

Research on the Commercial Value of Intelligent Eco-Friendly Dynamic Fireworks Systems

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Abstract

As an important carrier of Chinese culture for thousands of years, the fireworks industry has a broad and continuously developing foundation around the world, especially in the Chinese market. However, traditional fireworks face core challenges, including environmental limitations, frequent safety risks and insufficient ignition accuracy. Therefore, the intelligent transformation of the industry has become the key direction to overcome these bottlenecks. Most of the so-called “intelligent fireworks” are still limited to automated control and basic sensing capabilities, and lack real dynamic adjustment. This leads to immaturity of technology, low market acceptance and narrow business models, which hinders scalable and sustainable operations. In order to solve these industry pain points, this study proposes an intelligent environmental protection fireworks system centred on “end-to-end dynamic control”. It integrates three cutting-edge technologies: Generative Adversarial Networks (GAN), cross-scale digital twins, and neural differential equations. The system also establishes dual safeguards: virtual explosion chamber and AI-driven material performance audit. Neural differential equations work in parallel with simulation to reduce research and development (R&D) costs and solve price premium challenges; digital twins and professional liability insurance further remove market trust barriers; NDE-supported Function-as-a-Service (FaaS) model rebuilds the profit path; modularized interfaces and open platforms reduce the cost of supply chain collaboration. This research provides a full-chain optimized solution for the fireworks industry, balancing technical feasibility and business sustainability. It has accelerated the transition of the industry from traditional manufacturing to intelligent services and fostered an eco-friendly, safe and creative industrial ecosystem. The intelligent environmental protection dynamic fireworks system proposed in this study belongs to a conceptual framework. There is no prototype development or engineering verification.

The suggested content is no different from the actual display.

Keywords

Fireworks Industry, Smart Fireworks, Commercial Sustainability, Technology Acceptance, Digital Twins, Intelligent Transformation, Environmental Safety

1. Introduction

1.1. Research Background

As a cultural medium spanning thousands of years, fireworks play an irreplaceable role in celebrations, ceremonies and entertainment, while reflecting profound social emotions and collective memory. Their cultural and emotional value in modern life has not diminished. However, the traditional fireworks industry has long faced serious environmental and safety challenges. Air pollution and noise disturbance during the exhibition are becoming more and more prominent, and fire risks and ignition accidents poses a major threat to public safety. In recent years, a global wave of green technology has emerged, and environmental awareness is deeply rooted in public consciousness. Coupled with the rapid development of the intelligent entertainment industry, the integration of digital technology and cultural entertainment has become the core trend of industrial upgrading (Wang, 2025). Against this background, an intelligent environmental protection dynamic fireworks system has emerged. By deeply integrating digital technologies such as artificial intelligence, the Internet of Things (IoT) and big data with the fireworks industry, it has made many breakthroughs in intelligent control systems, environmental protection material applications and dynamic ignition technologies. The system retains the cultural and entertainment attributes of fireworks, while effectively responding to the environmental and safety challenges of traditional fireworks, providing a wide range of business opportunities. The current market products include commercial trials that combine automated control and simplified sensor technology with fireworks to achieve remote operation and basic environmental adaptation. These developments have laid the foundation for the further commercial adoption of the technology.

1.2. Problem Statement

With the emergence of the technical prototype of the intelligent environmental protection fireworks system, its scaling up is facing bottlenecks. The core problems include:

1) Business value sustainability: Can the intelligent environmental protection fireworks system establish a stable value cycle between its technical advantages and market demand to achieve long-term business returns?

2) Differences in market acceptance: What are the differences between different groups in terms of product recognition and demand? What are the core target

customer groups, and what are the specific potential application scenarios?

3) Challenges of technology monetization: In view of the problems of insufficient technological maturity, lack of market trust and outdated business models, how to establish a feasible way to effectively transform technological value into market value?

