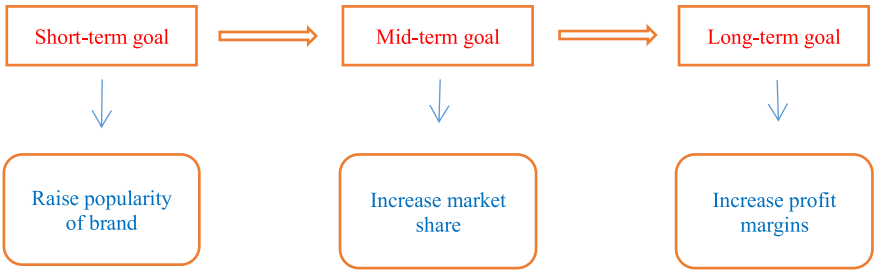

Figure 2. Enterprise development goals

Furthermore, in the process of innovating marketing concepts, enterprises also need to focus on strengthening the improvement and optimization of brand management marketing ideas and clarify the key points of brand management marketing at each development stage according to the different development stages [2].

4.2. Strengthening the perfection of the marketing system

Under the new economic situation, in the process of development, enterprises should build a complete brand management marketing system according to their own development conditions and improve their marketing level on the whole [3]. In the process of perfection, enterprises must scientifically design brand management marketing strategies, not only to strengthen product brand management marketing, but also to incorporate corporate brands and cultural brands into corporate brand management marketing, so as to improve the comprehensiveness of their brand marketing work [4]. There is also a need to pay attention to the formation of brand management and marketing synergy, so as to improve the comprehensiveness, coordination, and diversity of the brand marketing system. In this system, it is clear that all departments and staff within an enterprise must actively participate in research on brand management, marketing, brand promotion, *etc*., so as to ensure a systematic brand marketing work. While improving the brand management marketing system, it is also necessary to focus on expanding the marketing system, especially to combine corporate brand marketing with the external environment organically, so as to improve the influence and popularity of the brand [5]. At the same time, enterprises also need to increase investment in brand management marketing to support the implementation of multi-brand strategies and create sub-brands

according to the different positioning of enterprise products and the different needs of different consumer groups, so as to further improve the effectiveness of brand management marketing. The brand management marketing process is shown in **Figure 3**.

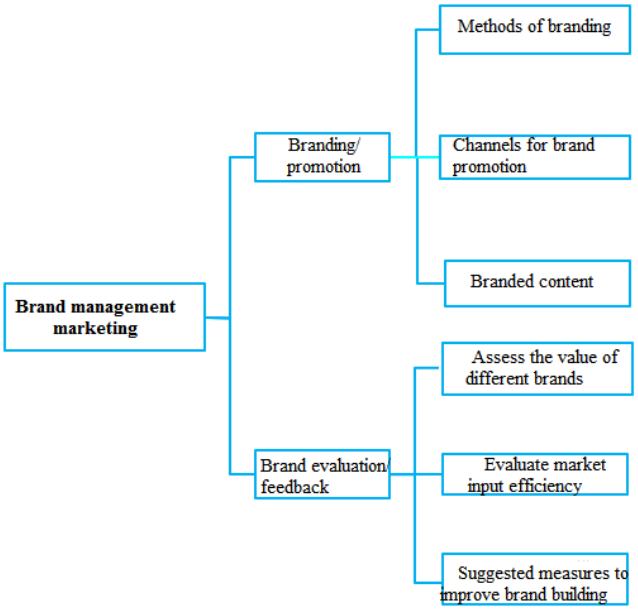

Figure 3. Corporate brand management marketing process

4.3. Accurate positioning of corporate brand products

Under the new economic situation, when an enterprise carries out brand management marketing, the enterprise must accurately position the product during the product design process. The product quality, product function, and target consumer groups need to be comprehensively analyzed during positioning [6]. Accurate corporate brand product positioning not only enables companies to occupy a certain market share, but also increases the loyalty and stickiness of target consumer groups. If the product positioning does not conform to the corporate brand image, it is likely to cause a certain resistance among consumers to consumption. When consumers have this kind of psychology toward the product, it is often difficult for the product to gain a foothold in the market and develop in the long run. For this reason, in order to expand product sales, increase market share, and win consumer recognition, enterprises need to start with a suitable brand positioning to satisfy the consumer experience of the product's target consumer group and ensure that consumers feel that the product purchased is worth their money.

4.4. Strengthen the development of brand after-sales service

Under the new economic situation, when enterprises carry out brand management marketing, they should not limit their goal to only increasing sales volume, but also to expanding their development vision to a longer-term perspective and focusing on the establishment of a good corporate brand, so as to highlight the brand value and thus expand the enterprise market development space [7]. For this reason, enterprises should focus on strengthening the development of brand after-sales service when implementing brand management marketing. After selling their products, enterprises should proactively get in touch with consumers, provide consumers with good after-sales service, accustom to the actual situation of consumers after the purchase, and encourage consumers to appreciate the corporate brand. The enthusiasm for after-sales service has established a good corporate image among vast consumer groups. Nowadays, many corporate brands would set up their own portal websites, give out VIP cards to consumers whose consumption reaches a certain

amount, provide exclusive VIP services to them, and register consumers' personal information such as their birthday, *etc*., when they apply for these cards. Through this, gifts or greetings can be sent to them on special occasions. Upon registering their personal information, it is then possible to contact the consumers after their purchase of any product to ask about their experience of using the product. In this way, consumers would be able to feel the after-sales service provided by the company [8].

4.5. Increase brand promotion

The identification of a brand is not determined by the enterprise but rather by the majority of consumers. For this reason, under the new economic situation, when enterprises carry out brand management marketing, they must intensify their brand promotion, so as to improve the popularity of corporate brands among consumers [9]. It is often difficult for the general public to accept and recognize an unknown brand. Even when buying products, consumers tend to choose brand products with higher popularity. Therefore, under the new economic situation, enterprises need to ensure that the early stage of brand management marketing is carried out well, so as to better promote the corporate brand through brand promotion. At this stage, with the continuous development of science and technology, the emergence of new media has provided a richer way for corporate brand promotion. When companies carry out brand promotion, they can use various new media platforms to expand the scope of publicity and promotion, so as to raise awareness and deepen the impression of the majority of consumer groups on the corporate brand. In that way, consumers will be more willing to purchase these corporate brand products, thus improving corporate sales and further promoting the development of these enterprises [10].

