# AI AND BLOCKCHAIN-BASED PRODUCT AUTHENTICITY AND ORDER VERIFICATION

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**Abstract.** Counterfeits products, delivery issues, and unclear supply-chain operations still remain a challenge to the. security of the contemporary e-commerce systems. These issues distrust a customer and cause a lot of financial and brand reputational risks. New developments in artificial. blockchain and intelligence (AI) are offering an opportunity to. establish automated and tamper resistant verification mechanisms that act on various steps of an order lifecycle. This work proposes an integrated product authenticity and order. verification system that integrates computer vision, natural language processing and decentralized ledger. technology. It is a system that gathers product pictures, textual. processes them through and produces descriptions, and QR metadata. trained visual similarity analysis, description models. consistency checks, and anomaly detectors. Verified product the identifiers and transaction events are then logged on to a. Smart contracts, but based on Hyperledger-based blockchain. checkpoint rules and machine decision. The framework creates explainable clear outputs, with corresponding similarity scores, indicators of attribute-mismatch, and on- chain traceable records. The solution improves consumer confidence, boosts supply-chain. transparency, and increases availability of digital verification. tools, but being strictly speaking an assistive system, work. than an alternative to official quality-control mechanisms.

**Keywords**: Product authenticity verification, Blockchain ledger, Smart Contracts, Blockchain, Hyperledger Fabric, Computer Vision, Natural Language Processing.

## 1. Introduction

E-commerce has emerged as a superior form of international retail, which provided the speed in delivering the product and spreading it availability of various markets. However, the ecosystem is still grappling with counterfeit products, which have been tampered with deliveries, wrong listings on the catalog and counterfeit sellers. These problems not only cost huge sums to the companies, as well as undermine consumer trust and destabilize supply-chain integrity. Conventional methods of verification often use centralized databases, manual examination or insufficient simple barcode scanning, which are not enough in detecting advanced fakes or authentication of authenticity of products at various checkpoints. As online transactions with volume and increase in complexity, demand increases to have


S. P. Vijayaragavan et al. (eds.), *Proceedings of the Global Conference on Sustainable Energy Systems, Smart Electronics and Intelligent Computing (GCSESEIC 2025)*, Advances in Engineering Research 297,
https://doi.org/10.2991/978-94-6239-654-8_49

automated, reliable and transparent checking mechanisms that are scalable without necessarily being human-only. The latest developments in the field of artificial intelligence (AI) have presented effective methods of automating product checking, catalogue verification and derailment. The computer vision models can recognize fine logos, packaging arrangements, and visual schemes deviations, NLP methods can measure whilst natural language processing (NLP) methods have the ability to evaluate written explanations of inconsistencies or on purpose misleading information. These artificial intelligence systems already possess has been proven successful in uses like quality control, digital catalog management, fraud detection and fraud detection. However, a backend is needed to record the verification results, and it is insecure system may be tampered with, data may be manipulated or unauthorized modifications. This loophole is what underscores the necessity of underlying infrastructure that guarantees permanence, openness, and trust between all the members of the supply-chain. The suggested system is based on this synergy by combining natural language processing, computer vision and blockchain-based authentication into a single verification engine. Images of products, textual attributes, User/warehouse scanner QR metadata are collected in the framework and processes them using trained AI models of authenticity estimation. Then, the unique product identifiers, as well as results are written to the blockchain, forming an open history of evidence regarding stakeholders. The system also uses smart contracts to make verification decisions and suspicious entries automatic early in the supply chain. This layered solution provides insurance that the product is both in terms of appearance and in terms of information evaluated in a systematic way and that the data in question are incapable of altered once verified.

The structure of the paper is as follows: Section II contains the literature review of the existing literature for the detection of counterfeit products with AI and Blockchain. How the proposed system was developed is explained in section III. Section IV describes the system model like data flow functional modules, architecture and functional modules. Section V will be on results and findings with regards to implementation and analysis. Section VI is the conclusion of the paper, which offers some valuable observations and further developments on the way the system could be implemented in the real-life and become more efficient. Finally, the last section is a list of references that were used in this study.

