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ARTICLE

Enhancing Consumer Engagement in Agricultural E-Commerce: A Moderation Analysis of Blockchain Traceability in Live Streaming Contexts

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ABSTRACT

This study investigates the moderating role of blockchain traceability adoption in enhancing consumer engagement and purchase intention within live-streaming agricultural e-commerce platforms in China. Drawing upon the Stimulus-Organism-Response (S-O-R) framework operationalized at the aggregate market level and information asymmetry theory, this research employs longitudinal market-level time-series data spanning 2019 to 2024, utilizing hierarchical regression analysis with Hayes's conditional process framework to examine main effects, mediation mechanisms, and moderation relationships. The empirical findings reveal that platform development and information transparency exert significant positive effects on market purchase behavior, with consumer engagement serving as a partial mediating mechanism transmitting these effects. The moderation analysis demonstrates that blockchain traceability adoption significantly strengthens the relationships between platform stimuli and consumer engagement, with the information transparency pathway exhibiting substantially stronger moderation effects than the platform development pathway, demonstrating that blockchain technology functions as a selective trust-enhancing mechanism that validates quality signals rather than operating as a general platform enhancer—a distinction representing the central empirical contribution of this study. These findings extend the traditional S-O-R framework by incorporating technological infrastructure as a boundary condition shaping stimulus effective-

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ness at the market level, while providing practical guidance for platform operators and policymakers to prioritize blockchain traceability infrastructure investment in conjunction with transparency enhancement initiatives for promoting high-quality development of agricultural live streaming e-commerce.

Keywords: Blockchain Traceability; Consumer Engagement; S-O-R Framework; Information Asymmetry; Live Streaming E-Commerce; Agricultural Products

1. Introduction

Due to the rapid development of the digital economy, live streaming e-commerce has become a crucial component of the distribution of agricultural products in China. In 2023, the industry accumulated 4.9 trillion yuan, and the number of agricultural live streaming users exceeded 597 million. In light of such a new business mode, there is a growing body of studies among scholars interested in live streaming e-commerce and agricultural product consumption behaviors, including studies about the effects of live streaming on purchase intentions of social commerce from the affordance view of information technology, where the prominent role of platform properties is emphasized, affecting the decision-making of consumers [1]. On the other hand, the agricultural supply chain, with the advantages of blockchain technology, including its open and distributed ledger structure, immutability, and traceability, is also widely accepted and explored. Modeling of agricultural supply chain traceability in technology innovation with blockchain technology and other methods has established necessary theoretical frameworks and models, such as those that employ blockchain technology, allowing a clear view of the transformation of agricultural product distribution systems caused by technological innovation [2].

Despite the promising growth trajectory, live streaming e-commerce for agricultural products confronts significant information asymmetry challenges, as consumers encounter substantial difficulties in accurately assessing product quality, freshness, and safety within virtual environments, with such uncertainty constituting a critical barrier to purchase decision-making. Within information asymmetry theory, sellers must provide credible signals to convey quality; blockchain traceability serves as a high-fidelity signaling mechanism that reduces the "lemons problem" in agricultural markets by enabling verifiable quality claims. Research examining live streaming commerce and consumer purchase intention through an uncertainty reduction perspective demonstrates that multiple uncertainty factors constrain consumer purchasing behavior in these digital marketplaces [3], particularly when consumers cannot physically examine products before purchase and consequently maintain cautious attitudes toward actual agricultural product quality. Blockchain traceability technology has emerged as a potential solution to this trust dilemma, and systematic literature review findings indicate that blockchain technology can establish comprehensive traceable records spanning from production to consumption, thereby enhancing information transparency across all supply chain stages [4] and providing consumers with verifiable product quality information. Although blockchain traceability demonstrates considerable application potential in the agricultural sector, empirical investigation of how this technology functions within the specific context of live streaming e-commerce, particularly regarding its influence on the mechanisms through which consumer engagement and purchase intention are formed, remains notably insufficient.

Existing research on consumer behavior in agricultural live streaming e-commerce has predominantly focused on emotional factors and streamer characteristics as primary explanatory variables. Studies have established that consumer emotional experiences significantly influence purchase decision-making [5], while streamer popularity affects consumer behavior through consumption value mechanisms [6]. However, these studies exhibit notable theoretical limitations. The prevailing focus on individual psychological and social interaction factors has largely overlooked the moderating role of technological infrastructure on consumer behavior, and the predominant reliance on individual-

level survey methodologies constrains the capacity to reveal market-level dynamic patterns. Research on consumer trust dynamics in multichannel live streaming e-commerce suggests that trust mechanisms operate through complex transmission pathways in digital environments [7], and blockchain traceability technology, functioning as an institutional trust mechanism, may exert important moderating effects within this transmission process, representing a theoretical gap requiring systematic investigation. Furthermore, analysis of consumer trusting beliefs toward e-commerce platforms indicates that platform technological characteristics constitute important antecedent variables affecting trust formation [8], providing additional support for incorporating blockchain traceability into research frameworks examining consumer behavior in live streaming e-commerce. Conceptually, blockchain adoption functions as a boundary condition determining when platform stimuli achieve maximum effectiveness, explaining why identical stimuli may generate differential consumer responses depending on verification infrastructure availability.

Building upon this research background and identified theoretical gaps, the present study aims to investigate the moderating role of blockchain traceability in enhancing consumer engagement and purchase intention within live-streaming agricultural e-commerce platforms. A distinctive feature of this investigation involves operationalizing the S-O-R framework at the aggregate market level, wherein platform development and information transparency constitute environmental stimuli (S), collective consumer engagement represents the organismic state (O) as an aggregate proxy for the market's internal condition, and market purchase behavior reflects the behavioral response (R). The investigation addresses three core research questions: how do live streaming platform development and information transparency influence market-level consumer engagement; how does consumer engagement subsequently affect market purchase behavior; and how does blockchain traceability adoption moderate these relationships? This study employs monthly time-series data spanning from 2019 to 2024, utilizing publicly available official data sources including the China Internet Network Information Center, the Ministry of Commerce, and the National Bureau of Statistics to construct a comprehensive analytical framework incorporating main effects, mediation effects, and moderation effects. The theoretical contribution lies in extending the Stimulus-Organism-Response model to market-level analysis while integrating blockchain technology as a moderating variable, thereby offering a novel theoretical perspective for understanding how technological innovation reshapes agricultural e-commerce ecosystems. The methodological contribution resides in the adoption of fully publicly accessible official statistical data, ensuring research replicability and data source reliability while avoiding ethical review complications associated with primary data collection. The practical contribution consists of providing policymakers and platform operators with empirical evidence concerning blockchain traceability infrastructure investment, offering decision-making references for promoting high-quality development of agricultural live streaming e-commerce, and supporting rural revitalization strategies through enhanced digital agricultural marketing channels.