5. Conclusion

Under the new economic situation, enterprises must attach great importance to brand management marketing in their operation and development; they also need to realize that it is impossible for brand management marketing to achieve significant results overnight, as persistence and continuous innovation and reform are required, along with enterprise development and market environment changes. There is a need to establish an advanced brand management marketing concept, build a complete brand management marketing system, accurately position the corporate brand products, and focus on strengthening after-sales service according to the actual situation of the current market and enterprise development in order to establish a good corporate image among vast consumer groups. In addition, enterprises must increase brand publicity and improve corporate brand awareness to expand their market shares and accrue greater development space under the new economic situation.

Disclosure statement

The authors declare no conflict of interest.

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Research on Enterprise Operation Mechanism Innovation Under Economic Transformation

Qingzhi Li[1,2†*]

[1]Jilin Railway Technology College, Jilin 132000, Jilin Province, China

[2]Woosong University, Daejeon 34606, Korea

[†]PhD Student of Woosong University, International Business Management

Corresponding author: Qingzhi Li, 282595354@qq.com

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Abstract: With the rapid development of the market economy, complex changes have occurred in the market environment, and the competition among enterprises has become extremely fierce. The transformation of the structure of the market economy has prompted enterprises to seek for new developments and innovations. Under the background of the new economy, enterprises must begin from the perspective of internal management and internal strategic development to ensure quality enterprise operation mechanism innovation. This would help direct enterprise operation and development as well as demonstrate the value of enterprise internal management. In this way, enterprises will be able to array their overall competitiveness. This paper comprises a detailed analysis of the connotation and innovation of enterprise operation mechanism under the economic transformation, with the purpose of investigating the innovation strategy of enterprise operation mechanism under the economic transformation.

Keywords: Economic transformation; Enterprise; Operation mechanism; Enterprise development; Development and innovation

Online publication: April 27, 2023

1. Introduction

Enterprise operation mechanism is the law of enterprise operation and development formulated in consideration of the actual situation of the enterprise. From an objective point of view, many enterprises have shown a lack of innovation in their operation mechanism. Both enterprise operation mechanism and enterprise operation management belong to the internal management of enterprises. Although they have some value in guiding the development strategy of enterprises, most enterprises, at present, pay more attention to their own operation production, neglecting the value of enterprise operation mechanism innovation. In addition, it is relatively simple to study the enterprise operation system management level in the Chinese academic field [1]. In order to realize the stable development of enterprises in the new era, a detailed analysis of the relevant contents of enterprise operation mechanism innovation under the economic transformation is carried out.

2. Overview of the connotation of enterprise operation mechanism

Enterprise operation mechanism covers the operation structure of the internal resources of an enterprise, showing the functions of various departments and the production work of the enterprise. With the help of

specific systems, the functions of various resources are closely linked in order to promote the mutual influence of these factors and demonstrate the value of different resources in enterprise operation and production. Enterprise operation mechanism guides and restricts the relationship among human resources, financial resources, and material resources as well as ensures the stable and high-quality implementation of enterprise daily operation and management under the interaction of various resources, thus exercising the future enterprise development strategy. From an objective point of view, enterprise operation mechanism ensures reasonable control and management of enterprise resources and that the strategic management and development goals are gradually met under the guarantee of a sound system [2]. Enterprise operation mechanism guides and restricts enterprise operation, development, and decision-making as well as promotes the stable development of enterprises under the corresponding system and norms.

3. Significance of enterprise operation mechanism innovation under economic transformation

3.1. Strengthens the comprehensive competitiveness of enterprises

As one of the core mechanisms of enterprises, enterprise operation mechanism must be developed and applied along with the changes in demands of the external and internal environment. Only in this way can the dynamic system keep pace with the times and shows the true value of enterprise operation mechanism. Under the background of the economic transformation, there are changes in the external and internal environment of enterprise development; in addition, the integration and pertinency of management are more prominent. Therefore, enterprises must consider the changing trends in their internal and external environment, formulate reasonable enterprise operation mechanisms, and carry out innovations. Enterprise operation mechanism is an important part of enterprise strategic development. Through enterprise operation mechanism innovation, enterprises can integrate various internal management resources, production resources, cultural resources, human resources, and many others with the external economic environment. According to the actual needs of enterprise development strategy, the existing enterprise operation mechanism can be optimized from various aspects, such as the economic theory and management theory, to meet the needs of enterprises for sustainable development. Especially under the current social background of the economic transformation, realizing enterprise operation mechanism innovation can help enterprises achieve internal system optimization and lay a solid foundation for enterprises to strengthen their overall competitiveness. Since enterprise operation mechanism innovation plays a guiding role in the stable development of enterprises, enterprises can truly carry out their operation and management, adapt to the development trends in the market economy, optimize the allocation of various resources, and effectively improve their overall competitiveness [3].

3.2. Controls the direction of enterprise operation and development

Under the background of the economic transformation, the introduction of various innovative business management ideas and contents has promoted enterprise economic management innovation and upgraded the traditional business operation mode [4]. With new concepts, new situations, and new requirements, enterprises must abide by the concept of sustainable development and reposition their business concepts in order to fit the development trend of the market economy. Through enterprise operation mechanism innovation, enterprises can closely observe the structure of the market economy, assume enterprise development as the core, standardize their operation and development goals, simplify their operation process, and clarify the direction of enterprise development. In the process of enterprise operation mechanism innovation, enterprises can also re-examine their position in the market, gauge their development, understand their internal and external development environment from an objective standpoint, accurately view their opportunities and challenges, as well as ensure a stable development.

3.3. Arrays the advantages of enterprise resources

Scientific and reasonable resource allocation is the backbone of enterprise operation and development. In the context of the economic transformation, a reasonable analysis of various enterprise resources can be performed from a long-term perspective, the resource allocation can be reasonably adjusted, and clear resource allocation goals can be formulated in line with the future development needs of the enterprise [5]. Through enterprise operation mechanism innovation under the economic transformation, enterprises can also analyze their performance system, promotion system, welfare system, and other systems. With the continuous optimization of the human resource system and other systems, they can strengthen the driving force of their talents, fully demonstrate the value of human resources, and create a good working and institutional environment for their employees. Enterprise operation mechanism innovation can help realize the reasonable allocation and control of internal resources by enterprises as well as the stable and sustainable development of enterprises [6].

