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Research Paper

Smart Contracts for Ethical and Resilient Food Industry Logistics

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Abstract

The integration of smart contracts is transforming logistics and supply chain management (LSCM) by improving transparency, visibility, and accountability. This study examines how automated digital agreements and secure nutritional labeling enhance credibility and safety in the food industry. Using encrypted ledgers and records, smart contracts help address challenges such as counterfeit products, fraudulent labeling, and ethical violations. The study aimed to evaluate smart contracts as a strategic tool for managing information throughout a food product's lifecycle, with emphasis on sustainability and ethical LSCM practices. A quantitative methodology was used, collecting survey data from 130 urban consumers in India who shop both online and offline. The survey captured consumer views on ethical consumption, organic versus processed foods, eco-friendly packaging, and pricing transparency. Findings show that although smart contracts are still emerging in the food sector, they can address major systemic issues. By defining accountability measures, these contracts can align societal well-being with industrial efficiency. This paper contributes to supply chain management research by highlighting the shift toward distributed information systems and emphasizing the importance of smart contracts in creating a transparent, ethical, and safe food supply chain for modern consumers.

Keywords: *Smart contracts, Logistics, Supply Chain Management, Sustainability, Food Supply Chain, Distributed Ledgers*

INTRODUCTION

Ethical issues like waste, contamination, and inefficient logistics drive costs and environmental risks in the food industry. Smart contracts enhance accountability, sustainability, and wellness by securing quality management and inventory replenishment without intermediaries. With growing social media awareness of nutrition and waste, India's billion-strong population is becoming increasingly conscious of food supply chain integrity. Additionally, studies have discussed how billions of tons of food waste worldwide are caused by perishable food (Banasik et al. 2017). In order to improve policy formulation on nutritious foods and promote consumer wellness and reduce the risk of chronic diseases, studies on the consumption of fruits, vegetables, wholegrain foods, grain-foods ratios, protein foods, and plant-based foods have been discussed (Brassard et al. 2022). Businesses also benefit by aligning with the Sustainable Development Goals of the United Nations. Specifically, the SDG11 objectives aim to enhance sustainable cities and communities (Hales and Birdthistle, 2023). Mobilising SDG12 objectives enhances co-creating sustainability across brands (Palakshappa and Dodds, 2020), and the SDG 12.3 goals enhance food supply chain management (Jacob-John et al., 2022).

Studies have explained that large social and practical implications were evident from extensive research on the subject that recommended implementation of sustainable practices involving the reduction of food waste and loss (Torrejón-Ramos et al., 2025). Food corporations struggle to manage diverse perishable goods while strictly complying with temperature-controlled

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transport regulations. These commodities are primarily categorized into fresh, frozen, and dry goods. Each group requires transit under controlled temperature settings in distinct ranges, which further deepens the complexity of the transport procedures (Vazquez-Noguerol et al., 2025).

Complete end-to-end accountability, safety, and accountability in the food supply chain sector have become priorities. In today's internet economy, networked businesses across cloud networks verify and share data regarding confidential business transactions and contracts. For instance, a private smart contract has obvious potential uses in Operations and Supply Chain Management (OSCM) and can offer security, timeliness, and accountability to all of its users (Pilkington, 2016; Isabel et al., 2024; Goertler, 2025). The topics being considered include the sustainability and credibility of food supply chains, industry practices, and how smart contracts can be used to audit impacts on customer wellness and experiences. This could promote sustainable production and consumption, as well as a shift in consumer attitudes toward responsible shopping and consumption in the online economy of food and grocery deliveries.

In the food retail and wholesale industries, smart contracts are making accountability easier and preventing fake products and counterfeiting (Gopalan et al., 2024). Further, technologies such as artificial intelligence (AI), the Internet of Things (IoT), Green Metrics, and Supply Chain Sustainability (Mursyada et al., 2025) can also be integrated into smart contract management by applying the SCOR 5.0 model for measuring key performance indicators in the food industry to enhance predictive accuracy, decision making, resource management, and manufacturing. According to studies on agricultural supply chains (Salah et al., 2019; Shahid et al., 2020), all transaction records, when integrated and maintained in distributed smart contract ledgers, offer a high degree of clarity and accountability. Even the biophysical characteristics of perishable goods can be traced to control temperature and humidity in cold chain logistics (Pournader et al., 2020; Isabel et al., 2024). Smart contracts are being extended to the food supply chain sector. Today, labeled products can be registered using RFID, which provides accountability and accuracy of information (Li et al., 2006). Smart contracts have been discussed in the context of encrypted distributed database systems within contractual agreements, involving efficient validation of assets, cost management, decentralized control structures in which no single organization holds power, and even the use of cryptocurrency (Swan, 2015; Isabel et al., 2024; Capocasale et al., 2025; Helo & Hao, 2019; Casey & Wong, 2017; Reyna et al., 2018; Cole et al., 2019). Further, the quality, grading, and standardization of food supply chain sectors may enhance the ethics and wellness of societies.

This comprehensive study provides an analysis and synthesis of the available research on smart contracts and their relevance to the food industry in terms of enhancing ethics and wellness in societies. There are very limited studies on how smart contracts impact the food industry in relation to ethics and wellness. Theories on smart contracts for the food supply chain sector need to integrate nutritional labeling, popularity, pricing, ethical business practices, packaging, disposal, recycling, organic fresh food, and wellness needs to enhance ethics, safety, and resilience. In the food supply chain, the majority of firms are grocery suppliers.

The study:

1. Given the advantages of smart contracts, this study offers its relevance to logistics and supply chain management within the food industry.
2. Provides discussions on how smart contracts in logistics and supply chain management could benefit the food industry in terms of ethics, accountability and wellness of societies.
3. Identify pertinent research issues and suggest a future study.