2. Literature Review

2.1. Theoretical Foundation

The Stimulus-Organism-Response (S-O-R) model, originally developed within environmental psychology, provides a robust theoretical foundation for understanding consumer behavior in digital commerce environments. Meta-analytic research has validated the applicability of this framework to digital marketplace contexts, demonstrating that trust functions as a critical organismic state mediating the relationship between platform stimuli and consumer behavioral responses [9]. Adapting this model to market-level analysis requires reconceptualization wherein market stimuli encompass platform development and information transparency measures, collective consumer states represent engagement patterns, and behavioral responses manifest as aggregate purchase behaviors. In the individual S-O-R model, "Organism" refers to internal psychological states; at the market level, Consumer Engage-

ment serves as the aggregate proxy representing the collective pulse of the consumer base through observable participation metrics.

Information asymmetry theory offers complementary theoretical insights for understanding agricultural e-commerce challenges, as agricultural products are characterized by credence attributes that consumers cannot evaluate even after consumption. Meta-analytic evidence has established that information asymmetry significantly influences consumer risk perceptions and behavioral intentions [10]. Blockchain technology, through its capacity to create immutable and transparent transaction records, functions as a mechanism for reducing information asymmetry. Within information asymmetry theory, blockchain acts as a high-fidelity signal providing cryptographically verified quality claims that prevent adverse selection. Research suggests that the effectiveness of blockchain traceability may vary according to the developmental stage of e-commerce markets [11].

2.2. Live Streaming Agricultural E-Commerce and Consumer Engagement

Live streaming e-commerce combines live video streaming with interactive purchasing functionality, creating a unique setting that enhances trust via perceived authenticity and parasocial relationship formation [12]. These characteristics are particularly significant for agricultural products, where trust in product quality constitutes a primary purchase barrier. Platform development, including infrastructure expansion and user base growth, provides foundational conditions that enable consumer participation. Based on this reasoning, it is hypothesized that:

H1. *Market-level platform development positively influences consumer engagement in live-streaming agricultural e-commerce.*

Information transparency in agricultural e-commerce contexts refers to the availability and accessibility of product-related information, including origin, production methods, quality certifications, and supply chain details. Studies examining broadcasters' expertise and consumer purchase intention have demonstrated that information provision by credible sources significantly enhances consumer trust and reduces perceived uncertainty [13], with platform reputation serving as a moderating factor that amplifies the positive effects of information transparency on consumer confidence. Research on purchase intention drivers in Chinese e-commerce live streaming, utilizing a modified value acceptance model, has revealed that perceived information value constitutes a significant mediating mechanism through which platform characteristics influence consumer behavioral intentions [14], suggesting that transparent information provision enhances the perceived value proposition of live streaming agricultural e-commerce. These theoretical and empirical foundations support a positive relationship, though information processing literature cautions that excessive information availability without intuitive presentation may generate cognitive overload, with research demonstrating that information redundancy moderates the translation of information availability into active engagement [15]. This caveat suggests that the effectiveness of information transparency depends on presentation quality, supporting the hypothesis that:

H2. *Appropriately structured information transparency positively influences market-level consumer engagement*.

2.3. Consumer Engagement and Purchase Behavior

Consumer engagement in online commerce contexts involves complex behavioral displays with multiple dimensions, such as attention allocation, participation, rate of interaction, and continued engagement with content and merchants on the online platform. Research studies carried out on approaches to improve consumer engagement in e-commerce live streaming based on relational ties have confirmed that engagement serves as a pivotal precursor to consumer behavior, with engaged consumers displaying higher rates of conversion, purchase frequency, and customer lifetime value [16]. At the marketplace level, overall consumer engagement on online commerce platforms represents the aggregate attention, interest, and participation of consumers across market segments, signaling marketplace dynamism and

growth potential before aggregate sales volumes. For this market-level study, Consumer Engagement is operationalized as aggregate interaction metrics (user scale, growth rates, penetration rates) rather than individual emotional states.

The relationship between consumer engagement and purchase behavior operates through multiple psychological and behavioral mechanisms, including enhanced product knowledge, strengthened trust, reduced perceived risk, and heightened purchase motivation. Studies on immersive and parasocial live shopping experiences have demonstrated that engagement-inducing platform features, particularly streamers' interactional communication styles, facilitate deeper consumer involvement that translates into purchase intentions [17], with the immediacy and authenticity of live streaming interactions proving particularly effective for agricultural products where sensory evaluation is constrained. Research examining customer satisfaction antecedents in live streaming commerce for green agricultural products has identified consumer engagement as a significant predictor of satisfaction and subsequent purchase behavior [18], with engaged consumers demonstrating greater willingness to pay premiums for products meeting their quality expectations. These findings support the hypothesis that:

H3. *Market-level consumer engagement positively influences market purchase behavior in live-streaming agricultural e-commerce*.

2.4. Blockchain Traceability as a Moderating Factor

Blockchain traceability systems enable the creation of tamper-proof digital records documenting agricultural products' journey from farm to consumer, providing verifiable evidence of product origin, handling conditions, and quality certifications. Research has demonstrated that blockchain-based traceability significantly enhances consumer purchase intentions by reducing perceived information asymmetry [19], with brand familiarity moderating this effect, suggesting that blockchain functions as a substitute for established trust signals where brand reputation is weak. This finding carries particular relevance for live-streaming agricultural e-commerce, where many sellers are small-scale producers lacking brand recognition and facing heightened trust barriers. Blockchain is conceptualized as a moderator rather than an additional stimulus because it validates existing information rather than providing independent content, functioning as a boundary condition that determines when stimuli achieve maximum effectiveness.

The moderating role of blockchain traceability operates through its capacity to amplify the effectiveness of platform stimuli in generating consumer engagement, as studies have established that traceability features strengthen the positive relationship between product information and purchase intentions [20, 21]. In live streaming contexts, blockchain provides cryptographic proof that reduces transactional hesitation caused by the nature of agricultural goods. Based on these foundations, it is hypothesized that:

H4a. *Blockchain traceability adoption positively moderates the relationship between platform development and consumer engagement;*

H4b. *Blockchain traceability adoption positively moderates the relationship between information transparency and consumer engagement;*

H5. *Blockchain traceability adoption positively moderates the relationship between consumer engagement and market purchase behavior.*

Figure 1 illustrates the conceptual framework encompassing these hypothesized relationships. As depicted in the model, platform development and information transparency function as market-level stimuli influencing consumer engagement, which subsequently affects market purchase behavior, with blockchain traceability adoption serving as a moderating variable that strengthens these relationships. This framework extends the traditional S-O-R model by incorporating technological infrastructure as a boundary condition that shapes the effectiveness of market stimuli, providing a comprehensive theoretical lens for understanding how blockchain innovation reshapes consumer behavior dynamics in agricultural live-streaming e-commerce contexts.