4. Innovation strategies for enterprise operation mechanism under the economic transformation

4.1. Create a good environment for enterprise operation mechanism innovation

In the current economic transformation and development, in order to keep up with the development of the times and gradually achieve one's own management and development goals, it is necessary to carry out reasonable enterprise operation mechanism innovation under the economic transformation so as to truly promote the economic transformation and development of enterprises. Government enterprises should array their own value and use their macroeconomic regulation function to guide the innovation and transformation of enterprises in a reasonable and scientific manner. They should actively promote the promulgation of policies and regulations, such as Several Opinions on the Optimization of State-Owned Industry Structure under Economic Transformation, Credit Fund Support for Real Enterprises, Preferential Tax Policies for Enterprises Under Economic Transformation, and Several Opinions on the Improvement of Enterprise Supply Chain under Economic Transformation, to guide enterprise operation mechanism innovation under the reasonable guidance of government departments [7]. In addition, they should provide a good external environment for the stable development of enterprises. The significance of enterprise operation mechanism innovation should also be recognized internally. Under the guidance of enterprise leaders, enterprise operation mechanism innovation should be introduced into the development strategy of enterprises, and all departments should be coordinated with their resources integrated so that each department can actively participate in enterprise operation mechanism innovation and provide a solid foundation for it [8]. Creating a good internal and external environment for enterprise operation mechanism innovation would lay the tone for the development of high-quality enterprises.

4.2. Dig deeply into the value of corporate culture

In order to truly demonstrate the value of enterprise operation mechanism innovation, it is necessary to strengthen the cohesion of employees on the basis of good cultural foundation, demonstrate the value of enterprise culture, promote the close integration between enterprise operation mechanism and enterprise culture, realize the integration of enterprise spirit, material, system, and many other elements, as well as optimize the original enterprise operation mechanism. Under the economic transformation, enterprises must create a good corporate culture environment, strengthen their own cultural construction, expand the connotations of corporate culture, and lay a solid foundation for new corporate culture innovations [9]. Through comprehensive investigations and in-depth studies, the regulations and rules that do not fit the development of enterprises should be removed or modified accordingly, and the system provisions that deviate from the corporate culture should be excluded. This fully demonstrates the supporting role of corporate culture in enterprise operation mechanism. By assuming corporate culture as the fundamental

guidance for enterprise operation mechanism innovation, enterprises can ensure that the innovation and development of their operation mechanism do not deviate from the original intention and clarify the direction of enterprise operation mechanism innovation on the basis of firm humanistic principles and enterprise development goals.

4.3. Combine enterprise operation mechanism innovation with organization management

An enterprise's organizational structure and operation mechanism should complement each other. Under the background of the economic transformation, it is necessary to ensure that the enterprise operation mechanism innovation is unified and compatible with the internal organizational structure of the enterprise in order to prevent the separation of enterprise organizational structure from enterprise operation mechanism and display the role of enterprise organizational structure [10]. Enterprise organizational structure and operation mechanism are mutually restrictive and interrelated. In the early stage of development, enterprises tend to pay more attention to economic cost control, leading to a relatively small number of enterprise members [11]. During this period, the ownership and management rights of enterprises are superimposed. The management rights are distributed among other subjects to realize the separation of management rights from ownership. This promotes enterprise operation mechanism innovation. Under the economic transformation, the innovation of the operation mechanism of enterprises must be in line with their organizational structure. Taking into account of the current internal organizational structure of enterprises, reasonable analyses should be made on the organizational structure of shareholders, directors, managers, management, and so on. On the basis of ensuring reasonable organizational structure and mutual restrictions among enterprises, good communication should exist among various departments, and the relationship between various organizational structures should be coordinated from the enterprise operation mechanism level. In addition, when innovating the enterprise operation mechanism, it is also necessary to take into account of the internal labor structure, improve the current labor and capital status, take advantage of the internal resources, and steadily achieve the enterprise strategic development goals on the basis of reasonable resource integration. The significance of enterprise internal organization management should be arrayed to achieve enterprise operation mechanism innovation and enterprise internal organizational structure fit [12].

4.4. Continuously optimize the human resource management mechanism

From an objective point of view, human resources are one of the driving forces to ensure enterprise development. Hence, it is necessary to emphasize on the importance of human resources in enterprise operation mechanism innovation. With the help of a high-quality, optimized human resource system, it is feasible to promote the advantages of human resources and demonstrate the driving force of employees. Aligning with the direction of enterprise operation mechanism innovation, the ideal human resource management system, the actual situation of enterprises, and the scale of operation, the human resource system should be carefully analyzed and regulated. With regard to the enterprise form, the existing human resource management mechanism should be improved via innovation, the enterprise development strategy and the enterprise talent goal should be closely integrated, and an ideal human resource management mechanism should be formulated. A reasonable salary incentive system, salary reward mechanism, and allowance reward mechanism would drive the enthusiasm of employees to participate in enterprise operation mechanism innovation. Adjusting the salary levels of employees at different positions and establishing a relatively fair salary system may render opportunities for independent development and realization of self-value among employees. The traditional human resource management mechanism should be transformed in view of its disadvantages, a reasonable and feasible constraint mechanism with sustainable development value should be established on the basis of enterprise operation mechanism

innovation, and every employee should be allowed to participate in enterprise development and construction [13]. All these efforts should be carried out on the basis of strengthening employees' sense of belonging, driving their work enthusiasm, and achieving the enterprise development goals.

5. Conclusion

In conclusion, China is currently in the stage of social transition. In order for enterprises to truly conform to the current social development trend, they, as the backbone to promoting the development of market economy, must face the current and future market development trends, join forces to carry out transformation, actively remodel their own organizational structure, realize enterprise operation mechanism innovation, continue to strengthen their overall competitiveness in the new era, and array the driving force behind their own development.

Disclosure statement

The author declares no conflict of interest.

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Influence of Ambient Temperature on the Thermal Safety of Fireworks Products in Civil Aviation Transportation

Lingling Ji*

Shanghai Civil Aviation College, Shanghai, China

***Corresponding author:** Lingling Ji, jilingling@shcac.edu.cn

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Abstract: Fireworks products are energy-containing materials and are hazardous during production, storage, transportation, and use. By analyzing the range of civil aviation ground ambient temperature and civil aviation cabin ambient temperature in storage and ground operation as well as establishing a spontaneous combustion mathematical model for cylindrical fireworks products based on the spontaneous combustion theory, we identified the critical temperature for spontaneous combustion of a single spray and analyzed the thermal safety of fireworks products under the civil aviation ambient temperature by example to provide theoretical support for the feasibility study of transporting fireworks products by civil aviation.

