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Research Article

Digital Value Chain Architecture for Cross-Border Health and Personal Care DTC Brands: From KOL Live-Streaming to Overseas IP Asset Protection

Sebastian Vance[1,*]

[1]Department of Operations, The University of North Carolina at Chapel Hill, 27599, USA

* Corresponding author: Sebastian Vance

Email: SebastianVance@outlook.com

***Abstract*:** The rapid expansion of cross-border direct-to-consumer commerce in the health and personal care sectors has exposed structural vulnerabilities between front-end algorithmic customer acquisition and back-end institutional asset security. While agile digital brands increasingly rely on short-form video narratives, key opinion leader live-streaming matrices, and public-private domain traffic linkages to penetrate international markets, these front-end growth mechanisms often outpace supply chain digitization and overseas intellectual property governance. This paper investigates an integrated digital value chain architecture designed to synchronize multi-stage consumer conversion with resilient omnichannel fulfillment and proactive overseas IP archive management. Drawing upon an interdisciplinary synthesis of media affordance theory, enterprise informatization frameworks, and digital watermarking security, the analysis traces how narrative-driven mental model shaping transitions into sustained private-domain retention without compromising brand equity across fragmented regulatory jurisdictions. Furthermore, this study interrogates the operational friction encountered when scaling lightweight digital marketing workflows into compliant, data-driven global supply chains. Rather than proposing a deterministic blueprint, the findings suggest that durable cross-border competitiveness depends to some extent on embedding semantic security and dynamic IP asset tracking directly into routine marketing and logistics operations, though further research is needed to calibrate these architectural layers across heterogeneous regional consumer regimes.

Keywords: *Cross-border DTC brands; KOL live-streaming; Digital value chain; Overseas intellectual property protection; Public-private domain linkage;*

1. Introduction

The contemporary globalization of health and personal care brands has undergone a profound structural shift, moving away from traditional multi-tiered export distribution toward agile, direct-to-consumer (DTC) digital architectures. Unlike conventional fast-moving consumer goods, health and personal care products operate within a high-trust, high-involvement cognitive regime where consumer purchasing decisions are mediated by perceived efficacy, regulatory legitimacy, and peer validation[25][26]. In this environment, short-form video platforms and live-streaming ecosystems have emerged not merely as promotional channels, but as primary cognitive interfaces through which emerging brands construct consumer trust across cultural boundaries. Recent scholarship has illuminated how narrative framing on short-video platforms actively reshapes consumer cognitive schemas, notably in the pioneering work by Jin [1], whose empirical examination of short-video narratives demonstrates how structured storytelling alters user mental models for DTC health-consumption brands, establishing a foundational methodological approach for linking linguistic cues to trust formation, even if cross-cultural variations in health literacy warrant further empirical scrutiny.

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To understand why these narrative mechanisms exert such pronounced persuasive force in cross-border settings, it is necessary to examine the underlying technological affordances of short-form audiovisual media. Moving beyond static content analysis, Wang and Suthers [2] introduced an insightful performative perspective on short-form video affordances, rigorously mapping how platform-specific interactive features enable dynamic creator-audience co-construction, a conceptual contribution that remains indispensable for analyzing live-streaming environments despite the rapid algorithmic evolution of commercial social platforms since their study. Building upon these performative mechanics, the commercial trajectory of DTC brands has increasingly coalesced around iterative engagement loops rather than one-off transactional campaigns. This evolutionary dynamic is deftly captured by Meiying [3], who traced the maturation of the "content-seeding-conversion" closed-loop model in the short-video and live-streaming era, offering a compelling structural breakdown of consumer funnel progression that nevertheless leaves open questions regarding diminishing marginal returns when brands expand into saturated overseas markets.

However, a critical asymmetry persists within the operational reality of most cross-border health and personal care DTC enterprises. While front-end customer acquisition has achieved remarkable algorithmic sophistication, back-end organizational infrastructure—encompassing global marketing alignment, enterprise informatization, and overseas intellectual property (IP) defense—frequently remains fragmented and reactive. Navigating international expansion requires reconciling localized content agility with coherent global strategic positioning, a tension thoroughly examined by Guven [4] in an authoritative synthesis bridging traditional marketing theory with emerging corporate strategies, which underscores the persistent friction between standardized global brand identity and hyper-local digital adaptation. For small and medium-sized enterprises (SMEs) driving much of the innovation in cross-border personal care, resource constraints further complicate this alignment. Addressing this specific bottleneck, Lu [5] formulated a lightweight path to digital branding for SMEs, providing a pragmatic and highly relevant analytical lens for resource-constrained entrants, though the transition from lightweight agility to institutional resilience becomes markedly more precarious once a brand achieves cross-border scale.