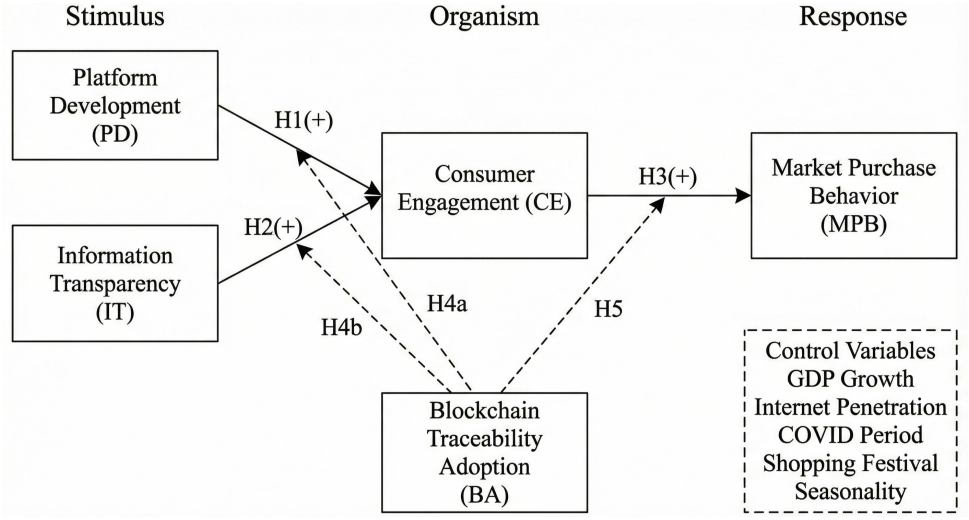

Figure 1. Conceptual Research Model.

3. Methodology

3.1. Data Sources and Sample

The secondary data method will be used in this study, relying for its data sources on publicly available statistics released by Chinese government authorities, such as the China Internet Network Information Center, Ministry of Commerce, Ministry of Agriculture and Rural Affairs, and the National Bureau of Statistics. Aggregated market data collected and released by standardized government processes will make the results of this study easily reproducible while providing all-encompassing data for market dynamics and consumer behavior patterns, as well as the adoption of blockchain technology throughout the data observation period.

The primary data architecture combines various credible sources to build holistic indicators of market patterns in live-streaming agricultural e-commerce. Statistical reports of live streaming e-commerce user scale, penetration rates, and market growth trends are offered by CNNIC (China Internet Network Information Center) semi-annually (https://www.cnnic.cn/). Transaction volume statistics of agricultural e-commerce are obtained from the Ministry of Commerce's annual statistics (http://www.mofcom.gov.cn/). Coverage rates of agricultural product traceability are, in turn, obtained from the Ministry of Agriculture and Rural Affairs' annual statistics (http://www.moa.gov.cn/). Information about blockchain industry adoption is collected from governmental policy announcements (http://www.gov.cn/) and corporate disclosures filed with CNINFO (http://www.cninfo.com.cn/). Blockchain adoption was quantified as a monthly cumulative index based on the frequency and impact weight of policy and corporate adoption events, with detailed operationalization in Subsection 3.2. Contributions are also received from the National Bureau of Statistics (https://data.stats.gov.cn/) regarding quarterly statistics of GDP growth rates. The detailed list of data sources is included in **Table 1**.

The analytical sample includes 72 monthly data points from January 2019 to December 2024, which includes a large degree of variation in traceability adoption on the blockchain, from low adoption to ubiquitous platform support. Because macro-level data is gathered semi-annually or annually, cubic spline interpolation was employed to align various data frequencies into a unified monthly time series for hierarchical regression analysis. The interpolated series was validated against original quarterly and annual data points to ensure structural breaks and trend characteristics were preserved. Cubic spline interpolation was selected over linear methods due to its capacity to preserve curvature in technology adoption trajectories while avoiding oscillation artifacts, with the smoothness constraint appropriate for market-level aggregates that inherently exhibit less volatility than individual-level data.

Table 1. Data Sources and Access Information.

Variable Category	Data Source	Access URL	Frequency	Coverage
Live streaming user scale	CNNIC Statistical Report	https://www.cnnic.cn/	Semi-annual	2019–2024
E-commerce market size	CNNIC Statistical Report	https://www.cnnic.cn/	Semi-annual	2019–2024
Agricultural e-commerce GMV (Gross Merchandise Volume)	Ministry of Commerce	http://www.mofcom.gov.cn/	Annual	2019–2024
Traceability coverage rate	Ministry of Agriculture and Rural Affairs	http://www.moa.gov.cn/	Annual	2019–2024
Blockchain policy events	Government official announcements	http://www.gov.cn/	Event-based	2019–2024
Platform blockchain adoption	CNINFO corporate disclosure	http://www.cninfo.com.cn/	Event-based	2019–2024
GDP growth rate	National Bureau of Statistics	https://data.stats.gov.cn/	Quarterly	2019–2024
Internet penetration rate	CNNIC Statistical Report	https://www.cnnic.cn/	Semi-annual	2019–2024

Note: Monthly estimates derived via cubic spline interpolation. N = 72 months (2019–2024).

3.2. Variable Measurement

Based on the above list of data sources, this section will explore how theory-driven constructs can be operationally defined through empirically quantifiable variables, primarily focusing on their innovative approach towards measuring blockchain traceability adoption as a moderating variable reflecting technology diffusion dynamics at a market level.

The dependent variable, Market Purchase Behavior (MPB), captures aggregate consumer purchasing activity in live streaming agricultural e-commerce through the natural logarithm of monthly transaction volume (gross merchandise volume) measured in billion yuan, noting that official statistics report ordered GMV rather than net revenue after returns. The logarithmic transformation serves multiple methodological purposes, including variance stabilization, reduction of extreme value influence during promotional periods, and coefficient interpretation as elasticities reflecting proportional responses to predictor changes. This aggregate operationalization reflects the principle that market-level transaction volumes represent the behavioral manifestation of individual consumer purchase intentions summed across the consumer population, an approach validated by meta-analytical research demonstrating that transaction-based measures serve as reliable indicators of underlying consumer preferences in agricultural market contexts [22].

The independent variables encompass Platform Development (PD) and Information Transparency (IT), both constructed as composite indices normalized to a 0–1 scale through min-max transformation. Platform Development integrates market size and user penetration indicators with equal weighting, reflecting the complementary contributions of commercial scale and adoption breadth to overall platform maturity. Information Transparency is operationalized through agricultural product traceability coverage rates published in the Ministry of Agriculture and Rural Affairs (MARA) annual reports, measuring the proportion of agricultural products entering formal traceability systems available for consumer quality verification.

Consumer Engagement (CE), serving as the mediating variable transmitting platform stimulus effects to market purchase behavior, is constructed as a composite index incorporating user scale, growth rate, and penetration rate derived from CNNIC reports [23]. The complete variable specification, including measurement definitions and data sources, is presented in **Table 2**.