Keywords: Civil aviation ambient temperature; Fireworks; Spontaneous combustion theory; Thermal safety

Online publication: April 27, 2023

1. Introduction

Fireworks and firecrackers are crafts made from pyrotechnic powder and produce sound, light, color, smoke, and other effects through combustion (explosion) reactions. Fireworks are colorful and festive, and now they have become an indispensable item during festivals and major celebrations. As the largest producer and exporter of fireworks and firecrackers, China has a huge demand for domestic and international transportation of fireworks and firecrackers. However, fireworks and firecrackers are energy-containing materials and are hazardous during production, storage, transportation, and use. Fireworks and firecrackers are mainly transported via land and sea. The low transportation efficiency and long transportation time heighten the uncertainty and risk of danger in the transportation process. The use of air transport, with high speed and high efficiency, would enhance the economic benefits of certain industries. In this paper, we analyze the civil aviation ambient temperature limit, establish a spontaneous combustion mathematical model for fireworks products based on the theory of spontaneous combustion, as well as calculate and analyze the thermal safety of fireworks products under the civil aviation ambient temperature.

2. Introduction to civil aviation transportation of fireworks products

According to the International Air Transport Association's "Dangerous Goods Regulations," fireworks products are assigned to five transport numbers UN0333–UN0337, of which the dangerous goods category and explosives assembly group of UN0336 include 1.4 G explosives, which can be transported by civil aviation all-cargo aircraft. 1.4 G fireworks and firecrackers mainly include fireworks shells, spit beads, rockets, bouquets, spray flowers, sparklers, Bengal sticks, runners, whip firecrackers, and other types of

fireworks [1]. In this study, the cylindrical spray product was selected for analysis.

3. Analysis of ambient temperature in civil aviation

The theory of spontaneous combustion provides an assumption that the environment in which the studied object is in is at a constant temperature, and the temperature of each point inside the system is equal to the ambient temperature at the beginning. As the reaction proceeds, the internal temperature exceeds the ambient temperature, and the geometric center of the system is the most unfavorable for heat dissipation. Thermal autoignition occurs if the rate of heat generation by the reaction is greater than the rate of heat loss to the environment. Fireworks and firecrackers are typical exothermic systems. When transported by civil aviation, it is necessary to consider the influence of civil aviation ground ambient temperature and civil aviation flight cabin ambient temperature on the thermal safety of fireworks and firecrackers during transportation.

3.1. Civil aviation ground ambient temperature

3.1.1. Extreme surface atmospheric temperature records

The surface atmospheric high temperature record is 56.7°C (Death Valley, California, USA on July 10, 1913), while the surface atmospheric low temperature record is -89.2°C (Antarctic on July 21, 1983). Civil aviation aircrafts performing international flight missions hardly encounter harsh environment at high or low temperature. If the influence of thermal radiation on ambient temperature is not considered, after a long time, the temperature of each part of the aircraft will be consistent with the ambient temperature. However, in actual engineering design, the influence of thermal radiation on temperature needs to be considered, and this influence is significant. Other than that, heat capacity, color temperature, and structural form also affect the actual temperature in different cabins and structures.

3.1.2. Effect of thermal radiation on temperature

For the extreme high temperature of aircrafts, it is necessary to consider the impact of solar radiation when the extreme high temperature appears. According to a document from the United States, the internal temperature of an aircraft when parked outside is 15–30°C higher than the ambient temperature. According to our aircraft temperature measurements data in the 1970s, the temperature of the internal equipment compartment of an aircraft under direct sunlight is 15–20°C higher than the ambient temperature. Based on actual measurement results, GJB1060.2-91 stipulates that the open-air parts shall conform to the high temperature extremes corresponding to the time the equipment is exposed to the site plus the rise in temperature generated by 1110 W/m^2 solar radiation (equivalent to 17°C). Although the thermal characteristics of different parts of the aircraft vary, after a long time, the maximum temperature of each part of the aircraft will reach about 74°C [2].

Radiation also affects low temperature extremes. During winter, the external environment of the aircraft is mainly white. When there is no solar radiation or wind at night and the color temperature of the aircraft is higher than that of the surrounding environment, the amount of outward radiation is greater than the amount of radiation it absorbs, thus causing the temperature of the aircraft to be lower than that of the surrounding environment. Foreign data and actual measurement results in China have demonstrated that the temperature in the cabin of an aircraft parked outside is 3–5°C lower than the ambience temperature; that is to say, the low extreme storage temperature of aircraft performing international flights should be around -95°C.

As mentioned above, the extreme ambient temperature that fireworks products may encounter when loading, unloading, and staying on the ground is the atmospheric temperature when the aircraft is on the ground; the maximum temperature is about 74°C, while the minimum is about -95°C.

3.2. Civil aviation cabin ambient temperature

During flight, the passenger cabin and cargo compartment of civil aviation airliners will heat and pressurize at the same time. The air pressure and temperature in the cabin are about 0.8 standard pressure and 24°C, respectively. The ambient temperature of the cabin and cargo compartment is basically the same. For all-cargo aircrafts, although the temperature of the cargo compartment of different types of cargo aircrafts is not exactly the same, the temperature range of the cargo compartment can be controlled between 0°C and 30°C. For example, the temperature control range of the main cabin, front cabin, rear cabin, and bulk cabin of B777-200F is 4–27°C. The minimum temperature range of the main cabin of B767-300F is 2–22°C, while the maximum temperature range is 18–30°C; the temperature range of the front cabin and the rear cabin is 4.5–10°C; the minimum temperature range of the bulk cabin is 4.5–10°C, while the maximum temperature range is 15.5–23.8°C.

Dangerous goods such as fireworks products are transported by all-cargo aircrafts, and the ambient temperature during the flight is the same as the temperature inside the cargo of the aircraft. Even if the specific flight conditions change, the changes in temperature range in the cargo compartment during flight will not exceed the range of extreme high and low temperatures on the ground, of which the high extreme temperature is about 74°C, while the low extreme temperature is about -95°C.