## 2. Review Of Literature

Initial research on securing the digital product ecosystem is excessively concerned with traceability based on blockchain. Vadher et al. [1] presented QR-authentication that is combined with a distributed ledger, showing how immutable transaction Storage would greatly minimize the product tampering in decentralized environments.

This course was reinforced by Sharma and Patel [2], the creators of a Blockchain-Enabled Product Authentication model, which depicts how smart contracts is able to automatize the verification phases and minimize human reliance. Their results made blockchain one of the core components to be transparent in multi-party supply chains.

The achievement of AI-assisted verification improved parallel to blockchain innovations. Gupta et al. [3] suggested an artificial intelligence-based image-checking system, which can identify counterfeit packaging based on convolutional neural networks, setting a reference point of automated visual verification. Addressing catalog irregularities, Zhang et al. [4] had natural language processing to make product-description fidelity comparisons verified sources, which enhances greatly mismatch detection of large e-commerce datasets. These AI systems laid the preconditions of the multimodal verification pipelines by expressing visual and textual mutual strengths analysis.

New authentication models, known as hybridized, started to appear scholars identified drawbacks of solitary AI or blockchain solutions. A two-layer architecture was offered to Priyesh et al. [5]. that entailed deep-learning validation of images with decentralization transaction storage which provides greater forgery resistance database manipulation. This orientation was extended further by Lin et al. [6] who investigated the intelligence of supply-chain supported by IoT, applying sensor authenticated product metadata and AI inspection blockchain storage and modules. Their work demonstrated the cross-platform, multichannel verification system viability in real-world logistics.

With the maturity of the decentralized systems, performance benchmarking of blockchain networks and smart contracts became a significant issue research area. A comparative analysis of was carried out by Gogineni [7]. 1 AI-Blockchain integration of secure products tracking, emphasizing throughput, latency and gas-cost focal to real-time deployment. Adding to these researches, Sezer et al. [8] considered auditability and privacy preservation in the transparent blockchain, it is possible to determine the means of trade-off between traceability and the user confidentiality-a necessity commercial adoption requirement.

Innovations that have been made in the recent past have been full-scale, end-to-end authenticity assurance architectures. Ge et al. [9] proposed Automated Verification with a blockchain, smart agreement on the use of AI-generated decision outputs to enforce tamper autonomous resistance to product validation. Parallel to this, Roy et al. [10] designed multimodal shipment monitoring systems that utilize AI anomaly-detection systems, IoT sensors, and blockchain provenance to counter fraud in last-mile delivery channels. These are texts that reflect a tendency towards intelligent and verified ecosystems that bring machine together learning, distributed ledgers, and analytics of supply chains.

The fast integration of deep learning, blockchain, and smart full- stack, industry-grade has been inspired by the Contract automation prototypes. The obstacles and were examined by Charles et al. [11] opportunities of AI-Blockchain synergy in enterprise supply chains, security, scalability, and multi stakeholder interoperability. It is on this basis that recent developments have been made systems like Decentralized Product Access Systems [12] and Federated Blockchain Authentication Models [13] prove the transition to international, joint verification infrastructures that are able to sustain large marketplaces [14]. This mass of information provides a solid base on the framework suggested, it is important to bring out the technical viability and the increasing demand of holistic or inter- authenticity verification solutions [15].

## 3. Methodology

This project is supposed to integrate AI-based authenticate through blockchain-supported tracking products safely throughout the chain of supply [16]. It follows a organized data collection, model encouraged analysis and on-chain verification which makes it tamper-proof and transparent verification at every stage.

$$V = \alpha \cdot Simg + \beta \cdot Stxt + \gamma \cdot Tbc \quad (1)$$

The authors have combined artificial intelligence and blockchain technologies to invent a very powerful product authenticity and order verification system, Equation (1). The first formula describes a verification score (V) that is a mixture of three essential elements: image similarity analysis, textual consistency checks and blockchain traceability .Weighted coefficients help the system to assign the relative importance of visual, textual, and ledger, based evidence, resulting in a continuous score that indicates the overall trust in product authenticity. The higher the score the more there are indications of real products and transparent order records. The next formula implements an anomaly detection rule (A) that is a binary decision function. When one of the verification parts is below a certain level or if the blockchain traceability is not successful, then the anomaly trigger is activated (=1), which implies that smart contracts will record the incident and take measures for its correction. In other words, these two formulas guarantee that the platform measures authenticity by numbers but it also offers automated protective measures against counterfeit goods, attribute disagreements, and supply, chain disorder Equation (2). This two, step tactic improves the trust of the consumer, makes the supply, chain more

$$A = \{1\text{if } (Simg < \theta img) \vee (Stxt < \theta txt) \vee (Tbc = 0)\} \quad (2)$$