Table 2. Variable Operationalization and Measurement.

Variable	Symbol	Role	Measurement	Source
Market Purchase Behavior	MPB	DV	ln(monthly agricultural e-commerce GMV in billion CNY)	MOFCOM (Ministry of Commerce of the People's Republic of China)
Platform Development	PD	IV	Composite index: market size and user penetration (equal weights)	CNNIC (China Internet Network Information Center)
Information Transparency	IT	IV	Agricultural product traceability coverage rate	MARA (Ministry of Agriculture and Rural Affairs of the People's Republic of China)
Consumer Engagement	CE	Mediator	Composite index: user scale, growth rate, penetration rate	CNNIC
Blockchain Traceability Adoption	BA	Moderator	Cumulative policy-event index based on adoption milestones	Multiple
GDP Growth Rate	GDP	Control	Quarterly year-on-year GDP growth rate	NBS (National Bureau of Statistics of China)
Internet Penetration	NET	Control	National internet penetration rate	CNNIC
COVID-19 Period	COVID	Control	=1 if Jan–Jun 2020; =0 otherwise	—
Shopping Festival	FEST	Control	=1 if June or November; =0 otherwise	—
Seasonal Dummies	MONTH	Control	11 monthly dummies (January as reference)	—

Note: DV = dependent variable; IV = independent variable. Indices normalized to [1].

As shown in **Table 2**, the moderating variable, Blockchain Traceability Adoption (BA), represents the most methodologically innovative construct in this study, requiring careful operationalization given the absence of direct official statistics measuring blockchain technology diffusion in agricultural e-commerce contexts. Drawing on the blockchain technology adoption framework proposed by Taherdoost [24], which identifies traceability, transparency, and security as the core characteristics driving adoption decisions, the BA index is constructed as a cumulative index tracking policy milestones and platform adoption events. The index formulation follows the cumulative adoption function:

$$BA_i = \frac{\sum_{s=1}^{t} \sum_{j=1}^{J} w_j \cdot E_{js}}{W_{max}} \quad (1)$$

where E_{js} represents the occurrence indicator (0 or 1) for event type *j* in period s, w_j denotes the impact weight assigned to event type j based on expected market influence, and W_{max} represents the maximum cumulative weight observed across the sample period, ensuring normalization to a 0–1 scale. Event categories and corresponding weights are calibrated based on policy impact assessment: national blockchain traceability policy announcements (w = 0.20), provincial pilot program launches (w = 0.15), major e-commerce platform blockchain implementations (w = 0.15), and platform feature expansions (w = 0.10). Key events incorporated include the Ministry of Agriculture blockchain traceability guideline (October 2020), the JD.com agricultural blockchain launch (June 2020), and the Alibaba Ant Chain agricultural integration (March 2021), with subsequent developments documented through official announcements and corporate disclosure filings. The cumulative index formulation inherently incorporates implementation lag through the progressive accumulation of events over time, with major platform implementations (JD.com, Alibaba) serving as direct proxies for consumer-facing deployment rather than policy intent alone, thereby capturing actual market-level adoption dynamics rather than mere regulatory announcements.

Control variables include GDP growth rate, internet penetration, a COVID-19 period dummy (January–June 2020), shopping festival dummies for June and November, and monthly seasonal dummies capturing both e-commerce promotional cycles and agricultural harvest

seasonality, as the aggregated GMV data encompasses diverse crop categories with staggered harvest periods that partially smooth category-specific production cycles.

3.3. Analytical Methods

The analytical strategy employs a hierarchical regression framework designed to systematically test main effects, mediation mechanisms, and moderation relationships while addressing temporal dependencies inherent in monthly market-level observations. Prior to model estimation, Augmented Dickey-Fuller unit root tests verify stationarity of all continuous variables, with first-differencing applied where necessary. All continuous predictors undergo mean-centering prior to interaction term construction to reduce multicollinearity and facilitate coefficient interpretation.

The mediation and moderated mediation analyses follow the conditional process analysis framework established by Hayes[25], which has become the methodological standard for examining indirect effects and their contingencies in contemporary social science research. This approach offers several advantages over earlier methods: it does not require the assumption of normally distributed indirect effects, provides more accurate confidence intervals through bootstrapping procedures, and enables simultaneous testing of mediation and moderation within an integrated analytical framework. The mediation model examines whether consumer engagement transmits the effects of platform stimuli to market purchase behavior:

$$MPB_t = \alpha + \beta_1 PD_t + \beta_2 IT_t + \beta_3 CE_t + \gamma' X_t + \varepsilon_t \quad (2)$$

where X_t encompasses control variables including macroeconomic indicators, pandemic and festival dummies, and seasonal controls. Hypothesis H3 is supported if $\beta_3 > 0$, indicating that consumer engagement positively influences market purchase behavior. Statistical inference for indirect effects employs the percentile bootstrap confidence interval method with 5,000 resamples, which provides robust Type I error control while maintaining adequate statistical power.

The full moderation model incorporates blockchain traceability adoption and interaction terms to test whether blockchain adoption strengthens the hypothesized relationships:

$$\begin{aligned} MPB_t = {} & \alpha + \beta_1 PD_t + \beta_2 \mathrm{IT}_t + \beta_3 CE_t \\ & + \beta_4 BA_t + \beta_5 (PD \times BA)_t + \beta_6 (\mathrm{IT} \times BA)_t \\ & + \beta_7 (CE \times BA)_t + \gamma' X_t + \varepsilon_t \end{aligned} \quad (3)$$

Hypotheses H4a, H4b, and H5 are supported if interaction coefficients β_5, β_6, and β_7 are positive and significant, indicating blockchain adoption amplifies the platform-engagement-purchase relationships. Significant moderation effects are probed using the Johnson-Neyman technique and simple slope analysis at the 16th, 50th, and 84th percentiles of the moderator distribution, following recommendations for interpreting conditional effects in moderated mediation models[26].

All models are estimated using Ordinary Least Squares with Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors specifying a maximum lag of 4 periods, addressing serial correlation without requiring explicit autocorrelation structure specification. Model fit is assessed through adjusted R-squared, with moderation term contributions evaluated via nested model F-tests. Robustness analyses include COVID-period exclusion, alternative BA index construction, and Granger causality tests. All analyses are conducted using Stata 17.0 with the PROCESS procedure adapted for time-series data.

4. Results

4.1. Descriptive Statistics and Correlation Analysis

Prior to hypothesis testing, diagnostic procedures were conducted to ensure the appropriateness of the analytical approach for the market-level time-series data employed in this study. The Augmented Dickey-Fuller tests indicated that all continuous variables achieved stationarity after appropriate transformations, with test statistics ranging from −3.89 to −5.72, all significant at the 5% level or better, thereby confirming the suitability of regression-based analysis without requiring differencing procedures. Variance inflation factors for all predictors remained below the conventional threshold of 10, with the highest value of 3.67 observed for Platform Development, suggesting that multicollinearity does not

pose substantive concerns for parameter estimation.