4. Spontaneous combustion model for fireworks products

Based on the thermal explosion theory, a single cylindrical firework is regarded as a chemical exothermic reaction system, and on the basis of the law of energy conservation, the following basic assumptions are made [3]: (i) in addition to the heat from chemical reaction, there is no other volumetric heat sources; the heat exchange between the substance and the environment occurs only on the surface of the system, and Newton's cooling law is satisfied; (ii) when ignition occurs, the conversion rate of the reaction substance is very low, so it is assumed that the change in the initial concentration of the reaction substance during the whole process from self-heating to explosion is negligible and the chemical reaction kinetics can be described by the so-called "zero-order reaction," obeying the Arrhenius law; (iii) the respective isotropy is within the substance; the physical properties of the substance (thermal conductivity, density, and specific heat capacity), the chemical properties (activation energy, pre-exponential factor, and heat of reaction), and the heat transfer conditions between the substance and the environment (surface heat transfer coefficient, ambient medium temperature, as well as the shape and size of the reactants) remain constant throughout the process from self-heating to explosion; (iv) since heat transfer inside the substance is caused by heat conduction and there is no relative motion of the reacting substances, there is no convective heat transfer; (v) there is close contact between the chemical inside the fireworks and the shell, *i.e.*, the contact thermal resistance is negligible.

4.1. Spontaneous combustion model for cylindrical fireworks

As shown in **Figure 1**, for a cylindrical exothermic system with a radius of a_0 and an aspect ratio of H in the cylindrical coordinate system, assuming that the central maximum temperature point O is the coordinate origin, the energy conservation equation of the cylindrical model is as follows:

$$\sigma c_v \frac{\partial T}{\partial t} = k\left(\frac{\partial^2 T}{\partial R_1^2} + \frac{1}{R_1}\frac{\partial T}{\partial R_1} + \frac{\partial^2 T}{\partial R_2^2}\right) + QA\exp\left(-\frac{E}{RT}\right) \tag{1}$$

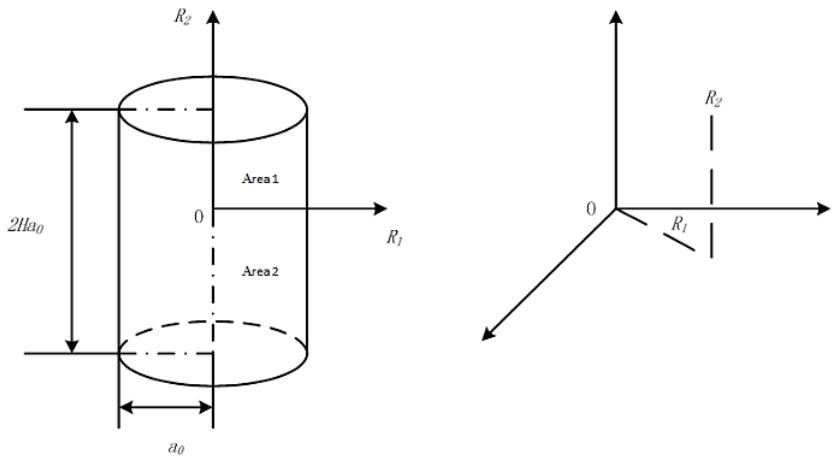

Figure 1. Schematic diagram of a finite length cylinder

In the steady state, $\frac{\partial T}{\partial t}=0$; hence, the energy conservation differential equation of the exothermic reaction in the steady state is as follows:

$$k\left(\frac{\partial^2 T}{\partial R_1^2}+\frac{1}{R_1}\frac{\partial T}{\partial R_1}+\frac{\partial^2 T}{\partial R_2^2}\right)+QA\exp\left(-\frac{E}{RT}\right)=0 \tag{2}$$

The upper and lower parts of point O satisfy the following two sets of boundary conditions, respectively. The boundary conditions of area 1 are as follows

$$R_1=0,\frac{\partial T}{\partial R_1}=0,\left(0\le R_2\le X\right) \tag{3}$$

$$R_2=0,\frac{\partial T}{\partial R_2}=0,\left(0\le R_1\le a_0\right) \tag{4}$$

$$R_1=a_0,k\frac{\partial T}{\partial R_1}+\chi\left(T-T_a\right)=0,\left(0\le R_2\le X\right) \tag{5}$$

$$R_2=X,k\frac{\partial T}{\partial R_2}+\chi\left(T-T_a\right)=0,\left(0\le R_1\le a_0\right) \tag{6}$$

The boundary conditions of area 2 are as follows:

$$R_1=0,\frac{\partial T}{\partial R_1}=0,\left(0\le R_2\le X-2Ha_0\right) \tag{7}$$

$$R_1=0,\frac{\partial T}{\partial R_1}=0,\left(0\le R_2\le X-2Ha_0\right) \tag{8}$$

$$R_1 = a_0, k\frac{\partial T}{\partial R_1} + \chi\left(T - T_a\right) = 0, \left(0 \le R_2 \le X - 2Ha_0\right) \tag{9}$$

$$R_2 = X - 2Ha_0, k\frac{\partial T}{\partial R_2} + \chi\left(T - T_a\right) = 0, \left(0 \le R_1 \le a_0\right) \tag{10}$$

where X is the distance from the ignition point to the upper end surface; T and T_a are the temperature in the system and the ambient temperature, respectively; k and σ are thermal conductivity and density, respectively; Q, E, and A are the heat of reaction, activation energy, and pre-exponential factor, respectively; R is the universal gas constant; and χ is the heat transfer coefficient.

For convenience of research, the following parameters with a dimension of 1 are introduced:

dimensionless coordinates $\rho_1 = R_1 / a_0$ (11)

dimensionless coordinates $\rho_2 = R_2 / Ha_0$ (12)

dimensionless temperature $\theta = \left(T - T_a\right) / \left(\mathrm{R}T_a^2 / E\right)$ (13)

dimensionless activation energy $\varepsilon = \mathrm{R}T_a / E$ (14)

Frank-Kamenetskii parameter $\delta = a_0^2 Q E \sigma A \exp\left(-E / \mathrm{R}T_a\right) / k\mathrm{R}T_a^2$ (15)

Biot number $Bi = \chi a_0 / k$ (16)

The dimensionless thermal explosion equation and boundary conditions of cylindrical fireworks can be written as follows

$$\frac{\partial^2\theta}{\partial\rho_1^2} + \frac{1}{\rho_1}\frac{\partial\theta}{\partial\rho_1} + \frac{1}{H^2}\frac{\partial^2\theta}{\partial\rho_2^2} + \delta\exp\left(\frac{\theta}{1+\varepsilon\theta}\right) = 0 \tag{17}$$

