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Design Innovation and Collaborative Supply Chain Management in the Development of Animation Derivatives

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Abstract: The rapid development of animation-related derivative products is undergoing a transition from full-process production in traditional factories to modularized division of tasks and supply chain collaboration. In 2025, the market size of derivative products tied to the animation industry reached RMB 652.1 billion, while the total retail value of collectible toys stood at RMB 67.69 billion, with new categories such as rotocast plush toys and AI-powered toys showing notable and sustained growth. However, beneath this rapid industry growth, the dual challenges of design homogenization on the creative side and lagging supply chain responsiveness on the manufacturing side have severely constrained both product quality and development efficiency. Drawing on comprehensive industry survey data, this paper systematically analyzes the manifestations and root causes of insufficient design innovation and supply chain collaboration failures in the development of animation derivatives. Countermeasures are proposed from four dimensions: deep intellectual property-based transformation, design process reengineering, industrial cluster collaboration, and flexible manufacturing adoption of advanced technologies. The study suggests that modular decomposition of components and specialized division of tasks provide an effective pathway to enhancing overall product quality. Furthermore, the quantitative management of supply chain collaboration plays a significant role in shortening delivery lead times and improving overall operational efficiency within the creative manufacturing sector, ultimately fostering sustainable market competitiveness.

Keywords: animation products; design innovation; supply chain; modular production; flexible manufacturing

1. Introduction

Animation derivatives constitute the core link in extending the value chain of the animation industry, and their development efficiency and product quality directly determine the monetization capability of IP commercial value. In 2025, the market size of derivative products related to China's animation industry reached RMB 652.1 billion. As an important category of derivatives, collectible toys recorded a total retail value of RMB 67.69 billion, representing a year-on-year increase of 45.4%. The rapid growth of the industry scale has imposed higher demands on the derivative development system. The traditional model of closed-loop full-process production within a single factory has revealed clear limitations when confronted with market demand for diverse product categories and rapid iteration. Product R&D and manufacturing are increasingly characterized by component-based coordination and specialized collaboration across the supply chain. Different functional components—such as rotocast shells, plush fabrics, main control chips, optical modules, and sound control components—are now assigned to specialized suppliers with technological advantages in their respective fields for development and production. These components are then integrated through a unified project management and quality control framework, which has become a mainstream industry practice. This transformation entails dual paradigm shifts in both design philosophy and supply chain management. This paper conducts an analysis along two

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dimensions—design innovation and supply chain collaboration—to explore pathways for optimizing the animation derivative development system [1].

2. Current Status and Challenges in Animation Derivative Development

2.1. Market Size and Industry Landscape

China's animation derivative market has attained a substantial industrial scale [1]. According to recent industry data, the market size of animation-related derivative products reached RMB 652.1 billion in 2025. The pan-ACG user base expanded from 210 million in 2017 to 526 million in 2025. Growth in the collectible toy segment has been especially pronounced. Industry statistics indicate that the Chinese collectible toy market totaled RMB 87.97 billion in 2025, reflecting a year-on-year increase of 21%, and for the first time exceeded the traditional toy market, which stood at RMB 80.13 billion. Projections suggest the collectible toy industry will grow from RMB 126.4 billion in 2026 to RMB 331.0 billion by 2030, representing a compound annual growth rate of 27.2%.

From the perspective of industrial spatial distribution, Dongguan serves as the core manufacturing hub for global collectible toys. Over a quarter of the world's animation derivatives and approximately 85% of China's collectible toy products are manufactured in Dongguan. In 2025, the Shipai Town collectible toy industrial cluster was designated a national-level characteristic industrial cluster for small and medium-sized enterprises, comprising 149 enterprises with a total output value of RMB 17.23 billion; the output value of industrial enterprises above designated size accounted for one-tenth of the national total. Within a 5-kilometer radius of the Shipai Collectible Toy Center, an integrated full-industry chain has been established, covering all stages from design and prototyping to mold making, plastic forming, surface finishing, and packaging.