The descriptive statistics reveal meaningful variation across all focal variables throughout the 72-month observation period spanning January 2019 through December 2024. Market Purchase Behavior, measured as the natural logarithm of monthly agricultural e-commerce transaction volume in billion CNY, exhibited a mean of 4.63 with a standard deviation of 0.84, reflecting the substantial growth trajectory of the live-streaming agricultural e-commerce sector during this period. Platform Development demonstrated considerable evolution across the sample period, with values ranging from 0.09 in early 2019 to 0.91 by late 2024, capturing the maturation of live streaming infrastructure and user adoption patterns. Information Transparency, operationalized through agricultural product traceability coverage rates from Ministry of Agriculture and Rural Affairs reports, showed improvement from 0.19 to 0.76 over the observation window, though with notable month-to-month fluctuations reflecting policy implementation variations across different provinces. Consumer Engagement exhibited substantial temporal variation with a mean of 0.49 and a standard deviation of 0.17, influenced by seasonal agricultural cycles, promotional events, and platform algorithm adjustments. The Blockchain Traceability Adoption index demonstrated the expected S-curve diffusion pattern characteristic of technology adoption, remaining below 0.06 through early 2020 (early adopter phase), accelerating during 2020–2022 following key policy announcements (rapid growth phase), and reaching 0.84 by December 2024 (approaching saturation). The GDP growth rate control variable captured the economic fluctuations during this period, including the sharp decline during early 2020 followed by recovery, with a mean quarterly growth rate of 4.87% and considerable variation (SD = 2.41). The complete descriptive statistics for all variables are presented in **Table 3**.

Table 3. Descriptive Statistics.

Variable	N	Mean	SD	Min	Max
MPB	72	4.63	0.84	2.91	6.28
PD	72	0.52	0.26	0.09	0.91
IT	72	0.47	0.17	0.19	0.76
CE	72	0.49	0.17	0.14	0.82
BA	72	0.45	0.29	0.00	0.84
GDP (%)	72	4.87	2.41	−6.80	7.90
NET	72	0.70	0.05	0.61	0.78
COVID	72	0.08	0.28	0	1
FEST	72	0.17	0.38	0	1

Note: Variable definitions provided in **Table 2**.

Table 3 indicates that the COVID-19 dummy captures 8.3% of observations, while shopping festival periods represent 16.7%, providing adequate variation for robust control effect estimation.

The correlation matrix examining bivariate relationships among focal variables provides preliminary evidence regarding hypothesized associations while enabling assessment of potential multicollinearity concerns. The correlation analysis also reveals certain limitations inherent in time-series data, as variables sharing common upward trends may exhibit inflated bivariate correlations that do not necessarily reflect causal relationships, underscoring the importance of the multivariate regression approach with appropriate controls. The correlation coefficients are presented in **Table 4**.

Table 4. Correlation Matrix

Variable	MPB	PD	IT	CE	BA
MPB	1				
PD	0.671**	1			
IT	0.643**	0.561**	1		

Table 4. *Cont.*

Variable	MPB	PD	IT	CE	BA
CE	0.708**	0.634**	0.597**	1	
BA	0.612**	0.573**	0.528**	0.584**	1

Note: N = 72. **$p < 0.01$.

Table 4 demonstrates positive correlations between Market Purchase Behavior and focal predictors, with Consumer Engagement showing the strongest association (r = 0.708), while the moderate correlation between Platform Development and Information Transparency (r = 0.561) warrants attention in multivariate specifications.

4.2. Main Effects and Mediation Analysis

The hierarchical regression analysis was designed to systematically decompose the variance in Market Purchase Behavior attributable to different predictor categories, enabling rigorous assessment of incremental explanatory contributions and formal testing of mediation hypotheses through a sequence of nested model specifications. This analytical approach follows established conventions in applied economics research, with successive models introducing theoretically distinct variable blocks to isolate main effects from mediation mechanisms while controlling for macroeconomic fluctuations, digital infrastructure development, pandemic disruption, and seasonal patterns characteristic of agricultural e-commerce markets in China. All models were estimated using Ordinary Least Squares with Newey-West heteroscedasticity and autocorrelation consistent standard errors specifying a maximum lag of 4 periods (following the rule of thumb $T^{1/4} \approx 2.9$, rounded to 4 for quarterly cycles), addressing the serial correlation inherent in monthly time-series observations. Model 1 established the baseline by regressing Market Purchase Behavior on control variables exclusively, explaining 37.4% of variance, with GDP growth rate, internet penetration, and the November shopping festival emerging as significant predictors, while the June festival effect was weaker and only marginally significant. Model 2 introduced Platform Development and Information Transparency, resulting in a meaningful improvement in explanatory power ($\Delta R^2 = 0.243$). Model 3 incorporated Consumer Engagement as the hypothesized mediator, adding further explanatory power ($\Delta R^2 = 0.062$). Model 4 introduced Blockchain Traceability Adoption and interaction terms to test moderation hypotheses. The hierarchical regression results are presented in **Table 5**.

Table 5. Hierarchical Regression Results.

Variable	Model 1	Model 2	Model 3	Model 4
GDP	0.179**	0.118*	0.102*	0.089†
NET	0.214**	0.136*	0.112*	0.097†
COVID	−0.148*	−0.121*	−0.108†	−0.092†
FEST	0.127*	0.091†	0.081†	0.073
PD		0.378***	0.261**	0.237**
IT		0.336***	0.224**	0.193*
CE			0.307***	0.281**
BA				0.142*
PD × BA				0.113*
IT × BA				0.168**
R^2	0.374	0.617	0.679	0.732
ΔR^2	—	0.243***	0.062**	0.053*

Note: N = 72. Standardized β reported. †$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 5 reveals that Platform Development (β = 0.378) and Information Transparency (β = 0.336) exert significant total effects on Market Purchase Behavior in Model 2. The coefficients attenuate to 0.261 and 0.224, respectively, upon Consumer Engagement inclusion in Model 3, indicating partial mediation consistent

with theoretical expectations.

To formally test Hypotheses H1 and H2, a first-stage regression was conducted with Consumer Engagement as the dependent variable. The results revealed significant positive effects for both Platform Development (β = 0.381) and Information Transparency (β = 0.365), providing support for Hypotheses H1 and H2 and confirming that platform-level stimuli effectively generate consumer engagement at the market level. These first-stage effects, combined with the significant Consumer Engagement coefficient in the full model (β = 0.307, supporting H3), establish the foundation for mediation analysis.