1.3. Research Objectives, Significance, and Methodology

The core goal of this research is to systematically evaluate the economic, brand and social value composition of the intelligent environmental protection dynamic fireworks system. Its significance is to provide novel market adoption methods for fireworks enterprises to promote market-ready results. This study adopts a comprehensive method including literature analysis, market research, case study and model prediction to analyze the industrialization in three dimensions: technical feasibility, market potential and policy environment.

This research belongs to the conceptual framework research. The main results cover three aspects. It integrates three cutting-edge technologies and puts forward the conceptual architecture of intelligent and environmentally friendly fireworks systems with full-chain dynamic adjustment. Based on market research, it determines the core target market and user needs, and provides accurate guidance market rollout. It establishes a multi-party cooperation commercial operation to provide a reference path for industrial transformation.

2. Theoretical Foundations and Literature Review

2.1. Technical Principles of the Intelligent Eco-Friendly Dynamic Fireworks System

The core of the system relies on artificial intelligence for precise control and calibrates the launch trajectory through path planning. It uses low-smoke, heavy metal-free pyrotechnic compositions and biodegradable shell materials to mitigate environmental pollution. At the same time, the dynamic adjustment driven by artificial intelligence achieves tailored and diversified emission effects.

Quantum Generative Adversarial Network is a classical algorithm-optimized model model inspired by the principle of quantum computing. It is implemented by classical computing hardware and uses the characteristics of quantum superposition and entanglement to sample millions of material combinations in parallel in high-dimensional quantum state space. Digital twin technology creates virtual simulations from microscopic molecular reaction to macroscopic smoke diffusion. The simulation model gives the effect and risk test without physical objects a high-fidelity virtual environment; the neural differential equations assume the responsibility of dynamic regulation and can give accurate parameters and fireworks effects; the virtual blasting room automatically produces extreme situations through the Generative Adversarial Network, and reproduces the risk of material fracture and explosion; material performance; the AI-driven material performance audit system automatically generates compliance reports that comply with

global regulations. System processing flow is shown in **Figure 1**.

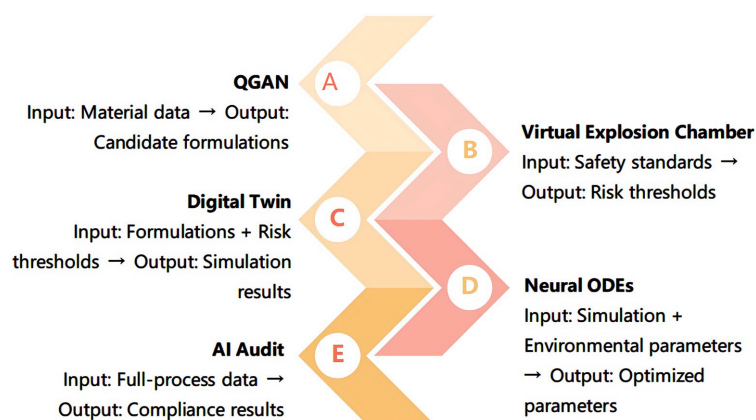


Figure 1. System processing flow.

2.2. Commercial Value Theory

The commercial value of the intelligent environmental protection fireworks system is multifaceted: economically, it provides product premium pricing, market growth potential and supply chain expansion opportunities; in terms of brand, its ecological intelligence positioning enhances its image and competitiveness; socially, it promotes cultural heritage protection, environmental protection and public safety.

2.3. Current Research Status and Limitations

The current intelligent fireworks system has made fundamental progress. In China, Hunan Liuyang Dongxin Fireworks Group and other products have achieved multi-point synchronous control and have been successfully applied to large-scale performances (Jintai Information, 2025). Internationally, companies such as Pirotecna Igual in Spain and Groupe F in France have developed environmental adaptive systems and advanced art synchronized control systems. Technical defects still exist: automation accuracy is insufficient, and communication delays and interruptions are prone to occur under extreme conditions (Light ZOOM Lumière, 2025); insufficient response to dynamic environmental changes, showing a response lag when responding to sudden environmental changes (Groupe, 2025); system maintenance costs are high, customizability is limited, and the overall technical maturity is still very low (Pirotecna Igual, 2025).