Exports have also demonstrated sustained expansion [2]. In the first three quarters of 2025, China's exports of festive products, dolls, and animal-shaped toys exceeded RMB 50 billion, reaching over 200 countries and regions worldwide. A leading domestic brand reported full-year 2025 revenue of RMB 37.12 billion, an increase of 184.7% year-on-year, with overseas revenue amounting to RMB 16.27 billion—representing 43.8% of total revenue. Its LABUBU series contributed RMB 14.16 billion in revenue. China's share of the global collectible toy market rose from 16.74% in 2020 to 22.91% in 2025, with further growth anticipated by 2030 (As shown in Table 1).

Table 1. Key Indicators of China's Traditional Toy and Collectible Toy Market in 2025

Indicators	Numerical Value
Market size of derivative products related to the animation industry	RMB 652.1 billion
Market size of traditional toys in China	RMB 80.13 billion
Market size of collectible toys in China	RMB 87.97 billion
Year-on-year growth rate of the collectible toy market	21%
Global market share of Chinese collectible toys	22.91%
Share of Dongguan's collectible toy production in national output	approximately 85%
Output value of the Shipai Town collectible toy industrial cluster in Dongguan	RMB 17.23 billion
Annual revenue of Pop Mart	RMB 37.12 billion
Proportion of overseas revenue for Pop Mart	43.8%
Retail sales of the rotocast plush toy category	RMB 17.5 billion
Market size of AI-powered toys	approximately RMB 29.0 billion

2.2. Design-Side Dilemmas: Homogenization and Inefficient Transformation

2.2.1. Superficial Extraction of IP Symbols

Currently, the design of animation derivatives faces widespread challenges stemming from superficial extraction of IP symbols [3]. Many derivative products rely on simple replication or pattern-based printing of IP imagery, without engaging in meaningful interpretation of the underlying cultural context, spiritual significance, or core values embodied by the IP. Consumer feedback highlights pronounced homogenization among popular IP products, with minimal brand differentiation; distributors observe sluggish sales for less prominent IPs and short-lived commercial peaks even for blockbuster IPs. For instance, flat-format derivatives—including badges, pins, and acrylic display stands—are predominantly developed from standardized licensed image libraries, severely constraining opportunities for design innovation or craftsmanship distinction; consequently, manufacturers compete primarily on speed of response. This surface-level development approach impedes the effective conversion of IP-related cultural assets into distinctive, value-added product offerings.

2.2.2. Weak Original Design Competence

Another factor constraining the quality improvement of derivative products is limited original design capability. Some animation IPs lack long-term strategic planning, resulting in rapid declines in popularity and insufficient systematic approaches to brand development. Although the domestic collectible toy market has expanded significantly over the past three years, local IPs face persistent challenges related to creative homogenization. In the rotocast plush segment, following Pop Mart's integration of rotocasting techniques with plush materials, numerous enterprises rapidly adopted similar production methods, leading to a surge of highly comparable offerings. This deficiency in original design undermines pricing power and hinders enterprises from establishing sustainable competitive differentiation amid intense market competition [3].

2.2.3. Prolonged Cycle from Design to Mass Production

The prolonged cycle from design to mass production constitutes another industry bottleneck. Under the traditional model, the process from conceptual design to finished product launch often spans several months, hindering timely alignment with time-sensitive market opportunities such as film releases or emerging cultural trends. For instance, in the derivative development for a recent animated feature, the brand owner finalized the design scheme with a manufacturing partner for an initial batch of 10,000 sets (comprising 300,000 units) in August 2024, yet the formal order was not placed until December 19 of the same year [1]. Although delivery was completed before the Spring Festival, the timeline remained exceptionally tight. This extended design-to-production cycle constrains the industry's responsiveness to market hotspots and concurrently increases inventory and market risks.