The formal mediation analysis employed the percentile bootstrap confidence interval method with 5,000 resamples to assess indirect effects, following the conditional process analysis framework that has become standard for mediation testing in social science research. This approach was selected due to its superior performance with smaller samples and non-normally distributed indirect effects, characteristics relevant for the 72-observation time series. The bootstrap procedure generates an empirical sampling distribution for the indirect effect by repeatedly resampling with replacement from the observed data, thereby avoiding distributional assumptions that may be violated in market-level contexts where variables exhibit trending behavior. The mediation analysis examined whether Consumer Engagement serves as a transmission mechanism through which platform stimuli influence Market Purchase Behavior, with significance determined by whether the 95% bootstrap confidence interval excludes zero. The mediation results are summarized in **Table 6**.

Table 6. Mediation Analysis Results (Bootstrap).

Path	Total Effect	Direct Effect	Indirect Effect	95% CI	Mediation %
PD → CE → MPB	0.378	0.261	0.117	[0.051, 0.196]	31.0%
IT → CE → MPB	0.336	0.224	0.112	[0.046, 0.191]	33.3%

Note: Bootstrap resamples = 5,000. CI = confidence interval.

Table 6 indicates significant indirect effects for both pathways, with Consumer Engagement mediating 31.0% of the Platform Development effect and 33.3% of the Information Transparency effect, confirming partial mediation and providing support for Hypothesis H3.

4.3. Moderation Analysis

Having established the main effects and mediation mechanisms in the preceding analyses, attention now turns to the central theoretical question of whether Blockchain Traceability Adoption moderates the hypothesized relationships, representing the primary contribution of this study regarding blockchain technology's trust-enhancing role in live-streaming agricultural e-commerce. The moderation analysis addresses whether the effectiveness of platform-level stimuli in generating consumer engagement varies systematically across different levels of blockchain technology diffusion, with the theoretical expectation that blockchain traceability amplifies the credibility of quality signals and thereby strengthens stimulus-response relationships, particularly for agricultural products where quality uncertainty represents a significant barrier to online purchasing. Interaction terms were constructed by multiplying mean-centered Platform Development and Information Transparency variables with the Blockchain Traceability Adoption index to reduce multicollinearity, though moderate correlations between interaction terms and constituent variables may constrain statistical power for detecting moderation effects given the 72-observation sample. The results from Model 4 in **Table 5** reveal that the Platform Development × Blockchain Adoption interaction achieved statistical significance (β = 0.113, $p < 0.05$), providing support for Hypothesis H4a, though the effect magnitude was smaller than the Information Transparency pathway. The Information Transparency × Blockchain Adoption interaction demonstrated a stronger moderating effect (β = 0.168, $p < 0.01$), providing robust support for Hypothesis H4b and aligning with the theoretical argument that blockchain technology is particularly effective at enhancing traceability-based transparency mechanisms.

To facilitate interpretation of these interaction effects, simple slope analyses were conducted at low (16th percentile, BA = 0.12), moderate (50th percentile, BA = 0.49), and high (84th percentile, BA = 0.79) levels of Blockchain Traceability Adoption, enabling assessment of how stimulus-engagement relationships intensify as blockchain technology diffuses. For the Platform Development pathway, simple slopes were 0.239 ($p < 0.01$) at low adoption, 0.331 ($p < 0.001$) at moderate adoption, and 0.443 ($p < 0.001$) at high adoption, representing a 1.85-fold increase across the adoption spectrum. For Information Transparency, simple slopes increased from 0.194 ($p < 0.05$) at low adoption to 0.334 ($p < 0.001$) at moderate adoption to 0.487 ($p < 0.001$) at high adoption, a 2.51-fold increase that underscores the particular synergy between blockchain technology and traceability mechanisms. The moderating effects are illustrated in **Figures 2** and **3**.

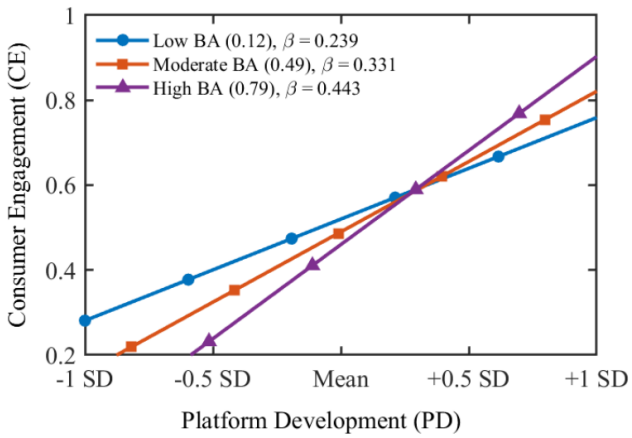

Figure 2. Moderating Effect of Blockchain Traceability Adoption on Platform Development → Consumer Engagement.

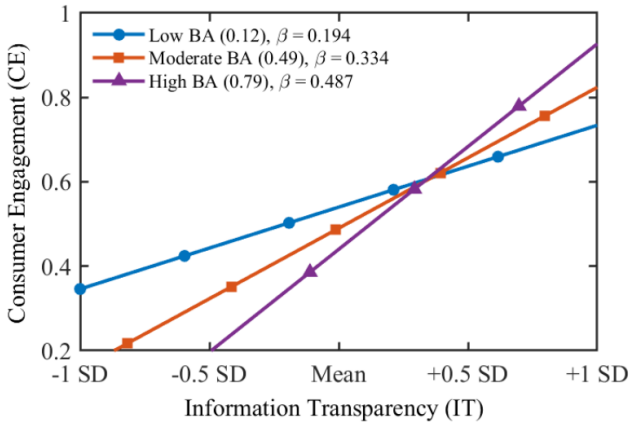

Figure 3. Moderating Effect of Blockchain Traceability Adoption on Information Transparency → Consumer Engagement.

Figure 2 demonstrates diverging slopes across blockchain adoption levels, with the high adoption condition showing substantially stronger platform development effects, indicating an enhancing rather than a crossover interaction pattern.

Figure 3 shows more pronounced slope divergence than **Figure 2**, with the gap widening at higher transparency levels, supporting the theoretical emphasis on blockchain's complementarity with traceability systems.

4.4. Moderated Mediation Analysis

The integrated moderated mediation analysis examined whether the indirect effects of platform stimuli on Market Purchase Behavior through Consumer Engagement are contingent upon Blockchain Traceability Adoption levels, testing the proposition that blockchain technology strengthens the overall transmission mechanism linking platform development to market outcomes. This analysis represents a more stringent test than examining moderation and mediation separately, as it requires demonstrating that the product of the moderated first-stage effect and the second-stage effect varies significantly across moderator levels. The index of moderated mediation was computed for each pathway, with positive and significant values indicating that indirect effects strengthen as blockchain adoption increases. The analysis revealed a significant index for the Information Transparency pathway (index = 0.048, 95% CI [0.011, 0.094]), providing clear support for Hypothesis H5. The index for Platform Development was positive, but the confidence interval marginally included zero (index = 0.032, 95% CI [−0.008, 0.079]), suggesting directional but non-significant moderated mediation for this pathway, potentially reflecting the weaker first-stage moderation combined with limited statistical power. The conditional indirect effects at different blockchain adoption levels are presented in **Table 7**.