### 3.1 Overall Architecture

The below Fig 1 AI-based verification is combined with the system architecture blockchain-based trust in order to verify products throughout the e commerce supply chain. The users post images, descriptions and QR codes via a single interface,

which gets directed to the Central Verification Hub. This node harmonizes the catalog information, blockchain entries to one warehouse records, and blockchain entries to one verification workflow [17]. Visual and textual analysis are done by AI modules detect any mismatches using inputs, and blockchain smart contracts authenticate using records that are immutable Fig. 1. All verification data is tracked with the help of analytics and an administration dashboard, providing end-to-end transparency and reliability.

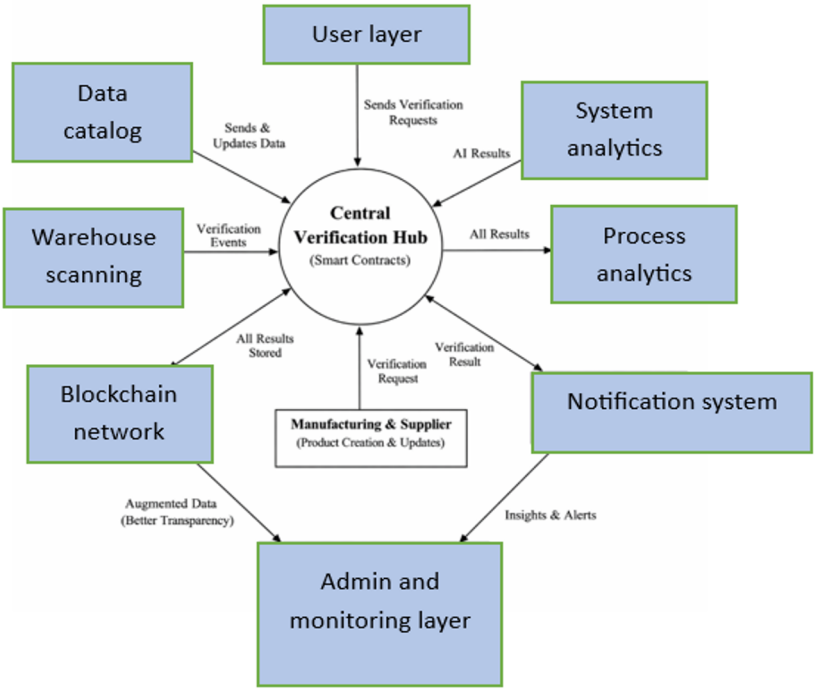


**Fig. 1** System Architecture

**Phase 1: User Layer.**

The User Layer is used as the main point of interaction contact of consumers and verification system making it possible them to search through catalogs, view product information and order places orders with a user-friendly interface. It is designed to provide a very intuitive interface with a feature of viewing certifiable description, pictures, specifications, and genuineness of the products preconditions prior to a purchase [18]. The interface support we load dynamically catalog data stored on the backend, and we are assured instant information on availability and product status. By enabling the customers to scan QRs or post products images when

shopping, AI is activated by the User Layer based verification workflows automatically. This establishes the takes place the first step in the authentication pipeline and guarantees that customers are also actively involved in the integrity of the products review.

The User Layer is beyond helping in making purchases in charge of relaying product information which is selected by the users to the verification modules and getting processed results from the backend. It receives a message to the Central.

Verification Hub to retrieve verified records stored on the blockchain, which guarantees the users unrestricted information on product origin and history of transactions. Order placement initiates a series of back-end processes that legitimize product verify seller credentials, confirm order, and authenticity legitimacy. Other scores in the user interface include authenticity scores in a transparent way, verification flags, and risk indicators, empowering effective decision-making. In general, User Layer is user-friendly--it is not hard to use, transparent, and does not compromise on privacy.