LITERATURE REVIEW

The systematic literature review on the topic was completed using the EBSCO and Emerald insight databases and focused on 45 articles from top ranked research publications related to smart contracts, distributed ledgers, encryption and cryptography, governance, food safety, circular economy, internet of things, machine learning and artificial intelligence relevant to logistics and supply chain management in the food sector.

Smart contracts

Smart contracts use a distributed database within a contractual agreement to store information, including business transaction data, and are controlled by a consensus process. They are protected by encryption (Swan, 2015; Isabel et al., 2024; Capocasale et al., 2025). Business contracts are now maintained as encrypted electronic ledgers in cloud services. A distributed ledger for supply chain management is a system of contractual agreements stored across a cloud network that ensures fairness and security by sharing transaction and user data across multiple computers (Helo and Hao 2019; Capocasale et al., 2025). This structure benefits commerce by preventing any single organization from having control (Casey and Wong 2017; Isabel et al., 2024; Capocasale et al., 2025). Encrypted distributed ledgers containing contractual agreements and adherence to ethics, wellness, and key performance indicators are suitable for the food supply chain sector.

For multi-organizational networks such as supply chains or financial consortia, smart contracts help maintain records across networks, incentivizing companies to track contract information. They are linked to cloud-based storage that facilitates, validates, and enforces contract conditions. These protocols can execute payment transactions (Pilkington, 2016; Isabel et al., 2024; Cole et al., 2019). Supply chain firms can also specify and validate assets using cryptocurrency in various transactions (Reyna et al., 2018; Cole et al., 2019). Supply chain networks integrating ISO 9000–certified suppliers are becoming more efficient, reducing paperwork and queries. Providing technological support to small and medium businesses within complex supply chains has improved efficiency (Gogola et al., 2024; Capocasale et al., 2025; Cole et al., 2019). Encrypted smart contracts in manufacturing have made inventory cost management, such as ordering, discounts, stock-outs, working capital, storage, obsolescence, and inefficiency, more confidential (Russell and Taylor, 2023; Queiroz and Fosso Wamba, 2019; Isabel et al., 2024). Transactional data are preserved in digital ledgers. This enables determining the provenance of assets, including location and contract records, in supply chain management. Incentives, cryptocurrency, and integration of quality suppliers for smart contracts and encryption of records containing confidential information encourage firm participation.

This is common in the shipping industry, where facilitating the movement of goods and the exchange of information, documents, and finances involves third parties such as freight forwarders, 3PLs, financial institutions, and customs officials (Carlan et al., 2022; Korepin et al., 2021; Jović et al., 2020). Additionally, information systems integrate data from sensors, Internet of Things (IoT) devices, data platforms, and distributed ledger technologies (DLT) (Farina et al., 2025; Isabel et al., 2024; Tönnissen & Teuteberg, 2019). Networked digital ledger systems eliminate reliance on trust, maintain confidentiality in contracts, and allow firms to keep accurate and legitimate copies without the risk of corruption or manipulation (Clasby & Wollega, 2020; Capocasale et al., 2025). Smart contracts, along with aggregators such as IoT, AI, and ML, can enhance the resilience of the food supply chain sector.

Smart contracts are categorized as public (e.g., Bitcoin) or private, distinguished primarily by network access. While public networks are open to all, they require immense computing power to maintain large distributed ledgers. Conversely, private contracts allow regulatory institutions to control entry through governance rules. Beyond managing transactions and bank guarantees in

cloud systems, integrating smart contracts with distributed ledger transactions, as seen in the shipping industry, can significantly enhance market value and prevent fraud.

Smart Contract Accountability in Logistics and Supply Chain Management

Reducing food contamination (Walmart, 2021), trade disputes (De Beers, 2022), and promoting fair trade (WE Charity, 2021) are linked to accountability in food supply chains. According to AICPA and CPA Canada (2017), permissioned smart contracts enable privacy in line with corporate governance best practices. Smart contracts are gaining momentum as tools to improve transparency and visibility in global food supply chains (Rogerson and Parry 2020). Studies show they enhance inter-firm capabilities when paired with technologies such as the Internet of Things (Lohmer et al., 2022; Isabel et al., 2024; Brookbanks and Parry, 2024). In supply chain management and manufacturing, smart contracts verify exchanged information with partners, and auditing promotes ethical business conduct (Gualandris et al., 2015; Isabel et al., 2024). Smart Contracts may facilitate alerts in food supply chain management for tracking the shelf life of products.

Key factors influencing smart contract adoption in operations and supply chain management include enabling conditions, trust, social impact, and effort expectancy (Quieroz et al., 2020; Isabel et al., 2024; Cole et al., 2019). Manufacturing firms investing in smart contracts tend to create stakeholder value and trigger positive stock market reactions due to agreement confidentiality (Klöckner et al., 2021). Benefits include improved efficiency, fewer procedures, and reduced human processing (Martinez et al., 2019). Smart contracts help firms visualize information flow and processes across the supply chain, enabling waste reduction and maintaining production targets. They increase efficiency by reducing processes, order time, and effort, while improving traceability and visibility across firms (Martinez et al., 2019; Fortin et al., 2023; Isabel et al., 2024), and strengthening governance. They also enable faster use, payment, invoicing, and more efficient workflows and corporate processes. Further, automation of smart contracts can be configured based on contractual agreements, customization, and confidentiality needs. Also, firm investments in smart contracts also facilitate a positive evaluation of stock market value.