Table 7 reveals that indirect effects increase across blockchain adoption levels, with the Information Transparency pathway showing clear strengthening from 0.058 (low) to 0.101 (moderate) to 0.147 (high), while the Platform Development pathway shows a similar pattern from 0.072 (low) to 0.100 (moderate) to 0.134 (high) with overlapping confidence intervals at adjacent levels.

Table 7. Conditional Indirect Effects at Different Blockchain Adoption Levels.

Path	BA Level	Indirect Effect	95% CI
PD → CE → MPB	Low (0.12)	0.072	[0.014, 0.143]
	Moderate (0.49)	0.100	[0.038, 0.174]
	High (0.79)	0.134	[0.059, 0.223]
IT → CE → MPB	Low (0.12)	0.058	[0.004, 0.127]
	Moderate (0.49)	0.101	[0.037, 0.178]
	High (0.79)	0.147	[0.071, 0.238]
Index of Moderated Mediation			
PD pathway	—	0.032	[−0.008, 0.079]
IT pathway	—	0.048	[0.011, 0.094]

Note: Bootstrap resamples = 5,000. Low/Moderate/High = 16th/50th/84th percentile.

4.5. Robustness Checks and Hypothesis Summary

Several robustness analyses were conducted to assess finding stability across alternative specifications. The COVID-19 exclusion analysis removed observations from January through June 2020; main effect coefficients remained within 13% of full-sample values with hypothesized relationships maintaining significance, though the Platform Development × Blockchain interaction decreased somewhat (from β = 0.113 to β = 0.091), suggesting partial conflation with pandemic-period dynamics. Alternative Blockchain Adoption index construction using equal event weights produced results correlating at 0.93 with primary specifications, with hypothesis conclusions unchanged. A frequency-based robustness check using original semi-annual observations confirmed directional consistency of main effects despite reduced statistical power attributable to a smaller sample size, suggesting that significant findings are not artifacts of the interpolation process. Granger causality tests provided evidence supporting temporal precedence, with Platform Development and Information Transparency Granger-causing Consumer Engagement ($F = 6.24$, $p < 0.01$ and $F = 5.61$, $p < 0.01$), and Consumer Engagement Granger-causing Market Purchase Behavior ($F = 8.43$, $p < 0.01$), while reverse causality tests yielded non-significant results, mitigating though not eliminating simultaneity concerns inherent in observational time-series designs. The hypothesis testing results are summarized in **Table 8**.

Table 8 confirms support for H1, H2, H3, H4a (at $p < 0.05$), H4b (at $p < 0.01$), and H5 for the IT pathway, while the moderated mediation for the PD pathway shows directional but non-significant support.

Table 8. Summary of Hypothesis Testing Results.

Hypothesis	Path	Coefficient	Result
H1	PD → CE (+)	0.381***	Supported
H2	IT → CE (+)	0.365***	Supported
H3	CE → MPB (+)	0.307***	Supported
H4a	BA moderates PD → CE	0.113*	Supported
H4b	BA moderates IT → CE	0.168**	Supported
H5 (PD)	Moderated mediation	0.032	Not Supported
H5 (IT)	Moderated mediation	0.048*	Supported

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

5. Discussion

The empirical findings provide substantial evidence for the hypothesized relationships among platform development, information transparency, consumer engagement, and market purchase behavior in live-streaming agricultural e-commerce, while illuminating the critical moderating role of blockchain traceability adoption. The present study demonstrates that platform development (β = 0.381) and information transparency (β = 0.365) significantly influence consumer engagement, supporting Hypotheses H1 and H2, which

align with theoretical expectations derived from the Stimulus-Organism-Response framework. These stimuli further exert significant total effects on market purchase behavior (β = 0.378 and β = 0.336, respectively), with consumer engagement partially mediating these relationships. These results extend prior individual-level understanding by demonstrating that such effects operate at the aggregate market level, thereby revealing systematic patterns amenable to platform-wide strategic interventions. The finding that platform development exhibits slightly stronger influence than information transparency suggests that technological infrastructure investment may yield more immediate market returns than transparency enhancement initiatives, though both pathways demonstrate substantial economic significance. This interpretation aligns with emerging perspectives emphasizing that infrastructure alone is insufficient without data-driven decision-making capabilities that translate technological investments into competitive advantage[27], suggesting that Platform Development implicitly captures strategic orchestration of digital resources beyond mere technical capacity.

The mediation analysis in this study reveals that consumer engagement transmits approximately 31.0% of the platform development effect and 33.3% of the information transparency effect, confirming Hypothesis H3 regarding partial mediation and demonstrating that collective consumer participation constitutes a critical intermediate mechanism linking platform stimuli to market outcomes. While prior research has established the importance of engagement in live streaming contexts at the individual level, the present findings extend this understanding by demonstrating that engagement operates as a market-level transmission mechanism, with aggregate participation patterns serving as leading indicators of subsequent transaction volume growth rather than merely reflecting individual purchase intentions.

The moderation analysis constitutes the primary theoretical contribution of this investigation, with the present study revealing that blockchain traceability adoption significantly strengthens both the platform development-consumer engagement relationship (β = 0.113, supporting H4a) and the information transparency-consumer engagement relationship (β = 0.168, supporting H4b). The substantially stronger moderation effect observed for the information transparency pathway provides empirical support for theoretical arguments positing that blockchain technology demonstrates particular effectiveness in enhancing traceability-based mechanisms[28, 29]. The simple slope analyses conducted in this study reveal a 2.51-fold increase in the information transparency effect across the blockchain adoption spectrum compared to a 1.85-fold increase for platform development. This finding validates Signaling Theory in digital agricultural markets: while information transparency acts as the quality signal, blockchain serves as the signal reliability mechanism, preventing market collapse into a "lemons" scenario, with synergistic properties amplifying combined effectiveness beyond independent contributions.