The dimensionless form of the boundary condition for region 1 is as follows:

$$\rho_1 = 0, \frac{\partial\theta}{\partial\rho_1} = 0, (0 \le \rho_2 \le x) \tag{18}$$

$$\rho_2 = 0, \frac{\partial\theta}{\partial\rho_2} = 0, (0 \le \rho_1 \le 1) \tag{19}$$

$$\rho_1 = 1, \frac{\partial\theta}{\partial\rho_1} + Bi_r\theta = 0, (0 \le \rho_2 \le x) \tag{20}$$

$$\rho_2 = x, \frac{\partial\theta}{\partial\rho_2} + HBi_{z1}\theta = 0, (0 \le \rho_1 \le 1) \tag{21}$$

The dimensionless form of boundary conditions for region 2 is as follows:

$$\rho_1 = 0, \frac{\partial \theta}{\partial \rho_1} = 0, (x-2 \le \rho_2 \le 0) \tag{22}$$

$$\rho_2 = 0, \frac{\partial \theta}{\partial \rho_2} = 0, (0 \le \rho_1 \le 1) \tag{23}$$

$$\rho_1 = 1, \frac{\partial \theta}{\partial \rho_1} + Bi_r \theta = 0, (x-2 \le \rho_2 \le 0) \tag{24}$$

$$\rho_2 = x-2, \frac{\partial \theta}{\partial \rho_2} + HBi_{z2} \theta = 0, (0 \le \rho_1 \le 1) \tag{25}$$

where x is the dimensionless value of the distance from the ignition point to the upper end surface, and the range of x is from 0 to 2; ρ_1 and ρ_2 are dimensionless coordinate measurements; θ is the dimensionless temperature rise; ε is the dimensionless activation energy; δ is the Frank-Kamenetskii parameter; Bi_r, Bi_{z1}, and Bi_{z2} are the *Biot* numbers of the side surface, upper end surface, and lower end surface, respectively.

4.2. Boundary condition processing

Since fireworks and firecrackers have relatively complex shell conditions, the influence of the shell and the surrounding air on the heat dissipation of pyrotechnic agents is considered, and the concept of equivalent *Biot* number is proposed, which reasonably simplifies the boundary conditions. The calculation process can be simplified. The boundary condition treatment of spray flowers is taken as an example in this paper. The shell condition of the side surface is a layer of kraft paper shell, and the shell condition of the upper and lower surfaces is a layer of sealing powder and a layer of mud bottom, respectively.

4.2.1. Treatment of side surface boundary conditions

The shell of the side surface of cylindrical fireworks is a single or multi-layer cylindrical paper shell. The heat transfer at the boundary of the side surface involves three processes: (i) heat transfer between the pyrotechnic agent and the paper shell, which mainly entails the problem of contact thermal resistance; (ii) heat transfer from the high temperature side to the low temperature side of the paper shell wall, whereby the heat conduction thermal resistance of the paper shell is involved in the heat conduction of the paper shell wall; (iii) heat transfer between the low temperature side of the paper shell wall and the external environment. The heat transfer process of the side surface shell is shown in **Figure 2**.

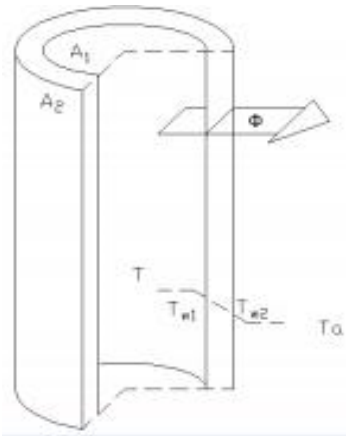

Figure 2. Schematic diagram of the heat transfer process of the side surface shell

According to the law of steady-state heat flow [4], the boundary conditions can be expressed as follows:

$$r = a_0, kA_1 \frac{dT}{dr} + \frac{T - T_a}{R_r + R_c + \frac{1}{\chi A_2}} = 0 \tag{26}$$

where A1 is the inner surface area of the paper shell, and k is the thermal conductivity of the pyrotechnic agent.

Introducing dimensionless parameters ρ_1 and θ, the above formula can be written as follows:

$$\rho_1 = 1, \frac{d\theta}{d\rho_1} + \frac{a_0}{A_1 k} \times \frac{1}{R_r + R_c + \frac{1}{\chi A_2}} \theta = 0 \tag{27}$$

The equivalent *Biot* number is defined as follows:

$$Bi_r^{'} = \frac{a_0}{kA_1} \times \frac{1}{R_r + R_c + \frac{1}{\chi A_2}} \tag{28}$$

The corresponding boundary conditions are then transformed into:

$$\rho_1 = 1, \frac{d\theta}{d\rho} + Bi_r^{'} \theta = 0 \tag{29}$$

From formula (28), we can see that when defining the equivalent *Biot* number, $a_0/(kA1)$ is the thermally conductive thermal resistance of the pyrotechnic agent. $R_r + R_c + 1/(\chi A_2)$ denotes the thermal conductivity thermal resistance of the pyrotechnic agent at the boundary through the paper shell and the air convection heat transfer thermal resistance. When the equivalent *Biot* number is small, the internal heat conduction resistance is far smaller than the convective heat transfer heat resistance at the shell, and the temperature drop is mainly manifested at the shell; when the equivalent *Biot* number is large, the temperature drop is mainly manifested in the pyrotechnic powder agent inside.

4.2.2. Treatment of upper and lower surface boundary conditions

The upper surface of the spray flower is a round cake-shaped sealing powder, and the treatment method for its boundary condition is the same as that of the lower surface mud bottom. The heat transfer process is connected in series with three links: (i) heat transfer between the pyrotechnic agent and the end surface, in which the main issue is contact thermal resistance; (ii) heat transfer from the low temperature side to the high temperature side of the end face, *i.e.*, heat conduction across the end face, involving the thermal resistance of the end face; and (iii) heat transfer between the low temperature side of the end face and the external environment (**Figure 3**).