Market acceptance of intelligent fireworks systems gets constrained by multiple factors. In B2B markets, significant cost pressures and compliance concerns show up. Overall pricing runs markedly higher than traditional firing solutions, while systems face technical fragility and environmental interference risks. On top of that, industry-wide technical standards for intelligent systems haven't fully come together yet. High demands during professional debugging stages on technical staff push up total project costs. These factors together hold back commercial customers' procurement enthusiasm, with the share of small and medium operators

trying out such products also ending up relatively low (Stats Market Research, 2026).

From the perspective of consumers, the main obstacles are unclear understanding and lack of trust. Although most consumers have heard of smart fireworks, they lack technical knowledge. Past failures, such as the failure of the drone-intelligent fireworks coordination system of European Celestial during the demonstration, greatly weakened the public's trust. In addition, some consumers have an emotional preference for the handmade craft of traditional fireworks, which further affects the market acceptance (China Fireworks and Firecrackers Association, 2025).

3. Commercial Value Analysis of the Smart Eco-Friendly Dynamic Fireworks System

The commercial value of the system lies in the innovation of materials science, artificial intelligence-driven precise control and calibration and visual effect demonstration. It solves the conflict between the environmental impact and performance of fireworks, while improving economic returns, brand influence and social benefits.

3.1. Economic Value

3.1.1. Efficiency and Cost Optimization

The core economic value of the project lies in improving R&D and production efficiency.

The system integrates digital twin technology, neural differential equations and Quantum Generative Adversarial Network modelling to ensure that the precise formula ratio meets safety standards and the stability of intelligent environmental protection fireworks. High-dimensional data enable exploration of millions of material combinations in quantum state space to quickly generate candidate solutions (Zhang et al., 2024). Digital twin technology (Jeong et al., 2022) establishes a simulation environment for candidate materials and verifies the process from molecular reaction to macroscopic discharge. The neural differential equation (Lehtimäki et al., 2024) dynamically tunes the parameters according to the verification results.

The whole technical workflow is as follows: Quantum GANs generate formulations → Virtual Explosion Chamber provides risk threshold feedback → Digital Twin validates effects → Neural Ordinary Differential Equations (Neural ODEs) optimize parameters → AI Audit System generates compliance reports.

3.1.2. Visual Analysis of Economic Value

The main economic value of environmental protection fireworks is value reuse and cost reduction. The following will make a detailed analysis of each module and give a quantifiable profit path.

Payers are divided into three types, and the corresponding scenarios are also different. It supports government departments in presenting urban festivals and

large-scale cultural & tourism events. It provides event planning and fireworks performances for business partners, and bespoke services for individual clients. The pricing strategy accurately meets the needs of different payers according to the scenario. The number of programs, usage time and the number of special effects are priced according to usage, and packages and exclusive services are priced by subscription.

The cost includes R&D technology cost, Virtual Explosion Chamber construction fee, certification compliance fee, basic operation fee, equipment rental fee, fireworks material fee, customer after-sales service fee, and marketing fee.

The core value of the FaaS model lies in its sustainability. The fireworks display process and the Virtual Explosion Chamber test process can be completed by adjusting the parameters in a simple way. The accumulation of data and experience enables reuse of display data and the safety risk prevention of new fireworks display scheme design. The core of the profit path is to use the FaaS model to continuously iterate, so that the value can be sustainable, the cost can be reduced, and long-term profits are likely to be achieved.

3.2. Brand and Marketing Value

Users of this system can significantly enhance their brand image. For city managers, the inclusion of intelligent and environmentally friendly fireworks into public activities not only shows the city's technological innovation and green initiative, but also shapes the identity of a modern and socially responsible city. For commercial brands, tailored intelligent fireworks shows provide unique visual wonders and promote sustainable value to consumers through environmental protection technology. According to Deloitte's 2024 sustainability report, Chinese executives have listed changes in consumer patterns or preferences as the main areas affected by climate issues, and 57% of people have clearly identified this impact (Deloitte, 2024). This shows that consumers are increasingly considering environmental factors in their purchasing decisions. Against this background, the project not only provides environmental protection technology, but also enhances the public's awareness of the corporate brand.