Audits of businesses using smart contracts to manage supply chain processes support governance of logistics costs, invoice accuracy, inventory, and balance sheet infrastructure. These agreements ensure confidentiality of costs, pricing, sales, discounts, billing, merchandising, storage, material handling, transportation, documentation, and credit management. Smart contract–based supply chain provenance increases consumer trust and efficiency (Isabel et al., 2024; Capocasale et al., 2025; Brookbanks and Parry, 2024; Cole et al., 2019). Many supply chain systems lack the ability to verify authenticated, coordinated shipment tracking across logistics. Despite widespread use for product identification, technologies like barcodes and RFID tags face issues with information management and interoperability (Bokolo, 2022; Isabel et al., 2024). Smart contracts can now manage the complexities of logistics and supply chain management and be integrated with company balance sheets for audits.

Operational inefficiencies also result from information system maintenance and paper-based records (Yiannas, 2018; Isabel et al., 2024). Smart contracts can strengthen inventory control by reducing average inventory and holding costs. Distributed ledgers provide critical data for product identification, location tracking, and handling in supply chains (Hughes et al., 2019). In transportation, smart contracts improve tracking and authenticate product provenance by integrating information and communication technologies (Kim & Laskowski, 2018; Capocasale et al., 2025). This way, smart contracts can reduce the bullwhip effects in demand and supply management of inventory.

Companies can monitor biophysical characteristics of cold chain goods, including temperature and humidity of perishables (Pournader et al., 2020; Isabel et al., 2024). This is critical for maintaining response and lead times based on market needs, especially in food supply chains. Smart contracts, enabled by database technologies, include distributed ledger technology (DLT), which records timestamped transactions secured by consensus and cryptography (Falcone et al., 2021; Herbe et al., 2024). DLT addresses trust-related issues through decentralization, democratization, and transparency (Grosse et al., 2021). Although this study focuses on DLT, many studies examine only smart contracts. As a type of DLT, both are relevant (Grosse et al., 2021; Isabel et al., 2024; Capocasale et al., 2025). The benefits of smart contracts in supply chains also apply to DLT. Research highlights their potential to improve business process management (BPM). This facilitates monitoring the shelf life of food products and updates for the replenishment of stocks in terms of freshness.

Walmart, Nestlé, and Maersk participate in IBM Food Trust, a private smart contract consortium for supply chain traceability (Nestlé, 2019; O'Leary, 2017). Database access is restricted to maintain privacy and control. Smart contracts also help prevent counterfeit goods, enhancing safety and speeding problem detection (Rogerson and Parry, 2020). Despite the importance of cooperation and information sharing, firms must protect confidential data from competitors. Due to concerns about data exposure and disclosure of business intelligence, most firms prefer private ledgers (Hald & Kinra, 2019). Smart contracts are being integrated widely by FMCG firms that require maintenance of private ledgers, audit trace, and accountability to prevent counterfeit goods and deliver goods to customers safely for consumption.

Origin of products in the food supply chain logistics

According to McCarthy et al. (2016), supply chain provenance extends beyond ownership to include records of all transactions and activities, including the movement of raw materials and finished goods in production and operations. In the food and pharmaceutical industries, traceability and visibility are critical, as contamination or counterfeiting can harm public wellness. The World Health Organization reports over half a million deaths from contaminated food, deficiencies and poor economies. By auditing supply chains, smart contracts enhance traceability, improve food safety, combat fraud, and ease recalls. This helps firms reduce contamination risks and quickly remove affected products (Friedman and Ormiston, 2022). Smart contracts also enable accurate tracking of medical products, reducing counterfeiting risks (Casino et al., 2019).

Sustainability and environmentally friendly goods

In order to integrate the three essential reverse supply chain operations of recycling, redistribution, and remanufacturing with smart contracts' three fundamental architectural elements of trust, traceability, and transparency, the Centobelli model explains the integration of smart contracts with end-of-life commodities data. Approximately 13% of greenhouse gas emissions are caused by logistics companies, which include shippers and service providers (Prataviera et al., 2023; Huge-Brodin et al., 2020). As a result, numerous businesses are implementing green logistics initiatives in the areas of product manufacturing, acquisition, and delivery. According to studies, companies and consumers do not actively support the circular economy, which aims to lessen the negative environmental effects of industrialization (Kirchherr et al., 2017). Smart contracts can help monitor greenhouse gas emissions and fuel efficiency needs of logistics companies to support a circular economy and environmentally friendly practices.

Food industry and sustainability

According to the UN Decade of Action on Nutrition, wellness diets and sustainable food systems are essential (Fanzo et al., 2020). Studies on fertilizers, agrochemicals, and feedstuffs highlight environmental and wellness impacts, suggesting alternative farm practices (Feuerbacher and Luckmann, 2023). Research also emphasizes integrating social and environmental metrics as agriculture shifts to a circular economy and green supply chains (Hazen et al., 2021). Smart contracts improve food traceability in retail and wholesale, helping prevent fraud and counterfeiting. Studies suggest storing all transaction records in secure, decentralized ledgers (e.g., IPFS) to ensure reliable, transparent supply chains (Salah et al., 2019; Yiannas, 2018; Shahid et al., 2020). Using smart contracts, contaminated products can be traced within a day, supporting food safety compliance (Material Handling and Logistics, 2017; Shacklett, 2017). Smart contracts may also help trace the use of pesticides and other chemicals in the food supply chain sector and reduce its impact.