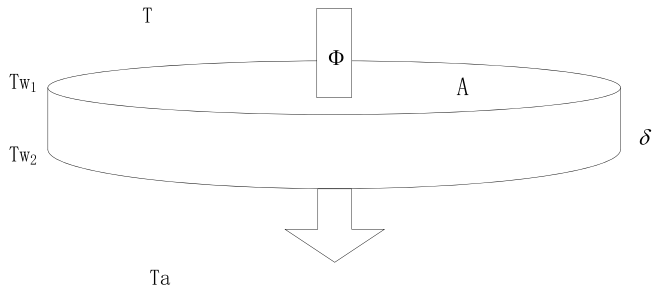

Figure 3. Schematic diagram of heat transfer process in the mud bottom

According to the law of steady-state heat flow [4], the boundary conditions can be expressed as follows:

$$r = Ha_0, kA\frac{dT}{dr} + \frac{T - T_a}{R_z + R_c + \frac{1}{\chi A}} = 0 \tag{30}$$

where k is the thermal conductivity of the pyrotechnic charge.

Introducing dimensionless parameters ρ_2 and θ, the above formula can be written as follows:

$$\rho_2 = 1, \frac{d\theta}{d\rho_2} + \frac{Ha_0}{Ak} \times \frac{1}{R_z + R_c + \frac{1}{\chi A}}\theta = 0 \tag{31}$$

The equivalent *Biot* number at the boundary of the upper and lower surfaces is defined:

$$Bi_{z1}^{'} = Bi_{z2}^{'} = \frac{Ha_0}{kA} \times \frac{1}{R_z + R_c + \frac{1}{\chi A}} \tag{32}$$

The corresponding boundary conditions are then transformed into:

$$\rho_2 = -1, \frac{d\theta}{d\rho_2} + Bi_{z2}^{'}\theta = 0 \tag{33}$$

5. Calculation of the thermal safety of fireworks products

Panda Fireworks' spray product "Blooming Butterfly Love" is taken as an example. The product is cylindrical, with a height of 188 mm, an inner diameter of 94 mm, a wall thickness of 2 mm, a thickness of

30 mm at the upper and lower end surfaces, an overall charge of 56 g, a charge height of 46 mm, and a charge density of 400 kg/m^3. The setting effect is as follows: white chrysanthemums, red and green beads, as well as 10 red, green, and yellow fried beads. This product uses black gunpowder as the injection gunpowder, and the effective gunpowder includes white gunpowder, red gunpowder, green gunpowder, and yellow gunpowder. Compared with the exothermic effect of black powder, the exothermic effect of the agent can be neglected [5]. The basic parameters of the spray are provided by Beijing Fireworks and Firecrackers Quality Supervision and Inspection Station.

5.1. Calculation parameters

Fountain tube height, l =188 mm; charge height, h = 46 mm; inner radius, $r_1 = a_0$ = 94/2 = 47 mm; outer-half diameter, r_2 = 98/2 = 49 mm; thickness of the upper and lower end surfaces, $\delta_1 = \delta_2 = 30$ mm; length-to-diameter ratio, $H = h/2a0$ = 0.489. The area of the end face, $A = \pi a_0^2$; the contact area between the pyrotechnic agent and the paper shell, $A_1 = 2\pi r_1 h$; the contact surface area between the shell of the fireworks and the air, $A_2 = 2\pi r_2 l$; the natural convection surface heat transfer coefficient χ of the air is 1–10 W/m^{2}K, where the heat transfer coefficient χ = 5; the thermal conductivity of black powder, k = 0.0847 W/m^{2}K; the thermal conductivity of paper shell, λ_r = 0.0357 W/m^{2}K; and the thermal conductivity coefficients of the sealing powder and mud bottom, $\lambda_{z1} \approx \lambda_{z2} = 0.95$ W/m^{2}K. Other physical and chemical parameters of the spray pyrotechnic agent are shown in **Table 1**.

Table 1. Calculation results of steady-state critical parameters of the spray "Blooming Butterfly Love"

Substances	Activation energy (J/kg)	Pre-exponential factor (s^{-1})	Heat of reaction (J/kg)	Thermal conductivity (W/m^{2}K)
Black powder	1.9100×10^5	1.40×10^{16}	1.5263×10^6	0.0847
Upper surface material (sealing powder)	–	–	–	0.9500
Lower surface material (mud bottom)	–	–	–	0.9500
Side surface material (paper shell)	–	–	–	0.0357

From the basic theory of heat transfer, the thermal conduction resistance formulas of single-layer flat wall and single-layer cylindrical wall are $R_z = \dfrac{\delta}{\lambda_z A}$ and $R_r = \dfrac{\ln(r_2/r_1)}{2\pi\lambda_r l}$ [4], respectively, which can be calculated as follows: upper and lower end surface thermal resistance, $R_{z1} = R_{z2}$ = 4.55KW, and side surface thermal resistance, R_r = 0.99KW. Substituting the above requirements into the formula (28), $Bi_r^{'} = \dfrac{a_0}{kA_1} \times \dfrac{1}{R_r + R_c + \dfrac{1}{\chi A_2}}$, and formula (32), $Bi_z^{'} = \dfrac{Ha_0}{kA} \times \dfrac{1}{R_z + R_c + \dfrac{1}{\chi A}}$, the side surface can be obtained. The equivalent *Biot* numbers of the upper and lower surfaces are $Bi_r^{'} = 2.7031$ and $Bi_{z1}^{'} = Bi_{z2}^{'} = 1.1726$.

5.2. Calculation results

When the spray product "Blooming Butterfly Love" is stored in a single cylinder, the corresponding critical parameter critical explosion criterion δ_{cr} is calculated to be 1.796424 by MATLAB programming [6,7], and the critical ambient temperature Ta,cr can be expressed by $\delta = a_0^2 Q E \sigma A \exp\left(-E/\mathrm{R}T_a\right)/k\mathrm{R}T_a^2$

(Frank-Kamenetskii expression), obtaining Ta,cr = 450.5K. When the "Blossoming Butterfly Love" is stored in a single tube, the critical ambient temperature is 450.5K.

The critical ambient temperature of the product is higher than the extreme high temperature of civil aviation transportation (347.15K), indicating that the thermal safety of the product is stable in air transportation and theoretically there will be no risk of spontaneous combustion.