3.3. Social and Environmental Value

Regarding environmental protection materials, the project uses potassium nitrate-sucrose green powder and ammonium nitrate composite propellant to achieve clean combustion to reduce source pollution during the ignition process; the thermoplastic starch plastic shell is rapidly degraded at high temperature (Shi et al., 2020), effectively preventing solid waste residue; adding tourmaline negative ion purifier to actively precipitate smoke grains, improve the air quality after discharge. These scientific-based innovative materials represent the core breakthrough of the project.

A study on the impact of Spring Festival fireworks emissions on the air quality of county-level cities shows that traditional fireworks are the main reason for the

sudden surge in PM2.5 concentration during the Spring Festival (Zhou et al., 2025). The widespread adoption of the project will greatly improve air quality and be consistent with the national pollution prevention and carbon neutrality strategy. At the social level, the project uses artificial intelligence technology to precisely adjust the fireworks show. Through simulation-based rehearsals, it improves the safety of activities.

4. Target Market Segmentation and User Needs Research Analysis

In order to systematically evaluate the market potential, define the target customer group, and accurately grasp their demand characteristics, this chapter adopts questionnaire analysis based on the STP (Segmentation, Targeting, Positioning) marketing framework. It subdivides potential markets, selects core target markets, and compiles corresponding user roles to provide data-driven insights for business strategy formulation.

4.1. Market Segmentation and Target Market Selection

4.1.1. Market Segmentation

1) University student market

This group is a typical representative of young people, with a high degree of acceptance of new things and strong communication power. The economic situation is average, but there is a strong desire to consume, which will lead the future market trend. Emphasis on technological experience can drive the industrial rejuvenation and innovation, facilitate the word-of-mouth communication of products, and attract market attention.

2) Enterprises and public institutions market

The group has a stable income, a mature consumption concept, and pays attention to product safety and brand value. It is the main source of stable commodity supply in industry. They will greatly improve the credibility of products and lay the foundation for the large-scale development of the industry.

3) General public market

The group attaches importance to the traditional consumption culture, the practicality and cost-effectiveness of products. Understanding the products will promote the expansion of the intelligent fireworks system market and create user groups for the development of the industry, so as to promote the digital transformation and intelligent upgrading of traditional fireworks.

4.1.2. Target Market Selection

According to the previous analysis, the ultimate target market of this study is the market of enterprises and public institutions and the market of college students. The former lays a solid commercial foundation for the product, while the latter makes innovation dynamic and reputable. The general public market has great potential, which can increase the possibility of products reaching the final popularity.

4.2. User Needs Research Design and Implementation

4.2.1. Sampling Methods

The investigation was conducted in Beijing. Survey samples are taken from college students, enterprise employees and ordinary citizens by stratified random sampling.

1) The university group chooses Beijing Institute of Fashion Technology and three surrounding comprehensive and polytechnic colleges, and randomly selects college students by grade and major;

2) Enterprises and public institutions, including finance, culture and tourism, government affairs, manufacturing and other enterprises and public institutions, select employees from Beijing and district-level enterprises and public institutions, and randomly sample according to work level and industry nature.

3) Citizens randomly select ordinary citizens from different communities, commercial districts, parks and other public places in Beijing, and stratify them according to age and residence.

During the sampling process, the proportion of each group of sample size is strictly controlled to ensure the representativeness of the sample and the comparability between groups. The investigation lasted for the last two weeks. A total of 450 questionnaires were distributed and 408 valid questionnaires were retrieved, with an efficiency of 90.7%. A total of 158 people, accounting for 38.7% of the total number, including 127 college students, accounting for 31.1% of the total number, 127 employees of enterprises and institutions, accounting for 31.1% of the total number, and 123 ordinary citizens, accounting for 30.2% of the total number. The sample structure is consistent with the proportion of the survey design, which can meet the requirements of statistical analysis. The sample group for the survey is shown in **Figure 2**.