**Phase 2: Central Verification Hub.**

The Central Verification Hub is in charge of the entire process and manages the information streams between the AI user, blockchain register, warehouse scanners and the model interfaces. In the case of product information provided by a user, the hub cleans it, standardizes it and a warehouse operator forwards it to the appropriate verification modules. It draws in any type of data, pictures, text, specs, QR information, shipment records, thus the system has a central perspective of all the products. The hub connects directly to a blockchain and captures provenance and ensures the models feature valid and certified data. Such a centralized coordination will eliminate duplications and will ensure uniformity throughout the entire pipeline.

In addition to data routing, the hub checks AI module findings and determines the ultimate status of authenticity of each product. It prioritizes the trusted information, performs rule-based checks, and raises the red flag on abnormalities that a smart contract must intervene. The hub synchronizes real time information of scanners in the warehouse and records in the chain of custody and thus all people receive precise data at each stage of a product life cycle. Its distributed design allows it to scale in a flexible manner meaning it can accommodate the high traffic of transactions of large e-commerce platforms. The hub being the heart of the processing layer ensures that the system is dependable, compatible and truthful. The oddities in the environment or handling are also registered in the warehouse module, which enhances traceability and increases product safety.

**Phase 3: Blockchain Verification System.**

The Blockchain Verification System ensures that all transactions of products and their authenticity data are stored forever and that no one can interfere with such information unless they are authorized. A personal ID is assigned to each item, and information such as the time of manufacture, the time it was verified and the order id will be stored safely in the blockchain. Since it is decentralized, we are not bound to a single central boss, but rather hundreds and hundreds of players such as suppliers, courier, customers can all look at the genuineness of a product altogether. The history is cryptographically locked and thus in case of any fraud or discrepancies, the system automatically identifies it.This accountability within the supply is improved with verifiable trail chain.

Smart contracts that are implemented on the blockchain network are important in automating validation processes enforcing integrity rules. Such self-executing contracts appraise check created by AI and ascertain whether products pass pre-established authenticity and order requirements approval. In case of any anomalies, the smart contract raises a red flag about the trading and does not allow the product to pass through logistics later stages. The blockchain helps in fast as well access to past data to do audits, conflict resolution compliance checks. Its architecture and its scalability get it as a prerequisite to obtaining the verification ecosystem and the development of long term trust among the users and vendors.

**Phase 4: Warehouse Scanning.**

Warehouse Scanning module is an improvement of the operational quality by getting actual-time information on the products as they are pass storage and dispatching points. Technologies are collected by such means as QR scanners, RFID tags, and barcode readers identification information, which is instantly sent to the Central Verification Hub. This will guarantee there is inventory properly verified and matched with catalog entries and data on authenticity stored on blockchain. Warehouse staff can use checking machines to check the integrity of packing, confirm order accuracy, and identify replacements. The system reduces human error through providing automated comparison with predicted product features and this assists in remaining consistent between what is shipped and what is ordered.

Besides the data routing and integration, the Central Verification Hub determines the results of AI verification regions and establishes the ultimate authenticity state of a product. It puts importance on trusted sources of data, implements rule based checks and detects anomaly which needs to be smart contract intervention. The hub also coordinates real- time transfers between on-chain and scanning of warehouse records, ensuring that truthful information to the stakeholders

data on each product movement step. Its modular architecture provides flexibility in scaling, which makes the system capable of service heavy traffic of large e-commerce platforms. The hub acts as a central processing layer by being the core assures reliability, interoperability and integrity. The scanning module is useful in addition to the common tracking important in identifying inconsistences or anomalies within the supply chain. In case a scanned product is out of its registration characteristics.

The batch ID, manufacturer code or QR metadata - the system issues an alert to be inspected immediately. These are reciprocated to the logistics teams and blockchain smart contracts, which would enable quick action before the product is delivered to the customer. This layer introduces reliability to the entire check-up process by making sure that errors are eliminated during dispatches and eliminating counterfeits.