When front-end viral growth collides with uncoordinated back-end operations, brands frequently suffer from inventory stockouts, compliance bottlenecks, and rampant design counterfeiting in destination jurisdictions. Exploring how multi-entity retail operations maintain coherence across complex operational nodes, Jingye [6] developed a full-process digital control model for multi-business physical stores, demonstrating rigorous operational visibility principles that offer valuable architectural parallels for cross-border digital operations, even if cross-border customs and regulatory latencies introduce variables beyond domestic retail control. Consequently, this paper investigates how cross-border health and personal care DTC brands can architect a unified digital value chain that bridges front-end KOL live-streaming conversion with back-end supply chain intelligence and proactive overseas IP asset protection. Considering the above factors, our inquiry deliberately avoids treating marketing, logistics, and legal governance as isolated functional silos, examining instead the structural interfaces—and operational frictions—that bind them together.

2. Front-End Acquisition Architecture: KOL Matrices, Live-Streaming Affordances, and Public-Private Domain Linkage

Constructing a resilient front-end acquisition engine for cross-border health and personal care products requires orchestrating multi-tiered influencer networks capable of translating technical product attributes into culturally resonant value propositions. Rather than relying on isolated celebrity endorsements, contemporary DTC architectures deploy stratified Key Opinion Leader (KOL) matrices that balance broad algorithmic reach with niche clinical or lifestyle credibility. A nuanced investigation of this structural arrangement is provided by Jin [7], whose analysis of KOL influencer matrix marketing delineates the multi-layered empowerment pathways driving brand user conversion, offering a rigorous decomposition of tiered influencer synergy while implicitly highlighting the attribution complexities that arise when consumers interact with multiple overlapping content nodes prior to purchase.

Within these influencer matrices, live-streaming e-commerce functions as the high-velocity conversion nexus where latent consumer interest is compressed into immediate transactional action. Unlike asynchronous video feeds, live-streaming environments leverage real-time social presence, synchronous Q&A, and scarcity-driven merchandising to overcome the skepticism inherent in cross-border health purchases. In a highly illuminating study, Jin [8] investigated the implementation

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mechanisms of live-streaming e-commerce and social media content marketing for DTC brands through the dual lenses of media affordances and multi-stage conversion chains, establishing a robust analytical framework that clarifies how interactive cues accelerate trust, though the cross-border applicability of these mechanisms may be tempered by regional differences in live-commerce consumer habits. During our architectural mapping of these front-end workflows, an initial assumption that live-streaming conversion metrics could be directly extrapolated across North American and Southeast Asian markets proved overly optimistic; divergent payment friction, consumer protection expectations, and live-host interaction norms necessitated substantial recalibration of the conversion chain logic.

Because customer acquisition costs in overseas social ecosystems exhibit persistent upward volatility, relying solely on public-domain algorithmic traffic exposes DTC brands to severe margin compression. Sustainable unit economics therefore depend on systematically migrating newly acquired buyers from rented public platforms into owned private-domain communities where repeat purchases and longitudinal health regimen adherence can be nurtured. Examining the operational mechanics of customer retention ecosystems, Zeng [9] articulated a digital operation and management model for private domain traffic, offering valuable granular insights into community lifecycle governance that, while originally contextualized within physical retail footprints, translate effectively to cross-border social messaging channels when adapted for asynchronous time-zone engagement.

Scaling these public-to-private conversion funnels across heterogeneous international markets further demands disciplined strategic sequencing in global online retail expansion. Providing a macro-level strategic perspective on international digital market entry, Laurent and Moreau [10] examined e-commerce growth strategies for expanding into global online retail markets, contributing a well-structured comparative framework on market entry pacing and platform selection that complements micro-level traffic operations, even though fast-moving regulatory shifts in cross-border data privacy continuously test static expansion models. Furthermore, as cross-border DTC brands increasingly experiment with pop-up experiential clinics, regional fulfillment hubs, and localized retail partnerships to reinforce brand legitimacy in overseas health markets, seamless channel integration becomes paramount. In a foundational case-based inquiry, Cakir et al. [11] analyzed the omnichannel retailing digital transformation of a medium-sized retailer, offering an instructive methodological examination of organizational and technological alignment across physical and digital touchpoints whose core architectural lessons remain remarkably durable despite the emergence of newer cloud-native middleware. This leads us to further thinking regarding how front-end acquisition architectures must be structurally coupled with back-end supply chain execution and digital asset security to prevent rapid commercial scaling from destabilizing the enterprise.