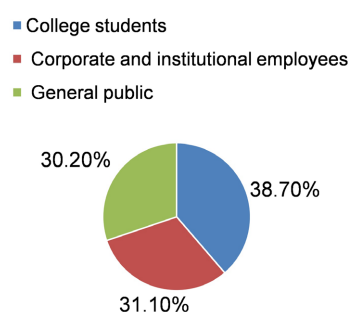


Figure 2. Survey sample group.

4.2.2. Structure of Questionnaire Tools

This survey uses the self-compiled “Intelligent Environmental Protection Dynamic Fireworks System User Demand Questionnaire”. Investigation content is shown in **Table 1**. The final version of the questionnaire is formed after literature research, expert consultation, and pre-research revision. It is divided into five aspects: demographic characteristics, cognitive and information channels, purchas-

ing decision-making factors, purchasing power and willingness to pay, and consumption scenario preferences, with a total of 22 items. It includes an attention check question, six scale questions, and the rest are single-choice questions and multiple-choice questions. The questionnaire uses the 5-point Likert scale (1 totally disagree, 5 completely agree) to measure attitudes and preferences. The specific structure and sample items are as follows:

Table 1. Intelligent environmental protection dynamic fireworks system user demand questionnaire investigation content.

| Questionnaire Dimensions | Item Type | Sample Item | Measurement Method |
|---|---|---|---|
| Demographic Characteristics | Single-Choice Question | Your age: <input type="checkbox"/> 18 - 25 <input type="checkbox"/> 26 - 35 <input type="checkbox"/> 36 - 45 <input type="checkbox"/> 46 - 55 <input type="checkbox"/> 55 years old and above | Categorical Variable |
| Cognitive and Information Channels | Single-choice + Multiple-choice Questions | Are you familiar with the smart eco-friendly fireworks system? <input type="checkbox"/> Yes <input type="checkbox"/> No; Through which channels did you learn about it? | Categorical Variable |
| Purchase Decision Factors | Scaled Questions | When selecting fireworks products, how much do you consider the following factors: 5-point Visual appeal/Safety/Environmental friendliness/Price | Likert scale |
| Purchasing Power and Willingness to Pay | Single-choice + Scale Questions | What price range are you willing to pay for smart fireworks products per purchase? What is your price acceptance level for smart fireworks products? | Categorical variable + Likert 5-point scale |
| Preferred Consumption Scenarios | Multiple Choice Questions | In which scenarios would you prefer to use smart eco-friendly fireworks? | Categorical variable |
| Attention Check | Anchor Question | Please select the option "Very Concerned" to complete the validity check for this questionnaire | Validity screening |

4.2.3. Quality Verification of the Survey

This study conducts double quality inspection from two aspects: the questionnaire collection stage and the data processing stage to ensure the validity and reliability of the research data.

1) Attention test, set the anchor attention test in the middle of the questionnaire (select "very concerned"), and the questionnaire will be judged as an invalid questionnaire if it is not returned as required. A total of 21 invalid questionnaires were collected in this survey;

2) Internal consistency reliability test, use Cronbach's α coefficient to test the six Likert scale items in the questionnaire. After the test results, it can be seen that the overall Cronbach's α value of this scale is 0.826, and the α coefficients of each dimension are greater than 0.751 and 0.843, all of which are greater than the acceptable standard of 0.7, which proves the internal consistency and reliability of the questionnaire scale.

4.2.4. Method of Test for Group Differences

In order to test whether there are significant differences in the cognitive level, purchasing decision-making factors, payment willingness and consumption scenario preferences of the three major groups, this study uses non-parametric testing to conduct a systematic analysis of group differences.

1) Use the Chi-square test (χ^2) to test classified variables (such as consciousness, information channels, consumption scenario preferences)

Check the statistical significance of the selection ratio of each option in different groups (test level $\alpha = 0.05$);

2) For ordinal variables (scale data such as purchase decision-making factors, price acceptance, etc.), the Kruskal-Wallis H test is used to test whether there is a significant difference in the scale scores between groups. If the overall test is significant, multiple comparisons are used to determine which groups have differences.