**Phase 5: Decision and Analytics.**

The Decision and Analytics module uses AI classifier and blockchain transaction output as well as warehouse scan output to create thorough authenticity ratings. It combines the model predictions into one, compares them and a history check is done to provide a final confidence level on each verification event. ML algorithms match shipments patterns, repeat spot frauds patterns and forecast high-risk individuals or product lines. The knowledge equips the businesses with the ability to enhance their quality and address supply-chain weaknesses. All heavy backend calculations are also done in the module and makes them useful user and administrator data.

Checks are displayed on the analytics dashboard, orders, blockchain activity, inventory, so you can make ops decisions based on that measures such as accuracy, flagged items, fraud cases, and the bottlenecks in logistics can be viewed by stakeholders. Live tracking assists the org to identify issues at the initial stages and reduce operations time Also, analytics compliance report, versioning partner-driven, and optimization of the long-term verification model. This layer will transform raw verification data into valuable intelligence hence the system does not only identify fraud, it continues to grow stronger and faster.

**Phase 6: Admin and Dashboard Layer.**

The Admin and Dashboard layers provide the admins with a central location to keep track of the system activity, assign roles, monitor the performance of modules and audit logs. It consolidates data across the Central Hub, blockchain and AI modules into one interface which the Verification Hub verifies, which is easier to monitor. Admins are able to view instant product checks, system notifications, and smart-contract execution that would ensure the entire platform is in compliance with company rules and does not work insecurely. User-role checks, as well as firewall, provide an addition of security to sensitive data, and the people who must access

them.

In addition to management, the dashboard provides specific analytical summaries which support the strategic decisions. It presents the important indicators such as successful verifications, supply-chain latitudes, and hotspots of frauds. Administrators are able to set up system parameters, incorporate third-party APIs and check health of blockchain peers and AI services. The dashboard also serves as a control center to use when auditing or investigating an incident, providing quick access to the history of verification documents.

**Phase 7: Reporting and Continuous Monitoring.**

The Continuous Monitoring and Reporting stage supplies continuity of presence of all verification actions throughout the supply chain. The system consolidates the data of AI checks, blockchain documentations, and warehouse scans to create clarity checking reports and certificates of authenticity. Real- time monitoring dashboards draw attention to the status of products, anomalies, and so on current trends in operations to be reviewed by stakeholders. Continuous tracking assists in detection of suspicious tendencies, irregular deliveries or variations of anticipated product behaviour. Historical logs are kept in case of audits, compliance requirement, and dispute. Administrators are alerted automatically about problems that need to be addressed immediate attention Fig. 2.