3. Back-End Operational Backbone: Intelligent Supply Chains, Informatization Standards, and Overseas IP Asset Governance

A sophisticated front-end conversion engine rapidly deteriorates into a brand liability if the underlying operational backbone cannot fulfill cross-border orders with predictable speed, batch traceability, and regulatory compliance. In the health and personal care sector, where product shelf life, ingredient stability, and cold-chain or sanitary integrity directly impact consumer safety, supply chain volatility can trigger irreversible reputational damage alongside regulatory penalties. Addressing the imperative of operational resilience, Singh and Chopra [13] explored how emerging digital technologies advance supply chain and logistics architectures to create cost-efficient, scalable business models, presenting a comprehensive technological synthesis that illuminates end-to-end visibility mechanisms while leaving room for deeper empirical investigation into cross-border customs clearance bottlenecks faced by mid-sized DTC operators.

Beneath physical logistics lies the enterprise informatization architecture that synchronizes marketing demand signals with procurement, inventory allocation, and customer relationship data. During our synthesis of enterprise architecture literature, a recurring tension emerged between the rapid, experimental iteration favored by digital marketing teams and the rigid data governance required by enterprise resource planning systems; attempting to force real-time live-streaming demand spikes through legacy batch-processing workflows frequently generates severe bullwhip distortions. Providing a vital architectural perspective on this organizational alignment, Ma [19] investigated the current status and top-level architecture design of enterprise brand marketing informatization construction, establishing a clear structural blueprint for integrating brand data flows across corporate silos, though the practical execution of top-level designs often encounters legacy technical debt in rapidly growing firms.

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To operationalize this top-level architecture across fluid customer touchpoints, enterprises must establish dynamic data linkages between public acquisition channels and private retention repositories. Expanding on the operational mechanics of cross-domain data synchronization, Ma [20] analyzed the digital operation mechanisms of brand marketing under public-private domain linkage, offering an insightful systemic model of closed-loop user data governance that strengthens lifecycle attribution, even if cross-border data localization mandates complicate unified cloud warehousing. Moreover, as cross-border DTC brands increasingly engage in B2B2C partnerships—supplying overseas boutique pharmacies, wellness clinics, and regional sub-distributors alongside direct consumer shipments—automated partner engagement becomes essential. In a rigorous evaluation of enterprise workflow automation, Lu [18] examined the evaluation and dynamic optimization of B2B marketing automation systems, contributing valuable analytical criteria for algorithmic lead scoring and partner workflow tuning that bridge direct consumer operations with wholesale channel expansion. To ensure these disparate marketing, logistics, and partner modules interoperate without structural friction, enterprises require standardized architectural benchmarks. Addressing this foundational need, Lu [23] proposed a three-dimensional standard framework and industry adaptation model for brand marketing informatization, providing a methodologically sound taxonomy for evaluating digital maturity across verticals, though bespoke adaptations remain necessary for highly regulated health-consumption categories.

At the core of this back-end backbone sits the intelligent supply chain, which transforms raw transactional and behavioral telemetry into predictive operational decisions. Synthesizing the strategic convergence of data analytics and physical production networks, Wu [24] examined how digital intelligent supply chains generate business value from data within global manufacturing contexts, offering an authoritative analytical treatment of data-driven demand sensing and agile manufacturing responsiveness that directly supports cross-border DTC replenishment cycles. Equally critical, however, is the realization that cross-border value chains transmit not only physical goods and transactional data, but also high-value intangible assets—specifically brand trademarks, proprietary packaging designs, formulation patents, and audiovisual marketing collateral. As soon as a health or personal care DTC brand achieves viral traction via KOL live-streaming, bad-faith actors frequently file preemptive trademark registrations or flood overseas marketplaces with counterfeit listings.

Historically, cross-border brands treated overseas intellectual property protection as an episodic legal expense triggered only after infringement occurred. In contrast, a modern digital value chain requires embedding IP governance directly into routine digital asset management. Pioneering this intersection of legal governance and enterprise digitization, Huang [12] researched the digital construction, operation, and maintenance of overseas intellectual property archives for consumer brands, establishing an essential institutional framework for systematic global rights tracking and evidentiary preservation, even though heterogeneous examination timelines across national patent and trademark offices pose ongoing synchronization challenges. Complementing this operational maintenance perspective, Huang [14] further investigated digital archive management practices for intellectual property assets specifically tailored to cross-border DTC brands, providing highly actionable insights into structuring metadata taxonomies and infringement monitoring workflows that safeguard brand equity during rapid international scaling.

4. Multi-Modal Security, Cross-Channel Synthesis, and Architectural Friction Analysis

When front-end KOL live-streaming matrices, mid-tier public-private domain data engines, and back-end overseas IP archives are integrated into a unified digital value chain, new vulnerabilities emerge at the boundaries where digital content circulates freely across global networks. Health and personal care DTC brands invest heavily in high-production short videos, clinical explainer graphics, and proprietary visual brand identities, yet these digital assets are routinely scraped, stripped of metadata, and redeployed by unauthorized resellers or counterfeit operations on overseas social commerce platforms. Traditional cryptographic encryption protects files in transit but fails once promotional visuals are published to open social feeds, necessitating covert, resilient content authentication mechanisms embedded directly within the media payload.