2.3. Supply Chain-Side Dilemmas: Lagging Response and Collaboration Failure

2.3.1. Imperfect Upstream Licensing Mechanisms

The rigidity of upstream IP licensing mechanisms directly constrains the efficiency and flexibility of derivative development [4]. Most domestic IPs lack forward-looking strategic planning, and their licensing frameworks remain inflexible. The business model of some enterprises functions primarily as an "IP conduit"—they do not hold the underlying IP rights, with all decision-making authority resting entirely with the copyright holders; most licenses are non-exclusive, thereby reducing their bargaining power within the industrial chain. Licensing agreements typically span one to three years, carrying inherent renewal uncertainty upon expiration. Common contractual shortcomings include unclear delineation of rights and obligations, ambiguous language, and imprecise definitions of usage scope—factors that may lead to contractual non-compliance or unauthorized use, such as over-scope production or improper sub-licensing. For instance, public reports indicate that the IP licensing fee for *Ne Zha 2* rose from approximately RMB 5 million before the Spring Festival to RMB 9 million; despite this sharp increase, demand from collaborating brands remained strong. The prevailing

model of broad licensing and short-term monetization is diminishing in effectiveness, and IP operations have transitioned toward a phase of refined, value-driven cultivation.

2.3.2. Slow Midstream Manufacturing Responsiveness

The midstream manufacturing segment exhibits limited responsiveness, reflecting broader challenges in supply chain coordination [5]. Under the traditional OEM model, the order-to-delivery cycle is lengthy, hindering adaptability to market demand patterns such as small-batch, high-variety production. During the widespread popularity of a certain mascot in 2022, several manufacturers declined large orders due to capacity limitations. Although Dongguan's Shipai Town hosts a well-developed industrial cluster, individual factories retain constrained output capabilities. When a manufacturer received an additional RMB 100 million order for products linked to a popular animated film, its existing workforce of 200 personnel proved inadequate to fulfill the requirement. This illustrates a common challenge: midstream manufacturing facilities often struggle to scale rapidly in response to sudden, substantial demand surges.

2.3.3. Extensive Downstream Channel Management

Coarse-grained management of downstream channels and demand further weakens supply chain collaboration. Key challenges include delays in authentic supply chain execution and the widespread circulation of counterfeit goods. In some instances, counterfeit versions enter the market in large volumes even before authentic products are shipped. Publicly available data indicate that, from January to November 2025, among intellectual property crime cases prosecuted by procuratorial authorities involving cultural and creative products, 20 involved the IP character "Ne Zha" and 13 involved "Pop Mart." Lax downstream channel oversight compromises the lawful rights and interests of intellectual property holders and adversely affects market stability. Insufficient demand forecasting capabilities lead to simultaneous oversupply of niche IP products and shortages of high-demand IP products, hindering precise coordination across supply chain nodes.

3. Pathways to Design Innovation

3.1. Deep Interpretation and Semiotic Innovation of IP Content

Breaking the deadlock of design homogenization hinges on deep, culturally grounded transformation of IP content. Design teams must prioritize the cultural essence of the IP over superficial visual replication. A representative case demonstrates this principle: a collaborative project reinterpreted cinematic source material not through literal reproduction, but via narrative re-creation—infusing collectible cards with autonomous storylines while integrating advanced printing technologies such as hot stamping, holographic film, reverse printing, and lithography [2]. Product lines included chibi-style character cards and traditional Chinese painting-inspired portrait cards, shifting the functional status of these items from commercial merchandise to culturally resonant artifacts. This approach transforms derivative products into affective conduits between the IP and its audience, rather than transactional commodities.

Systematic symbol management is essential for sustainable IP symbol innovation. Comprehensive symbol usage guidelines—specifying proportions, color modes, and permissible distortion thresholds for core visual elements—must be institutionalized to safeguard semantic integrity across derivative applications. Successful implementations include region-specific product variants, such as Merlion-themed editions for Singapore, gold-threaded costume editions for Thailand, and matador-inspired editions for Spain, alongside commissioned collaborations with local artists to develop new IPs tailored to regional aesthetics and narratives. Such strategies achieve dual objectives: preserving the foundational recognizability of the IP while enabling authentic, context-sensitive expression.