Research shows smart contracts and the Internet of Things (IoT) improve waste reduction, process optimization, transparency, and traceability (Quiroz-Flores et al., 2024; Brau et al., 2024). Studies also examine wholesale and optional pricing of farm produce and its ethical impact on farmers and supply chains (Jain et al., 2023). Market oversupply can raise transport costs and lower prices, discouraging small farmers. However, agro-industries create multiplier effects in value addition and employment, supporting rural development (Gardijan and Lukač, 2018). In agriculture, costs, prices, efficiency, equity, inclusivity, product offerings, and cooperatives must be balanced. The food supply chain includes perishable goods, processing facilities, supermarkets, storage, markets, origin, and transportation with refrigeration. This structure can also support audits (Gopalan et al., 2024). Smart contracts may facilitate employment in the rural sector to meet the demand and supply for markets and may also help regulate pricing.

Cost of logistics, safety and food security

Whole genome sequencing is increasingly necessary to identify wellness food supply chains and reduce foodborne illness, improving efficiency in industrial food supply management. Foodborne illnesses cause many fatalities linked to liver, kidney, and neurological damage (Johnson, 2019). Supply chains face severe risks from biological contaminants like Salmonella and E. coli, as well as chemical toxins and parasites, which cause widespread illness and death. The food sector spans production, processing, and retail, operating within a complex ecosystem of economics, technology, and governance. Factors such as infrastructure, trade policy, and affordability further influence this broader landscape. Public awareness, labeling, education, and sustainability efforts add value by informing consumers about diet, safety, and benefits (Fanzo et al., 2020). Smart contracts may facilitate the study of pathogens and risks in the food supply chain sector to reduce their impact.

Smart contracts in food retail and distribution store encrypted data on batches, including origin, ID, expiration, shipping, and other business data. They are also used in finance, academia, industry, pharma and wellness care, energy, and government. Profitability of fresh produce depends on value, shelf life, labor, price, and manufacturing costs. Food and packaging waste processing and environmental impacts remain challenging. Studies assess environmental impact across the supply chain, identifying the location, type, and volume of waste (Banasik et al., 2017). Evaluating food supply chains requires considering storage of perishables, waste processing, and production types and options. Smart contracts facilitate the monitoring and reduction of wastes.

A product's nutritional value can influence demand. Overproduction in agriculture has caused significant losses. The Internet of Things, artificial intelligence, and automation are transforming farm-to-food supply chains. For example, RFID improves mapping of demand, supply,

and production, reducing the bullwhip effect and improving resource management (Shukla et al., 2023). Studies also show shipping firms adopting token systems for logistics, supply chains, and finance (Thuermer, 2017). Production is influenced by volume, inventory, manufacturing options, supply, shelf life, and waste processing.

Production lines face issues such as estimating demand, storage, production time, processing and holding capacity, costs, pricing, and energy losses from fuel and transport. Studies show preventing food and packaging waste best reduces environmental impact, and energy analysis helps balance energy use, waste, and impact reduction. (1) Market demand and food waste processing (2) surplus inventory management (3) food waste prevention (4) production selection, (5) capacity planning, and (6) shelf life of inventories were all accounted for by constraints in the industrial production of food.

Research Problem

Integration of smart contracts for the logistics and supply chain management in ethical and fair trade is becoming relevant. Industry 4.0 is seeing the integration of artificial intelligence, Internet of things and Machine Learning into the food industry. Also, activism towards nutritional education, diets, physical fitness, hygienic food, labeling, processing of waste and packaging is gaining popularity across social networks. Research has also demonstrated that distributors and sellers that add product value and customer service to the circular economy and green supply chain improve the reputation of businesses and organizational performance in terms of investments (Hazen et al., 2021).

Research questions identified:

1. What is the relevance of smart contracts in logistics and supply chain management in improving ethics and consumer wellness?
2. How can awareness regarding nutritional labeling, wellness diets, sustainable packaging and shelf life of products add value to smart contracts for logistics and supply chain management?
3. What are the government's policy initiatives on nutrition standards, diet laws, public awareness campaigns, nutritional labeling and advertising, nutritional education, fiscal measures like taxes or subsidies, and government assistance for the food industry?

RESEARCH METHOD

The agricultural and food delivery sectors offer rich research opportunities into market cultures, logistics challenges, and consumer awareness of supply chain costs and waste processing. This study explores smart contracts and distributed ledgers within the food sector, integrating a systematic literature review with a survey of 130 urban customers (aged 20–25) who were mainly students at a management institute familiar with online and offline shopping. The statistical analysis explains Chi square tests completed on binary dichotomous data from 130 responses using SPSS. Using purposive sampling on categorical and binary data, the research examines 12 categorical attributes using a survey questionnaire (see appendix) of customer experiences, namely, (1) includes nutritional labeling, (2) ethical business, hygiene and packaging, (3) online grocery shopping, (4) sustainable packaging, (5) disposal and recycling, (6) labeling of preservatives, (7) offline grocery shopping, (8) online food orders, (9) offline food orders, (10) popularity, reliability and wholesale pricing, (11) freshness and organic products and (12) healthy diets and calorie consumption. This survey is exploratory and non-probabilistic.

Objective of the study:

1. To study the relevance of smart contracts in logistics and supply chain management in the food industry for enhancing ethics and wellness, and what the benefits are.
2. To statistically evaluate customer experiences regarding ethics and wellness in the food supply chain sector, and why its integration into smart contracts for food industries is necessary.
3. To study how smart contracts can enhance the logistics and supply chain management for the food industry and why.

Survey Questionnaire:

A purposive sampling technique was used to conduct a questionnaire survey of over 130 regular consumers in India, in the age group of 20 to 25 years, who were familiar with online and offline shopping of food items and groceries. The study analyzed shopping experiences, knowledge, and sensitivity to the industry, incorporating insights from online food discussion forums and social networks. Respondents provided data on grocery shopping habits and opinions on nutritional labeling, diets, hygiene, organic foods, and waste management.