All data are processed and statistically analyzed using SPSS 26.0 to ensure the scientific and statistical significance of the conclusion of group differences.

4.3. Target User Profile Analysis

4.3.1. User Awareness and Information Acquisition

The following table shows the survey subjects' understanding of intelligent fireworks and information sources. User's channels for obtaining information about smart eco-friendly fireworks are shown in **Table 2**. It can be seen from the results that the three groups of people have a big difference in their understanding of the concept of intelligent environmental protection fireworks. The recognition rate of college students is 68.4%, mainly through short videos, social media, etc. The recognition rate of enterprise employees is 52.8%, mainly through professional media such as industry websites. The recognition rate of ordinary citizens is 41.5%. There are significant differences in the awareness and information acquisition channels of the three main groups by using the chi-square test method.

Table 2. User information acquisition channels.

| | Category | Frequency | Percentage | Remarks |
|-------|---------------------------------------|-----------|------------|---|
| Group | College Students | 108 | 68.4% | Douyin, Bilibili, Xiaohongshu, Moments, Official Accounts |
| | Corporate and institutional employees | 67 | 52.8% | Zhihu, industry WeChat groups, official accounts, Douyin |
| | General public | 51 | 41.5% | Short video feeds, TV news, neighborhood group chats |
| | Merged | 226 | 55.4% | |

The survey results show that college students are the main potential consumers of intelligent and environmentally friendly fireworks, because different groups have different ways to obtain information, mainly through short videos, social platforms, professional industry channels, life scenes, etc.

4.3.2. Purchase Decisions and Product Expectations

The Proportion of Factors Influencing User Purchase Decisions is presented in **Figure 3**. The Sample Data on Factors Influencing User Purchase Decisions is presented in **Table 3**. College students pay more attention to the visual effect of the new product, followed by the price. The most important thing for new products is safety, followed by environmental protection. The public's preference for new products is the balance between safety and price. According to the Kruskal-Wallis H test, it can be seen that the three groups are visually attractive ($H = 22.41, P < 0.001$), safety ($H = 15.63, P < 0.001$), environmental friendliness ($H = 10.28, P < 0.01$), price ($H = 28.75$).

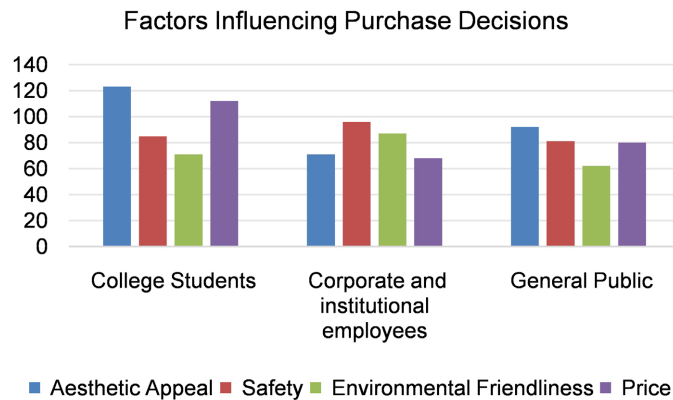


Figure 3. Proportion of factors influencing user purchase decisions.

Table 3. Sample data on factors influencing user purchase decisions.

| Category | Sample Size (N) | Aesthetic Appeal | Safety | Environmental Friendliness | Price |
|--|-----------------|------------------|--------|----------------------------|-------|
| College Students | 158 | 123 | 85 | 71 | 112 |
| Target Audience Enterprise and institutional employees | 127 | 71 | 96 | 87 | 68 |
| Ordinary Citizens | 123 | 92 | 81 | 62 | 80 |
| Merge | 408 | 286 | 262 | 220 | 260 |

It can be seen from the data that there are also large differences in the main factors that various groups pay attention to in the purchase decision of intelligent fireworks. Environmental factors account for a small proportion of demand, but environmental requirements are the conditions that all groups must meet for procurement decisions.