3.2. Design Process Reengineering and Agile Transformation

Agile transformation of the design process effectively shortens the conversion cycle from design to mass production. The AI Design and Prototyping Center, jointly established in Shipai Town in Dongguan and the Dongguan Artificial Intelligence Research Institute, produces physical samples within 48 hours and initiates mass production within 72 hours, converting 2D concept art into marketable collectible toy products in just three days. This efficiency gain stems from modular restructuring of the design process: the traditional linear workflow is decomposed into concurrently executed modules—concept design, structural design, and process design—with all modules progressing in parallel.

Design process reengineering also involves forming cross-functional teams. The 'modular disassembly plus parallel development' model developed by Weisi Collectible Toy Technology Center leverages digital tools such as 3D printing for rapid validation, AI-simulated molding parameters, and cloud-based collaborative design, compressing the mold development cycle by 80% and reducing the mass-production cycle by 83%. Functions including design, engineering, production, and quality control are integrated collaboratively from project initiation, rather than being sequentially handed off in the traditional manner. This shift significantly enhances the efficiency of transforming ideas into finished products.

3.3. Material, Process, and Digital Innovation

Material and process innovation provides the physical foundation for design innovation. Rotocast plush represents the most revolutionary category innovation in the collectible toy industry at present. The combination of rotocasting techniques and plush fabrics has shifted the industry's material orientation, with collectible toys gradually gravitating from PVC figurines toward plush products. Projections based on retail value indicate that the share of rotocast plush in China's collectible toy market is expected to grow from 20.0% in 2025 to 41.7% by 2030. Rotocast plush recorded retail sales of RMB 17.5 billion in 2025, with a compound annual growth rate (CAGR) of 144.6% from 2020 to 2025. Behind this category innovation lie breakthroughs in materials science and manufacturing processes; the composite technique combining rotocast shells with plush fabrics requires solving technical challenges such as material compatibility and structural stability.

Digital innovation is reshaping the entire chain of design and development. Artificial intelligence demonstrates significant potential in trend forecasting, creative generation, and supply chain optimization [6]. AI-powered design tools can assist in generating design proposals, optimizing product structures, and simulating production processes, thereby reducing trial-and-error costs. Market data indicate that the size of the AI-integrated toys sector in China reached approximately RMB 29.0 billion in 2025. The integration of digital design tools with intelligent manufacturing enables small-batch customization and rapid iteration, offering broader scope for design innovation.

Design innovation also needs to extend downstream into the supply chain [7]. Modular architecture requires designers to plan functional components during the product concept stage, specifying interface standards, dimensional tolerances, and material compatibility requirements for each component. What designers deliver is no longer a single, integral product blueprint, but rather a design package that includes independent technical specifications for each functional component—such as rotocast shells, plush fabrics, and electronic elements. This conceptual shift toward "Design for Manufacturing" (DFM) ensures effective alignment between the design phase and the specialized division of tasks across the supply chain, laying the technical foundation for subsequent collaborative production.

4. Countermeasures and Implementation of Supply Chain Collaborative Management

4.1. Industrial Cluster Collaboration: From "Solo Efforts" to "Networked Synergy"

The core of industrial cluster collaboration lies in integrating dispersed production units into an organic whole, and the practice of Shipai Town in Dongguan provides an

empirical reference. When faced with an order exceeding RMB 100 million for Ne Zha 2 derivatives, Wogongchang initiated collaborative production with multiple collectible toy enterprises within Shipai Town, thereby bringing over one hundred enterprises into the cooperation network. Twelve mold manufacturers, thirteen producers, and over a hundred raw material and surface finishing enterprises formed a joint supply system, with order matching and task allocation completed through the production capacity big data platform established by the local government. The one-stop support capability within the 5-kilometer industrial ecosystem inside the cluster enabled synchronized operation across all stages—raw material supply, mold development, plastic forming, surface finishing, quality inspection, and logistics and shipping. Upstream and downstream enterprises advanced their respective module production tasks in parallel, ultimately compressing the delivery cycle from 15 days under the traditional model to 10 days (see Table 2). These data confirm the significant effectiveness of network-based coordinated interaction within industrial clusters in reducing production lead times.