Theory: With a focus on sustainable and optimized food supply chain production, perishable foods, food security, and improved processing of food waste and packaging waste, this study is theoretically based on the ecosystem of the food supply chain and food delivery sector from an awareness perspective on how businesses can integrate smart contracts into the life cycle of food products, manufacturing, processes, packaging, and waste management. Theories on smart contracts for the food supply chain sector need to integrate nutritional labeling, popularity, pricing, ethical business practices, packaging, disposal, recycling, organic fresh food, and wellness needs to enhance ethics, safety, and resilience, as well as facilitate standards. In the food supply chain, the majority of firms are suppliers of groceries.

Our first hypothesis concerns the relevance of smart contracts and blockchains between businesses in the food industry that consolidate business processes involving smart contracts, shipping, and transportation of goods (Rai et al., 2012).

H1: Integrating smart contracts into food supply chains enhances diets, nutritional impact, cost control, shelf life, law enforcement, and eco-friendly practices.

H2: Smart contracts that integrate food safety standards and legislation for accountability, traceability, food security, physical fitness, sustainability, and eco-friendly practices benefit food supply chain businesses and customers.

FINDINGS AND DISCUSSION

Reliability and Validity

Integrating your systematic literature review and empirical findings, this study identifies key smart contract attributes, including accountability, encryption, and distributed ledgers—that impact societal ethics and health through improved food resource and financial management. Integrating publication synthesis with survey data enhances the study's credibility, while chi-square tests in SPSS ensure statistical reliability. Furthermore, the SCOR Model provides KPIs to optimize smart contract efficiency across delivery lead times, production flexibility, and asset management.

These findings align with previous studies that emphasize the importance of transparency, traceability, and accountability in food supply chains, particularly in relation to consumer trust, safety, and ethical business practices. For example, Capacci et al. (2012) highlight the role of labeling, education, and regulatory policies in improving consumer awareness, while Sharma et al. (2019) emphasize that limited technology and weak policy implementation can hinder sustainable

and circular supply chain practices. Therefore, the present findings strengthen prior arguments that technological tools such as smart contracts can support more transparent, ethical, and sustainability-oriented food supply chain systems.

A brief, 12-attribute questionnaire was developed in collaboration with respondents to ensure content validity and survey efficacy. To maximize response rates and data interpretability, the survey targeted a known audience of approximately 130 management students aged 20–25 in India. This cohort provided comparative data on their online and offline shopping experiences.

Statistical Analysis

SPSS was used to complete and explain Chi-square tests, omnibus tests, significance, explanatory power, predictive accuracy, and goodness of fit, including the Hosmer and Lemeshow Test, which were evaluated using cross-tabulations and logistic regressions. Out of 130 responses, a few customer responses may have been incomplete, and this was observed during the statistical analysis in SPSS. The data, however, were cleaned to a significant extent.

Tables 1 and 2 analyze a strong correlation between customer responses regarding nutritional labeling, wellness diets, ethical business practices, hygiene, and packaging. Statistical analysis in SPSS for the omnibus test and goodness of fit, including the Hosmer and Lemeshow Test, demonstrates high significance and goodness of fit among predictors that collectively improve the model. Many consumers prefer offline grocery shopping because of the convenience of nutritional labeling.

This result is consistent with earlier research showing that food labeling and consumer information play an important role in shaping healthier and more responsible food choices. The finding that consumers associate nutritional labeling with offline grocery shopping supports previous arguments that clear and accessible product information can influence purchasing behavior and improve consumer confidence. However, the present study extends previous discussions by linking labeling not only to health awareness but also to broader ethical concerns, including hygiene, packaging, and responsible business conduct.

Table 1. SPSS analysis - Variables in the Equation

	B	S.E.	Wald	df	Sig.
Nutrition_Labeling(1)	1.236	.529	5.454	1	.020
Freshness_Organic(1)	1.156	.480	5.798	1	.016
Constant	-1.841	.579	10.098	1	.001

Table 2. SPSS Chi-Square Tests. Labeling of Preservatives, Ethical Business, Hygiene & Packaging

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.867[a]	1	.002		
Continuity Correction[b]	8.525	1	.004		
Likelihood Ratio	9.387	1	.002		
Fisher's Exact Test				.003	.002
Linear-by-Linear Association	9.789	1	.002		
N of Valid Cases	126				

Table 3. Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	103.740[a]	.337	.474

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	.437	4	.979

The logistic regression analysis in Table 3 examines the factors that influence whether a consumer prioritizes Ethical Business, Hygiene, & Packaging. The model is statistically significant and reveals that environmental sustainability and transparent labeling are the primary drivers of this ethical consumer behavior. Explanatory Power: The Nagelkerke R^2 is .474, suggesting the included variables explain roughly 47.4% of the variance in ethical business priorities. Goodness of Fit: The Hosmer and Lemeshow Test yielded a high *p*-value of .979, indicating that the model's predictions align very closely with the observed data. The model's explanatory power supports the argument that ethical consumption is influenced by multiple interconnected factors rather than a single purchasing motivation. This aligns with Brassard et al. (2022), who suggest that food-related choices are closely connected to health, dietary quality, and long-term wellness outcomes. At the same time, the strong role of sustainability and labeling in this study indicates that consumers increasingly connect personal wellness with wider environmental and ethical responsibilities.

Table 4. Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	35.956[a]	1	<.001		
Continuity Correction[b]	33.675	1	<.001		
Likelihood Ratio	42.514	1	<.001		
Fisher's Exact Test				<.001	<.001
Linear-by-Linear Association	35.673	1	<.001		
N of Valid Cases	127				

The table 4 indicates that because the p-value is much lower than the standard alpha level of 0.05, there is a highly statistically significant association between sustainable packaging and ethical business practices. This means a consumer's interest in sustainable packaging is not independent of their interest in ethical business practices; the two are deeply linked.