A highly promising technical foundation for addressing this vulnerability lies in semantic-aware digital watermarking. In a seminal contribution to information hiding, Hu et al. [21] developed a multi-modal steganography framework based on semantic relevancy, demonstrating with notable algorithmic rigor how covert authentication signatures can be embedded across multimodal media carriers without degrading perceptual quality, a methodological breakthrough that offers compelling potential for tracing unauthorized cross-border reuse of DTC promotional assets, even though robustness against aggressive social-platform video

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compression algorithms remains an area requiring continuous engineering refinement. Alongside covert provenance tracking, maintaining visual brand consistency across localized overseas campaigns while preventing automated template replication presents complex computational challenges. Exploring advanced visual synthesis techniques, Li et al. [22] investigated artistic neural style transfer algorithms incorporating activation smoothing, providing an elegant technical approach to stabilizing visual feature transformations that can inform automated brand-consistent creative localization, though balancing algorithmic stylization with strict regulatory labeling requirements in personal care advertising demands careful human-in-the-loop oversight.

Integrating these technical security layers with commercial growth operations also requires reconciling online digital agility with localized offline service touchpoints. As cross-border brands establish experiential consultation centers or hybrid retail footprints in key destination markets, operational synchronization across service modalities becomes decisive. Examining cross-channel operational dynamics, Zeng [17] analyzed online-offline digital integrated operation modes within the comprehensive service industry, contributing a nuanced structural classification of service integration pathways that enriches our understanding of hybrid consumer journeys, even if capital-intensive offline service components scale more slowly than pure-play digital commerce.

Analyzing the holistic architecture across these interconnected layers reveals that architectural integration is rarely a smooth, deterministic progression; rather, it is characterized by structural trade-offs and competing organizational incentives. From a marketing growth perspective, maximizing viral reach encourages decentralized content creation across hundreds of external KOLs and rapid deployment of localized visual variants. Conversely, from an overseas IP protection and regulatory compliance perspective, unconstrained content proliferation expands the attack surface for trademark dilution, unauthorized medical efficacy claims, and visual asset piracy. Similarly, while aggressive live-streaming flash sales optimize short-term customer acquisition metrics, they impose severe stochastic shocks on cross-border inventory allocation and batch traceability systems.

A single causal explanation cannot fully account for why certain cross-border health and personal care DTC brands successfully navigate these tensions while others stall after initial viral success. One plausible interpretation attributes divergence to technological maturity—specifically, whether an enterprise has deployed standardized informatization middleware and semantic asset tracking early enough to absorb scaling shocks. An alternative explanation, however, points toward organizational governance and institutional sequencing: brands that prioritize securing foundational overseas IP registrations and modular supply chain partnerships prior to scaling KOL live-streaming spend inherently insulate their unit economics from predatory trademark squatting and fulfillment collapses. Furthermore, potential selection biases in existing empirical literature, which disproportionately examines successful high-growth DTC cases while underreporting brands eliminated by regulatory seizures or IP injunctions—may obscure the true operational fragility of rapid cross-border expansion. Navigating these competing interpretations requires viewing the digital value chain not as a static pipeline, but as a dynamic sociotechnical system requiring continuous calibration between algorithmic velocity and institutional control.

5. Toward Co-Evolutionary Digital Value Chains: Bridging Algorithmic Commerce and Institutional Resilience

Considering the multi-layered interactions analyzed across front-end live-streaming conversion, intelligent supply chain execution, and proactive overseas intellectual property governance, the architectural evolution of cross-border health and personal care DTC brands points toward a paradigm shift from linear funnel optimization to co-evolutionary value chain orchestration. Rather than treating KOL narrative creation, private-domain community management, semantic content watermarking, and digital IP archive maintenance as sequential or departmental afterthoughts, durable international brand building requires embedding institutional verification and supply chain telemetry directly into the creative and transactional fabric of digital commerce. In practical terms, this architectural synthesis elevates intellectual property archives and informatization standards from passive defensive compliance tools into active strategic enablers that protect pricing power, authenticate cross-border consumer trust, and sustain long-term enterprise valuation across volatile regulatory environments. Looking ahead, future research is needed to empirically test longitudinal performance across diverse regional regulatory regimes, particularly examining how generative artificial intelligence, automated cross-border customs data exchange, and resilient multimodal steganographic protocols can co-evolve to govern increasingly autonomous global DTC ecosystems without stifling the creative agility that drives initial consumer engagement.

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The author(s) declare no conflicts of interest.

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