Table 2. Supply Chain Collaboration Efficiency Indicators for the Shipai Town Collectible Toy Industrial Cluster

Indicators	Numerical Value
Number of enterprises in the industrial cluster	149 enterprises (cluster enterprises)
Supporting upstream and downstream enterprises	over 400
Coverage range of the industrial ecosystem	5 km ²
Average full-process delivery cycle	10–20 days
Mold development cycle under the traditional model	60 days
Mold development cycle under the collaborative model	10 days
Mass-production cycle under the traditional model	60 days (baseline)
Mass-production cycle under the collaborative model	10 days
Prototyping time of the AI Design and Prototyping Center	48 hours
Time to initiate mass production at the AI Design and Prototyping Center	72 hours
Improvement margin of production efficiency	20%
Improvement margin of yield rate	5%–10%

The value of industrial cluster collaboration can be quantified using a supply chain collaboration efficiency formula. Let the delivery cycle of a single factory under the traditional model be denoted as T_0 , and the parallel production cycle of N collaborating enterprises under the collaborative model be denoted as T_n . Then the collaborative efficiency improvement coefficient can be defined as Equation (1):

$$\eta = \frac{(T_0 - T_n)}{T_0} \times 100\% \quad (1)$$

Taking the Shipai Town collectible toy industry as an example, with $T_0=60$ days (traditional model) and $T_n=10$ days (collaborative model), the collaborative efficiency improvement coefficient is calculated as $\eta=(60-10)/60 \times 100\% \approx 83.3\%$. This efficiency gain stems from the combined effect of modular task decomposition and parallel production. Within the 5-km² industrial ecosystem of Shipai Town, all supporting services—including raw materials, mold making, plastic forming, packaging, quality control (QC), and logistics—are fully integrated as a one-stop solution, enabling a full-process delivery cycle of 10 to 20 days on average. The geographical proximity of the industrial cluster reduces logistics and communication costs, thereby providing a physical foundation for "networked collaboration."

4.2. Flexible Production and Digital Supply Chain Development

Flexible manufacturing is a key capability enabling supply chains to respond effectively to market uncertainty. Collectible toy brands widely adopt the flexible order model characterized by 'small batches and multiple runs.' Through flexible manufacturing, doll production has achieved a rapid-response capability that supports small-batch

production and frequent reorders, facilitating faster detection of market signals and accelerated design iteration. Small-batch production with minimum order quantities in the dozens is now operationally feasible, and 3D printing technology has enabled efficient rapid prototyping. A leading enterprise in this domain demonstrates core competencies in AI-assisted design, seven-day ultra-fast prototyping, and flexible manufacturing.

Digital supply chain construction provides systematic support for flexible manufacturing operations. One prominent brand's supply chain management center operates according to the 3A principles—agility, adaptability, and alignment. Its responsibilities span production, design, development, warehousing, and logistics, functioning as an integrated middle-office platform that coordinates across multiple functional departments. The adoption of the PPM (parts per million) defect rate standard drives continuous improvement in manufacturing efficiency and product quality. The digital supply chain platform enables seamless data integration across demand forecasting, capacity planning, and quality control, significantly enhancing responsiveness and cross-functional collaboration accuracy.

Product quality control can be established through a quantitative indicator system from a modular perspective [8]. Suppose a collectible toy product consists of k independent functional modules, with the defect rate of the i -th module denoted as p_i (where $i=1,2,\dots,k$). Under the assumption that defects among modules are mutually independent, the overall product yield R can be expressed as Equation (2):

$$R = \prod_{i=1}^k (1 - p_i) \quad (2)$$

Taking a rotocast plush toy as an example, suppose the defect rate of the rotocast shell module is $p_1=0.02$, the defect rate of the plush fabric module is $p_2=0.015$, the defect rate of the apparel accessory module is $p_3=0.01$, and the defect rate of the electronic module is $p_4=0.005$; then the overall product yield is calculated as $R=(1-0.02)\times(1-0.015)\times(1-0.01)\times(1-0.005)=0.98\times0.985\times0.99\times0.995\approx0.951$. This calculation demonstrates that even when each module is individually controlled to a relatively high standard, the overall yield after integrating multiple modules still faces significant challenges. The PPM (parts per million) defect rate standard is specifically designed to address this issue by controlling the defect rate of each module at the parts-per-million level, thereby ensuring the quality of the final product [6, 9].