The high Chi-Square value 35.956 and the extreme significance level <.001 confirm that sustainability is the single most important predictor of whether a consumer values ethical business and hygiene. In a marketing or operational context, these two values should be treated as part of the same consumer "mindset."

This finding is in line with prior sustainability and supply chain studies that identify packaging, waste reduction, and responsible production as important indicators of ethical business behavior. It also supports the view that sustainability-oriented practices are no longer perceived only as environmental strategies but also as visible signals of corporate responsibility and integrity. Unlike studies that mainly discuss sustainability from the firm or policy perspective, the present study provides empirical evidence from consumer responses, showing that sustainable packaging

strongly shapes perceptions of ethical business and hygiene.

Among those who prioritize sustainable packaging, 96.5% also prioritize ethical business and hygiene. Consumers concerned with labeling and preservatives are much more likely to value ethical business practices. 76.6% of those concerned with labeling also prioritize ethical business. 71.7% of those focused on wellness diets also care about ethical business. Whether a consumer prioritizes freshness and organic products seems to have very little bearing on their concern for ethical business and hygiene.

The weaker association between freshness or organic products and ethical business priorities provides an important contrast with previous studies that often associate organic or fresh food preferences with responsible consumption. This suggests that, within the present sample, consumers may distinguish between personal health-oriented attributes and broader ethical or sustainability-oriented attributes. Therefore, the findings partly contradict assumptions that organic or freshness concerns automatically translate into stronger ethical business expectations.

The data suggests that a consumer's concern for "Ethical Business, Hygiene, & Packaging" is deeply tied to environmental and transparency concerns (sustainability and labeling) rather than personal wellness concerns (calories and organic status). Statistical tests in SPSS demonstrate that it is particularly strong at identifying those who do prioritize ethical business (90.7% accuracy). Consumers who prioritize sustainable packaging are 35 times more likely to also prioritize ethical business and hygiene compared to those who do not. This confirms a massive overlap between environmental sustainability and ethical business expectations.

Overall, the empirical findings confirm and extend previous literature by showing that transparency, sustainable packaging, and ethical business expectations are mutually reinforcing. The results also indicate that smart contracts can serve as a practical governance mechanism to strengthen these relationships by improving traceability, reducing information asymmetry, and supporting accountability across food supply chain actors. In this way, the discussion demonstrates that the findings are not isolated statistical outcomes but are theoretically connected to previous studies on food labeling, sustainability, responsible consumption, and technology-enabled supply chain governance.

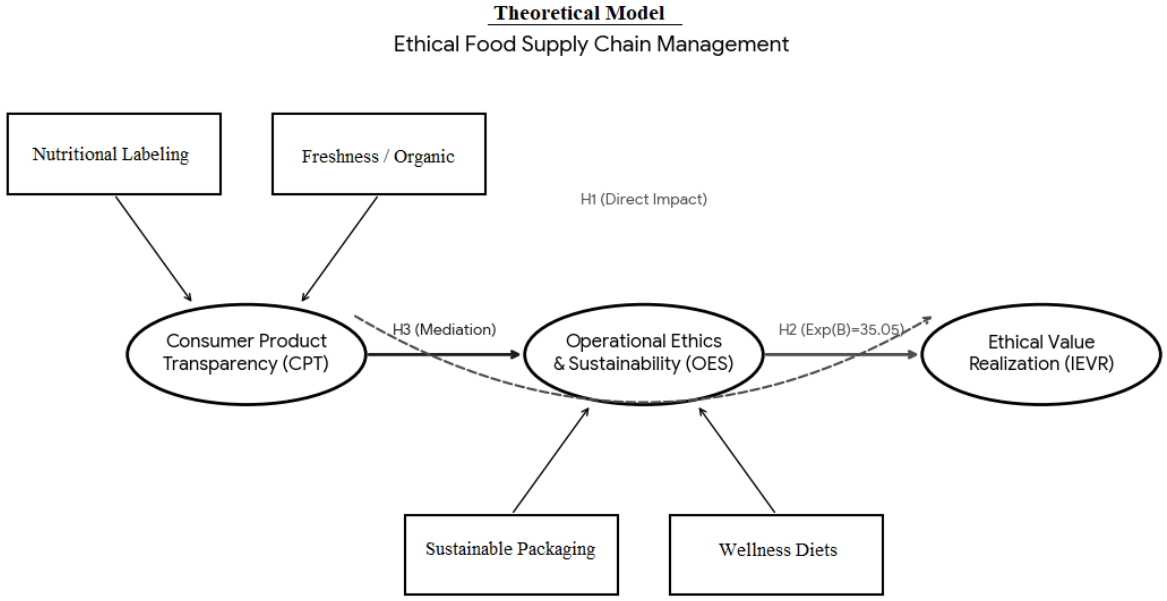

Figure 1. Theoretical model of smart contracts and ethical food supply chain management

CONCLUSIONS

Consumers value ethics and hygiene nearly as much as nutritional information, though awareness of labeling and preservatives exceeds that of calorie intake. While online shopping is favored for reliability and pricing, offline shopping remains preferred for convenient access to nutritional labels. Ultimately, transparency and sustainability drive ethical behavior, with sustainable packaging serving as the strongest predictor of perceived business integrity and responsible consumerism. These values form a single consumer mindset: 96.5% of those prioritizing sustainable packaging also value ethical business and hygiene. Consumers concerned with labeling and preservatives are more likely to value ethical practices—76.6% prioritize ethics, and 71.7% of those focused on wellness diets do as well.