6. Conclusion

The range of civil aviation ground ambient temperature and civil aviation flight cabin temperature in civil aviation storage, ground operation, and other operations was found to be 178.15–347.15 K. Based on the theory of spontaneous combustion, we established a spontaneous combustion mathematical model for cylindrical fireworks products. The spray product "Blossoming Butterfly Love" was selected. The critical temperature of its spontaneous combustion was calculated to be 450.5 K, which is higher than the extreme high temperature in civil aviation transportation. This shows that the spray is thermally stable during air transportation and theoretically there will be no danger of spontaneous combustion. However, considering that fireworks products will be stacked during transportation, due to the mutual interference of thermal fields among multiple single-tube fireworks and poor heat dissipation conditions, the critical ambient temperature will be reduced, thereby reducing the thermal safety as well. The thermal safety of stacked fireworks products in civil aviation transportation requires further research.

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Disclosure statement

The author declares no conflict of interest.

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1. Negotiation research spans many disciplines [3, 4].
2. This result was later contradicted by Becker and Seligman [5].
3. This effect has been widely studied [1–3, 7].

Personal communications and unpublished works can only be used in the main text of the submission and are not to be placed in the Reference section. Authors are advised to limit such usage to the minimum. They should also be easily identifiable by stating the authors and year of such unpublished works or personal communications and the word 'Unpublished' in parenthesis.

E.g. (Smith J, 2000, Unpublished)

References

This section is compulsory and should be placed at the end of all manuscripts. Do not use footnotes or endnotes as a substitute for a reference list. The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should be excluded from this section.

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Journal

Journal article (print) with one to three authors

[1] Yao Y., Xia B. Application of Phase Frequency Feature Group Delay Algorithm in Database Differential Access. Computer Simulation, 2014, 31(12): 238-241.

Journal article (print) with more than three authors

[2] Gamelin F.X., Baquet G., Berthoin S., et al. Effect of high intensity intermittent training on heart rate variability in prepubescent children. European Journal of Applied Physiology, 2009, 105: 731–738.

Journal article (online) with one to three authors

[3] Jackson D., Firtko A., Edenborough M. Personal resilience as a strategy for surviving and thriving in the face of workplace adversity: a literature review. Journal of Advanced Nursing, 2009, 60(1): 1–9,

Journal article (online) with more than three authors

[4] Hargreave M., Jensen A., Nielsen T.S.S., et al. Maternal use of fertility drugs and risk of cancer in children—A nationwide population-based cohort study in Denmark. International Journal of Cancer, 2015, 136(8): 1931–1939.

Book

Book with one to three authors

[5] Schneider Z., Whitehead D., Elliott D. Nursing and midwifery research: methods and appraisal for evidence-based practice. 3rd edn. 2009, Elsevier Australia, Marrickville, NSW.

Book with more than three authors

[6] Davis M., Charles L., Curry M.J., et al. Challenging spatial norms. 2013, Routledge, London.

Chapter or Article in Book

[7] Knowles M.S. Independent study. In Using learning contracts. 1986, Jossey-Bass, San Francisco, 89–96.

Others

Proceedings of meetings and symposiums, conference papers

[8] Chang S.S., Liaw L. and Ruppenhofer J. (eds). Proceedings of the twenty-fifth annual meeting of the Berkeley Linguistics Society, February 12–15, 1999: general session and parasession on loan word phenomena. 2000, Berkeley Linguistics Society, Berkeley.

Conference proceedings (from electronic database)

[9] Bukowski R.M. Prognostic factors for survival in metastatic renal cell carcinoma: update 2008. Innovations and challenges in renal cancer: proceedings of the third Cambridge conference. Cancer, 2009, 115 (10): 2273, viewed 19 May 2009, Academic OneFile database.

Online Document with author names

[10] Este J., Warren C., Connor L., et al. Life in the clickstream: the future of journalism, Media Entertainment and Arts Alliance, 2008. viewed 27 May 2009, http://www.alliance.org.au/documents/foj_report_final.pdf

Online Document without author name

[11] Developing an argument n.d., viewed March 30 2009, http://web.princeton.edu/sites/writing

/Writing_Center/WCWritingResources.htm

Thesis/Dissertation

[12] Gale L. The relationship between leadership and employee empowerment for successful total quality management. 2000, University of Western Sydney.

Standard

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Government report (online)

[15] Department of Health and Ageing. Ageing and aged care in Australia, 2008, viewed 10 November 2008, http://www.health.gov.au/internet/main/publishing.nsf/Content/ageing

No author

[16] Guide to agricultural meteorological practices. 2nd edn, Secretariat of the World Meteorological Organization, 2010, Geneva.

Note: When referencing an entry from a dictionary or an encyclopedia with no author there is no requirement to include the source in the reference list. In these cases, only cite the title and year of the source in-text. For an authored dictionary/encyclopedia, treat the source as an authored book.

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As part of the submission process, authors are required to check off their submission's compliance with all of the following items, and submissions may be returned to authors that do not adhere to these guidelines.

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3. Where available, URLs for the references have been provided.

4. The text is single-spaced; uses a 12-point font; employs italics, rather than underlining (except with URL addresses); and all illustrations, figures, and tables are placed within the text at the appropriate points, rather than at the end.

5. The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines, which is found in About the Journal.

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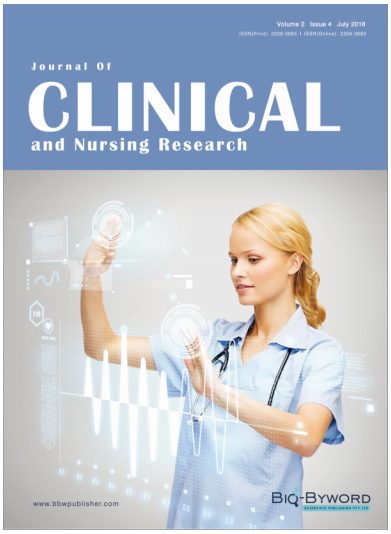

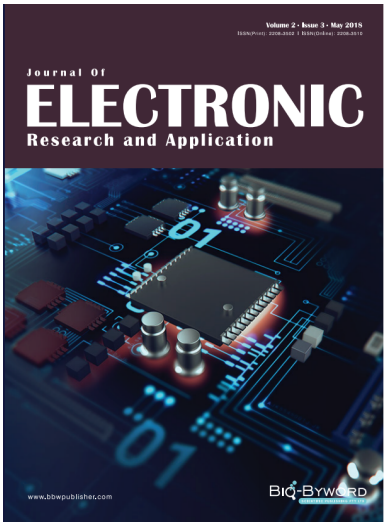

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