4.3. Licensing Mechanism Optimization and Omni-Channel Collaboration

The optimization of licensing mechanisms is a prerequisite for unlocking the collaborative efficiency of the supply chain. The model of extensive licensing and short-term monetization is proving ineffective, and intellectual property operations must transition into an era of intensive cultivation [10]. Licensors should establish a tiered licensing system that grants differentiated rights based on the licensee's design capabilities, production capacity, and channel resources, rather than adopting a one-size-fits-all image library licensing model. Contractual terms should clearly define key elements such as the scope of authorization, duration, quality standards, and quality control requirements, so as to minimize ambiguities in rights and obligations.

Omnichannel collaboration requires downstream channels to be upgraded from "sales terminals" to "data nodes." Physical stores should evolve from mere points of sale into immersive intellectual property experience spaces. Through the integration of online and offline data, enterprises can gain real-time visibility into sales dynamics across different regions and channels, enabling precise replenishment and dynamic pricing. Data from the General Administration of Customs indicate that exports of collectible toy products increased by 11.4% year-on-year in the first three quarters of 2025. The rapid growth of overseas markets demands that the supply chain possess global collaborative capabilities; behind the significant overseas revenue contribution lies the support of a social media structure organized around a central global account coordinated with regional accounts, alongside a multi-regional supply chain system.

4.4. Product Refinement, Componentization, and Modularization

The refinement, componentization, and modular design of products form the micro-foundation for specialized coordination and collaboration across the supply chain. The widely adopted "rotocast plush" process in the collectible toy industry requires precise integration among interdependent stages including rotocasting, plush fabric processing, apparel manufacturing, and accessory production. A single product may involve over a dozen manufacturing partners—hats produced by apparel specialists, necklaces by jewelry manufacturers—with all elements consolidated into final integration. This industrial coordination capability necessitates that, during product design, each functional element be structured as an independent module capable of separate development, production, and quality assurance.

Modular structuring allows suppliers in distinct technical domains to apply their domain-specific expertise. Rotocast shells are assigned to facilities specializing in rotational molding, plush fabrics to enterprises with advanced textile capabilities, and core electronic components—including main control chips, optical modules, and audio control units—to dedicated electronics manufacturing providers. Within Pop Mart's supply chain ecosystem, Dongguan contributes over 70% of total production capacity; in 2020, more than 30 OEM and partner enterprises delivered components for Pop Mart. Each supplier operates at peak proficiency within its domain, and all elements undergo coordinated integration through a unified project management and quality assurance framework [11, 12]. This approach—characterized by component-driven development, domain-specialized coordination, and system-level integration—supports consistent enhancement of overall product quality.

5. Conclusion

The animation derivative industry is currently undergoing a shift from quantitative growth to qualitative advancement. With a projected market size exceeding RMB 650 billion in 2025, the sector holds significant potential for development; however, challenges including design homogenization and inefficiencies in supply chain coordination continue to impede industrial upgrading. This analysis indicates that design innovation hinges on deep transformation of IP content and agile reengineering of design workflows, while effective supply chain coordination relies on networked collaboration among industrial clusters and the implementation of adaptive production systems. A model based on functional component standardization and specialized role allocation enables suppliers across vertical segments to leverage domain-specific expertise, with final integration achieved through a unified quality assurance framework—this approach supports measurable improvements in overall product quality. The collaborative ecosystem of the Shipai Town industrial cluster in Dongguan and the operational principles underlying Pop Mart's 3A supply chain offer instructive benchmarks for the sector. Looking ahead, the increasing integration of AI technologies, digital design tools, and intelligent manufacturing capabilities is expected to further reshape design practices and supply chain dynamics in animation derivatives.

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