4.3.3. Purchasing Power and Purchase Desire

The willingness to pay data clearly shows the economic affordability of each group. The User purchasing power proportion is presented in **Figure 4**. 82.9% of college students spend no more than 500 yuan at a time, and 47.5% do not exceed 300 yuan; the company's employees have the strongest consumption power, 43.3%

of them can spend 1000 - 3000 yuan; the consumption level of the general public is 48.0% are willing to pay less than 500 yuan, and 28.5% are prepared to spend pay 1000 - 2000 yuan. Chi-square (χ^2) test results prove that there are differences in the willingness of the three groups to pay, $P < 0.001$.

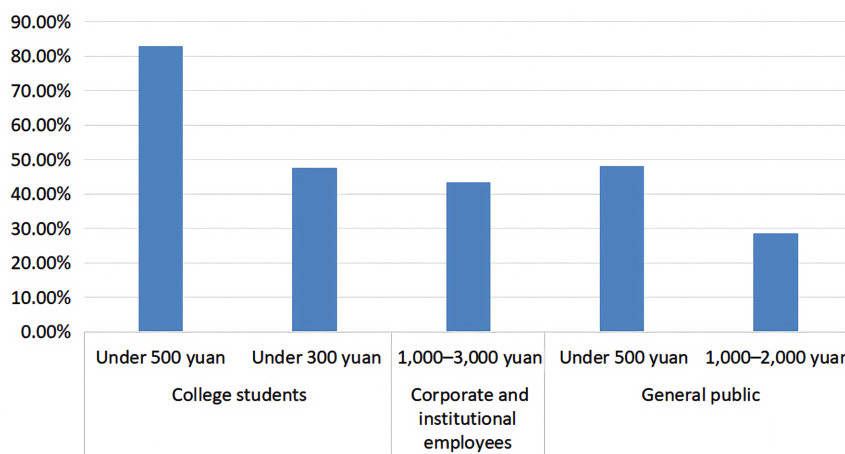


Figure 4. User purchasing power proportion.

It shows that the employees of enterprises and public institutions are the main consumers of intelligent environmental protection fireworks. For college students and ordinary citizens, the affordable price is mainly below 500 yuan, and products above 1000 yuan can be launched for enterprise customers.

The User Consumption Scenario Data is presented in **Table 4**. The Preferred consumption scenarios are illustrated in **Figure 5**. The respondents' preferences for intelligent fireworks scenes are generally the same. The proportion of traditional festival scenes selected as the first choice is 53.2%, followed by enterprise marketing activities, accounting for 21.7%, and the selection of major activities and competitions is also relatively high, reaching about 13.3%. After the Chi-square test, there is no significant difference in consumption scene preferences among the three groups ($\chi^2 = 5.27$, $P > 0.05$), that is, different groups have the same demand for consumption scenarios for intelligent and environmentally friendly fireworks.

Table 4. User consumption scenario data.

| | Category | Frequency | Percentage | Remarks |
|----------|-----------------------------------|-----------|------------|-------------------------------|
| Scenario | Traditional Festival | 217 | 53.2% | Core Consumption Scenarios |
| | Corporate Marketing | 89 | 21.7% | Commercial Use Cases |
| | Large-scale Events & Competitions | 54 | 13.3% | Public consumption scenarios |
| | Entertainment and Celebrations | 48 | 11.8% | Private consumption scenarios |

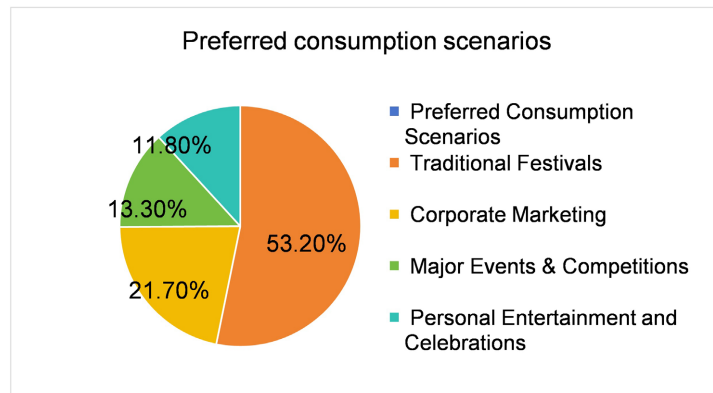


Figure 5. Preferred consumption scenarios.