These findings are consistent with previous studies that emphasize the importance of labeling, transparency, and consumer awareness in promoting responsible food choices and improving trust in food systems. The results also support prior arguments that sustainability and ethical business practices are increasingly interconnected, especially in food supply chains where packaging, traceability, hygiene, and product information directly influence consumer perceptions. However, the study also shows a partial contrast with previous assumptions that freshness and organic product preferences are always strongly associated with ethical business concerns, since the present findings suggest that sustainability and labeling are stronger predictors of ethical priorities than personal wellness attributes alone.

Research on fruit, vegetable, whole grain, protein, and plant-based consumption informs policies promoting wellness diets and reducing chronic disease risk (Brassard et al., 2022). To support food delivery and retail, smart contracts should integrate resilient farming, nutritional labeling, life cycle assessment, cost optimization, waste processing, and environmental and wellness gains. It is widely known that logistics firms coordinate with third parties—including freight forwarders, 3PLs, and customers and are crucial to facilitate and sustain global trade. Ultimately, smart contracts facilitate the delivery of eco-friendly products while streamlining logistics for a more sustainable food industry.

By connecting the empirical results with previous research, this study concludes that smart contracts can strengthen ethical food supply chain management by improving transparency, accountability, and traceability. The findings enrich the discussion on sustainable food systems by demonstrating that consumer expectations for ethical business, hygiene, and sustainable packaging can be supported through technology-enabled supply chain governance. Therefore, the study contributes to both theory and practice by showing how smart contracts, consumer ethics, and sustainability-oriented supply chain practices can work together to support responsible consumption, food safety, and long-term public health outcomes.

Theoretical Implications

Theories may also explore how nutritional labeling, freshness, and the shelf life of food products affect sustainability and the SDG Goals, as well as how logistics and supply chain management may utilize the SCOR model and other KPIs to improve efficiency, ethics, and wellness within the food industry and improve customer behavior and attitudes toward responsible consumerism. This may also be relevant to sustainable packaging and wellness diets. This study also demonstrates how transparency and sustainability ultimately drive ethical behavior, with sustainable packaging and responsible consumerism serving as the strongest predictors of perceived business integrity. Smart contracts enhance supply chain safety, sustainability, and quality while reducing counterfeiting and transaction costs. In agriculture, smart contracts may be used to enhance traceability, ensuring safety and accountability while reducing bullwhip risks through encrypted data exchange.

Practical Implications

Smart contracts enhance supply chain safety, sustainability, and quality while reducing counterfeiting and transaction costs. By utilizing encrypted, consensus-governed distributed databases, these private contracts ensure transparency and security in Operations and Supply Chain Management (OSCM). Integrating ISO 9000-certified suppliers further streamlines production and reduces administrative burdens. Additionally, encryption protects sensitive financial data, securing inventory costs related to storage, obsolescence, and working capital against unauthorized access.

Fiscal measures (taxes or subsidies) affect public distribution quality. Policies have improved awareness through campaigns, labeling, education, and regulations (Capacci et al., 2012). However, poor policies, limited technology, and low farmer awareness hinder sustainable, circular supply chains (Sharma et al., 2019). In agriculture, smart contracts enhance traceability, ensuring safety and accountability while reducing bullwhip risks through encrypted data exchange. By integrating with cloud systems and the Internet of Things (IoT), these contracts support bank guarantees, fraud prevention, and real-time auditing. This decentralized approach improves visibility and trust across production and operations, streamlining global food supply chains. To protect privacy, smart contracts restrict database access to inter-firm agreements while mitigating counterfeiting and improving safety resolution speeds. In the food and pharmaceutical sectors, this provides the traceability essential for managing public health risks, including real-time shelf-life alerts.

Smart contracts streamline production and operations by automating cross-firm traceability and reducing lead times. In logistics, automated audits simplify invoicing and inventory monitoring while securing sensitive operational data. Integrating the SCOR 5.0 model into these contracts enhances predictive accuracy and resource management through standardized KPIs. Ultimately, leveraging decentralized ledger technology (DLT) fosters trust and provides a foundation for future research incorporating AI, machine learning (ML), and IoT to advance global food safety standards. Encrypted distributed ledgers that integrate ethics, wellness, and KPIs are ideal for the food supply chain. When combined with IoT, AI, and ML, smart contracts enhance sector resilience by enabling precise provenance and cross-firm tracking. As industries move toward full automation, these contracts offer the customization and confidentiality needed for secure operations. Finally, utilizing incentives, cryptocurrency, and high-quality supplier integration encourages firm participation and creates new market opportunities similar to those observed in the shipping industry. Firm investments in smart contracts can boost stock market valuation by integrating logistics data directly with company balance sheets for streamlined audits. These systems reduce bullwhip effects and optimize inventory through real-time shelf-life monitoring, ensuring product freshness. In the FMCG sector, private ledgers enhance accountability and prevent counterfeiting, ensuring consumer safety. Furthermore, smart contracts support a circular economy by tracking fuel efficiency, greenhouse gas emissions, and chemical usage (e.g., pesticides). By enabling precise monitoring of pathogens and waste, these technologies significantly mitigate operational risks and environmental impacts.

By enhancing logistics, safety, and food security, these technologies align with UN Sustainable Development Goal 11 (Sustainable Cities and Communities). Furthermore, offline grocery shopping supports SDG 11 by promoting walkable neighborhoods and local economies, helping planners reduce delivery emissions while boosting urban resilience and social inclusion through the appeal of “freshness.” For SDG 12 (Responsible Consumption and Production), the Customer Brand Co-creation Model highlights packaging as a primary ethical touchpoint, alongside responsible activism and consumerism. Sustainable packaging signals corporate integrity, encouraging responsible consumption. Smart contracts support SDG 12.3 by enhancing

accountability and tracing product origin throughout the supply chain. To protect privacy, smart contracts restrict database access to inter-firm agreements while mitigating counterfeiting and improving safety resolution speeds. In the food and pharmaceutical sectors, this provides the traceability essential for managing public health risks, including real-time shelf-life alerts. By improving the transparency of "use-by" and "best-before" labels, these systems help manage shelf life, build consumer trust, and significantly reduce food waste.