The moderated mediation results from the present analysis reveal nuanced patterns warranting careful interpretation. The information transparency pathway demonstrates significant conditional indirect effects strengthening from 0.058 at low blockchain adoption to 0.147 at high adoption, providing support for Hypothesis H5 through the IT pathway, while the platform development pathway exhibits a similar directional pattern with overlapping confidence intervals at adjacent levels, indicating that H5 for the PD pathway was not supported. This pattern distinguishes "hygiene factors" from "value-added factors" in the Herzbergian sense: Platform Development represents a hygiene factor essential for market existence but yielding diminishing returns beyond threshold levels, with consumers expecting platform maturity as a baseline condition that blockchain cannot significantly enhance. Conversely, Information Transparency constitutes a motivator where blockchain's cryptographic verification addresses specific uncertainty associated with product quality rather than platform functionality, explaining the differential moderation patterns across pathways. This differential pattern, unique to the present market-level investigation, suggests blockchain traceability functions primarily as a trust-enhancing mechanism amplifying the signaling value of transparent information rather than operating as a general platform enhancer. This inter-

pretation aligns with theoretical perspectives emphasizing blockchain's selective effectiveness in contexts characterized by information asymmetry [30, 31], while extending these frameworks by demonstrating the mechanism's operation at aggregate market levels. Agricultural products represent a particularly appropriate context for this synergy because food possesses credence attributes that consumers cannot assess through visual inspection during live streaming, rendering blockchain-transparency complementarity substantially stronger than for search goods.

The robustness analyses strengthen confidence in the primary findings while revealing important boundary conditions specific to the agricultural e-commerce context. The stability of main effects following COVID-19 period exclusion suggests that observed relationships reflect fundamental market dynamics rather than pandemic-specific artifacts, though attenuation of the platform development × blockchain interaction indicates that accelerated digital adoption during lockdown periods may have amplified the apparent moderating effect. The Granger causality tests provide temporal precedence evidence supporting the hypothesized causal sequence, lending additional credibility to the proposed theoretical model.

These findings carry important theoretical implications for understanding technological innovation's role in reshaping consumer behavior dynamics within agricultural e-commerce ecosystems. The demonstrated moderating role of blockchain traceability extends the traditional S-O-R framework by incorporating technological infrastructure as a boundary condition shaping stimulus effectiveness, an extension that addresses limitations in existing theoretical applications that have not adequately accounted for technology diffusion effects [32, 33]. The differential moderation patterns documented in this study indicate that blockchain technology operates selectively through mechanisms aligned with its core traceability functionality rather than functioning as a universal trust enhancer, providing nuanced guidance for platform operators and policymakers seeking to optimize technology investment strategies in agricultural e-commerce contexts. Future research might examine technological complementarities between blockchain traceability (providing verification infrastructure) and generative AI applications (enhancing content personalization) that jointly shape consumer experiences in live streaming contexts [34], as blockchain addresses trust through validation, while AI-driven innovations may amplify engagement through creative content generation.

6. Conclusions

This study employed monthly time-series data spanning January 2019 through December 2024 (N = 72) to investigate the moderating role of blockchain traceability adoption in shaping consumer engagement and purchase behavior within live-streaming agricultural e-commerce platforms in China, utilizing a hierarchical regression framework with Hayes's conditional process analysis to test main effects, mediation mechanisms, and moderation relationships simultaneously. The empirical results demonstrate that platform development ($\beta = 0.381$) and information transparency ($\beta = 0.365$) exert significant positive effects on consumer engagement (supporting H1 and H2), with these stimuli further influencing market purchase behavior through consumer engagement, which partially mediates these relationships by transmitting 31.0% and 33.3% of the respective effects (supporting H3). The moderation analysis reveals that blockchain traceability adoption significantly strengthens both the platform development-consumer engagement relationship ($\beta = 0.113$, supporting H4a) and the information transparency-consumer engagement relationship ($\beta = 0.168$, supporting H4b), with simple slope analyses indicating a 2.51-fold increase in the information transparency effect and a 1.85-fold increase in the platform development effect across the blockchain adoption spectrum. The moderated mediation analysis confirms significant conditional indirect effects for the information transparency pathway (index = 0.048, 95% CI [0.011, 0.094], supporting H5 for the IT pathway), while the platform development pathway exhibits directional but non-significant moderated mediation (H5 for the PD pathway not supported), suggesting that blockchain traceability functions primarily as a trust-enhancing mechanism that amplifies the signaling

value of transparent information rather than operating as a general platform enhancer.

These findings carry substantial theoretical and practical implications for understanding how technological innovation reshapes consumer behavior dynamics within agricultural e-commerce ecosystems. The theoretical contribution lies in extending the Stimulus-Organism-Response framework to market-level analysis while incorporating blockchain technology as a boundary condition shaping stimulus effectiveness, thereby addressing limitations in existing theoretical applications that have not adequately accounted for technology diffusion effects in digital agricultural marketplaces.

The practical implications differentiate recommendations for distinct stakeholders: policymakers should prioritize standardizing traceability data formats and interoperability protocols to ensure blockchain-verified information is readable and comparable across platforms, given the stronger moderation effects observed for the Information Transparency pathway compared to Platform Development. Platform operators should focus on integrating blockchain verification into consumer-facing interfaces with intuitive presentation designs, particularly for agricultural products where quality uncertainty represents a significant purchasing barrier.

The study acknowledges limitations, including reliance on interpolated monthly estimates from semi-annual and annual official statistics, potential simultaneity bias between Platform Development and Consumer Engagement that OLS-based approaches cannot fully address despite Granger causality evidence, supporting temporal precedence, the use of ordered GMV that does not account for return rates, the absence of individual-level consumer data, and the geographic restriction to the Chinese market context that may constrain generalizability. Future research should address these limitations by incorporating primary consumer survey data to triangulate market-level findings, extending the analytical framework to cross-national comparative contexts, and examining heterogeneous effects across different agricultural product categories and platform types to refine the understanding of blockchain traceability's differential effectiveness in diverse agricultural e-commerce settings.

Author Contributions

Conceptualization, L.W. and S.I.N.; methodology, L.W.; software, L.W.; validation, L.W., S.I.N., and N.K.B.; formal analysis, L.W.; investigation, L.W.; resources, S.I.N.; data curation, L.W.; writing—original draft preparation, L.W.; writing—review and editing, S.I.N. and N.K.B.; visualization, L.W.; supervision, S.I.N. and N.K.B.; project administration, S.I.N.; funding acquisition, S.I.N. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Ethical review and approval were waived for this study because it exclusively utilized publicly available aggregated market-level data from official government statistical sources (China Internet Network Information Center, Ministry of Commerce, Ministry of Agriculture and Rural Affairs, National Bureau of Statistics). No primary data collection involving human subjects was conducted.

Informed Consent Statement

Not applicable. This study analyzed publicly available secondary data and did not involve human participants.

Data Availability Statement

The data presented in this study are openly available from the following public sources: China Internet Network Information Center (https://www.cnnic.cn/), Ministry of Commerce (http://www.mofcom.gov.cn/), Ministry of Agriculture and Rural Affairs (http://www.moa.gov.cn/), National Bureau of Statistics (https://data.stats.gov.cn/), and government official announcements (http://www.gov.cn/). The compiled dataset and analysis code are available from the corresponding au-

thor upon reasonable request.

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Conflicts of Interest

The authors declare no conflicts of interest.

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