According to the above data, it can be seen that users place greater value on festivals and commercial use more. The product should take the festival scene as the starting point for large-scale penetration, taking into account the expansion of business scenarios such as enterprise sales.

4.4. Product Value and Market Alignment

Based on the above analysis, the intelligent environmental protection dynamic fireworks system is positioned as a safe, controllable and environmentally friendly brand in the market. By integrating innovative artificial intelligence applications, it enhances the user experience without affecting the visual impact.

The intelligent fireworks system of the project achieves security compliance, technical immersion and market access through artificial intelligence technology, and fully meets the core market needs. The system provides reliable safety guarantee and cutting-edge technology display experience, while streamlining the proportion of materials to control costs and promote future market expansion.

5. Development Pathways for Commercializing Intelligent Eco-Friendly Dynamic Fireworks Systems

5.1. Government Policy Standards

Governments should play a guiding role in formulating targeted policies that meet national carbon neutrality goals. Establish special subsidies for intelligent environmental protection fireworks systems, and provide research and development support and market incentives for environmental certification products. Reduce the cost of enterprise research and development and promotion through tax reduction and preferential government procurement. Use community outreach and online scientific videos to conduct public environmental education activities to raise the society's awareness of green fireworks. A unified technical standard should be established for environmentally friendly fireworks, and core indicators such as pollutant emissions and material degradation rate should be specified. Certification support should be provided for these systems to guide the industry to achieve green and sustainable development.

5.2. Industry Implementation

Under the guidance of government policies, the industry should actively promote the green transformation of fireworks. The company should actively adopt the environmental material ratio and dynamic control technology of the system, form a complementary alliance, share research and development resources, streamline the service system, and improve the overall production efficiency. Regarding technical licensing, we will provide the licensing of the formula optimization model for traditional fireworks enterprises, and achieve the monetization of technical value through licensing fees or sales revenue sharing. An iterative technology sharing mechanism will be established to enable enterprises to continuously optimize product performance through the analysis and feedback of emission data and operational experience. Mutual supervision of environmental compliance will ensure that products meet national security and environmental standards, and jointly maintain the green image of the industry.

5.3. Consumer Oversight Participation

Consumers should consciously accept the environmental consensus and give priority to intelligent dynamic fireworks systems that meet ecological standards. In the process of purchase and use, monitor fireworks products and evaluate their environmental compliance. Share experience through e-commerce reviews, community feedback and other channels to help enhance the ecological performance of products. Jointly promote the concept of environmentally friendly fireworks and cultivate the social trend of green consumption.

5.4. Multi-Stakeholder Advancement of Smart Fireworks Commercialization

This section outlines the three-pronged approach to establishing a commercial framework for intelligent environmental protection dynamic fireworks systems: the government lays the foundation for development through policy subsidies, standard setting and public education. The industry accelerates the green transformation by sharing technology, cooperating through alliances and converting values. Consumers promote the growth of market demand through ecological-conscious selection, active supervision and word-of-mouth promotion. While implementing the technology, this method has established market barriers and created a sustainable ecosystem for the intelligent and environmentally friendly fireworks industry—from precision intelligent design to end-user needs.

6. Conclusion

This study builds a “full-chain dynamic adjustment” intelligent environmental protection fireworks system. This provides a technical solution to overcome the challenges of market adoption. Economically, the system drives the function-as-a-service (FaaS) model. In terms of brand and society, it promotes the green and low-carbon development of the fireworks market.

Future research should focus on three key directions: exploring the tailored user-centric of the consumer side; expanding the digital fireworks scene through integration with the metaverse and virtual reality; and deepening the comparative study of the international market to promote the global export of technical standards. This will eventually foster a new industrial ecosystem that is technically feasible, market-validated and commercially sustainable.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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