LIMITATIONS AND FURTHER RESEARCH

Purposive sampling was applied in the study. Other research methodologies may be explored to reduce bias in statistical analysis. The study may be extended to the sampling of other demographics, age groups and interviewing of subject matter experts. This may bring more valuable insights into the configuration of smart contracts. Studies may explore policy formulations for the food supply chain sector. As the food consumption varies across nations, the need for food safety standards also may vary in terms of ethical norms and wellness. A meta-analysis on social network groups and discussions on the topic would provide themes for studies. A worldwide centralized database may be required for nutritional labeling, food safety and the monitoring of pathogens and risks and dissemination of alerts. Demand and supply needs for the food sector may be regulated with fair price shops or farmer's markets. SDG goals may also be integrated into smart contracts. Studies can also share insights into how governments are promoting smart contracts across the food supply chain sector. Further, studies and reports along with government intervention could promote standardized ways of processing food waste and processing of packaging waste. Research needs to also discuss ways to integrate IoT, ML and AI into the food supply chain sector to improve ethics and wellness. Future studies may explore opportunities for startups and how they can facilitate improvements in smart contracts. Global consensus may be required to study the impact of greenhouse gas emissions and promotion of renewable energy sources and fuels with the help of smart contracts for better environmental practices.

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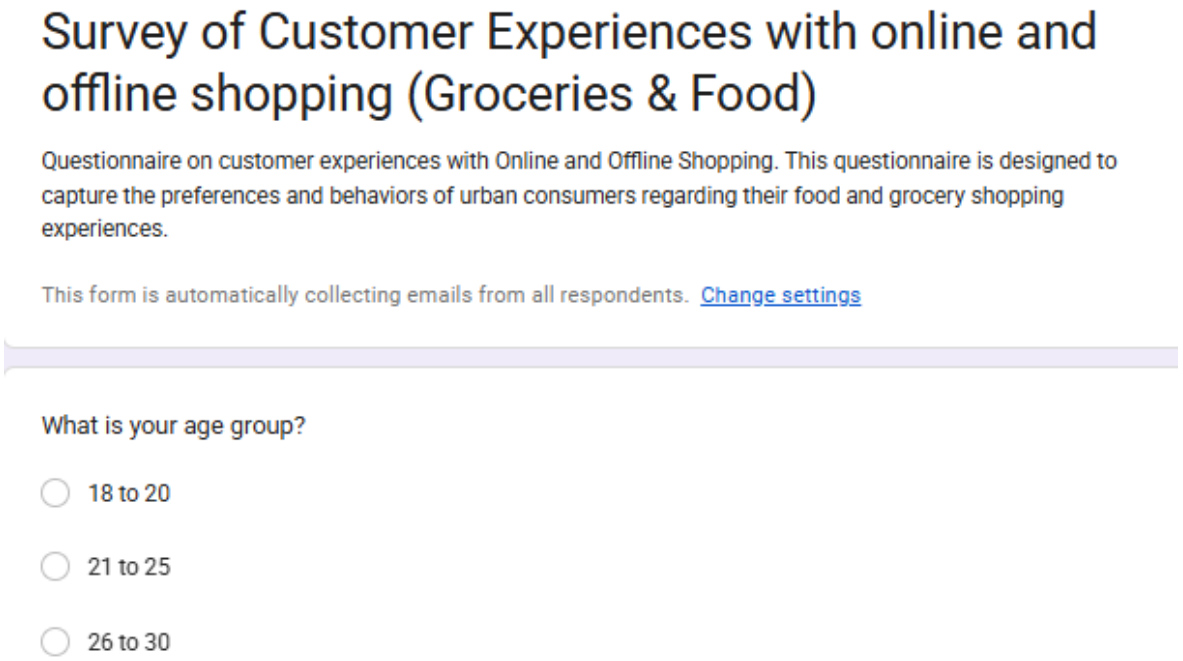
Appendix



Do you spend often for family groceries and food orders (Online/Offline)?

- Yes
- No

Which state do you represent?

Short answer text

Questions regarding your experiences with online & offline shopping (Groceries & Food)

1. Do you regularly check the nutritional labeling before purchasing a food product? *

- Yes
- No

2. While shopping for groceries (Online/Offline), I prefer to buy from sellers who practice ethics, hygiene and sustainable packaging practices? *

- Yes
- No

3. I regularly order for groceries or food online *

- Yes
- No

4. Are you willing to pay a premium price for products * that use plastic-free, sustainable packaging?

- Yes
- No

5. Do you prefer recyclable packaging and disposal instructions on packaging while shopping * for groceries and food items?

- Yes
- No

6. Are you sensitive towards purchasing food items or groceries (Online/Offline) that list * artificial preservatives on product labels?

- Yes
- No

7. Do you prefer offline grocery shopping at markets? *

- Yes
- No

8. Do you often place online food orders? *

- Yes
- No

9. Do you prefer dining out? *

- Yes
- No

10. Do you prefer to shop online or order food online due its popularity, reliability and pricing? *

- ○ Yes
- ○ No

11. Do you prefer to shop for fresh products and organic products *

- ○ Yes
- ○ No

12. Are you into healthy diets and conscious about calorie consumption? *

- ○ Yes
- ○ No