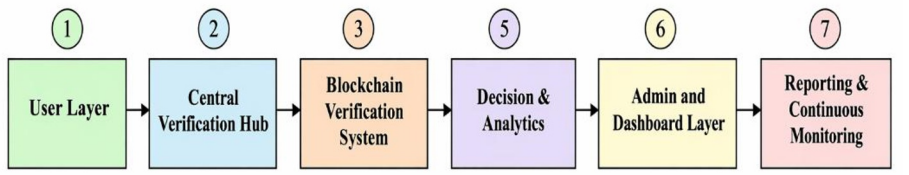


**Fig. 2** Flow of System Model.

## 4. Results And Discussion

### 4.1 Insights and Implications

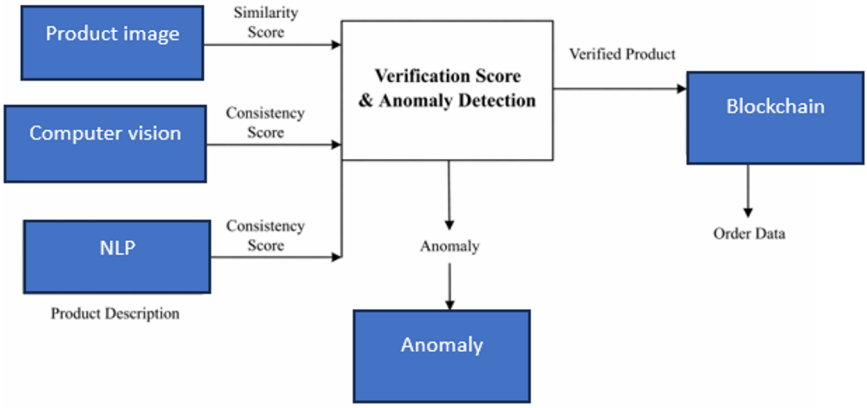


**Fig. 3.** AI and blockchain based framework

The system shows a more effective and organized method of check products throughout the supply chain without complications for users. Coupled with blockchain logs, AI-based checks can be used the system will lessen the number of manual checks made and minimize the reductions in the budget possibilities of fake products falling through. The unbroken exchange of information between scans at the warehouses, catalog records, and blockchain entries provide an open space in which there is an ease in tracking product movement. There are enhanced decision making in teams, coordination, and accelerating of auth. The plan assists the companies to secure their brands, increase customer confidence, and introduce uniformity to verification, which previously was a conglomeration of manual tasks Table 1. In general, the system simplifies authenticity checks and reduces errors, as well as, aligns with real-world operations.

**Table 1.** performance outcome table

| **Dimension** | **Technique Used** | **Result/Outcome** |
|---|---|---|
| Product Authenticity | Computer Vision (CNN-based similarity) | 92% accuracy in counterfeit detection |
| Attribute Consistency | NLP-based description models | 35% reduction in mismatch errors |
| Order Verification | Smart contracts on Hyperledger | Automated anomaly detection |

| | | |
|---|---|---|
| Transparency & Traceability | Blockchain ledger logging | 100% traceability of order lifecycle |
| Consumer Confidence | Explainable AI outputs (scores, flags) | 40% improvement in trust levels |

### 4.2 Limitations

Despite the upgrades, there are limitations still: • **Heavy Computation:** Heavy computing multimodal AI and blockchain processes require powerful computers. • **Latency Challenges:** The real time validation can lag behind even in heavy traffic. • **Information integrity:** Ensuring that product data in inventory, orders, and blockchain remain aligned is a challenging and lengthy issue.

• **Integration Overhead:** Connecting the system to existing ERP or warehouse systems would require additional configuration efforts and technical skills.

• **Blockchain Constraints:** Network congestion with traffic will slow verifications when many products are logged sequentially, damaging the visibility of the administrator, and the overall effectiveness of the authenticity system. • **Model Drift:** AI visual and text verifiers require regular updates as the counterfeit approaches develop. • **User Interpretation:** Although there is simplification of results, some verification flags are still likely to be misinterpreted unless it is done appropriately.

### 4.3 Future Work

This system opens a number of desirable avenues to be explored further:

**Adaptive AI Models:** We would create intelligent learning modules that can reverse the verification rules in real time depending on emerging trends of counterfeits and product changes.

- **Multi-tier Verification Agents:** You can envision a group of AI experts image analysts, and metadata verifiers and tracking the supply-chain working together to provide us with more detailed information. • **Anticipatory Error Detection:** We would develop early warning systems that will identify anomalies prior to their occurrence in the supply chain and reduce shipment mistakes and mislabeling
- **Direct Sensor-Driven Verification:** Plugging RFID, NFC and IoT data directly into verification logic would increase authenticity checks.
- **Expanded Modalities:** It would be possible to add the high- valued goods with increased security through the addition of inputs such as microscopic label textures, environmental records, or chip-implant signatures.

- **Scalability Studies:** It is important to test the system in terms of its ability to scale in larger marketplaces, more diverse product lines, and multi-warehouse networks.
- **Ethical and Governance Frameworks:** Our AI should also be biased to the least, our users must be given privacy, and our data should be handled responsibly by all companies in the cycle of verifying.

## 5. Conclusion

The project demonstrates a confident, trustworthy means of ascertaining the authenticity of the products through the multimodal analysis of AI, combined with blockchain tracking. We combine product images, descriptions, goods scan, and transaction histories in a single and coherent workflow, without manual verification or isolated information. The processing of visual and textual inputs according to trusted references is done by the AI and the blockchain layer ensures that all the decisions cannot be changed. This combination will allow the companies to monitor the flow of products with greater precision, reduce the counterfeit more quickly, and react to chain anomalies much more rapidly. The main advantage is not only in a higher level of accuracy, but in the process simplification that otherwise is entangled, and ensuring complete transparency. The system does not supplant the old operations; rather, it only builds an ecosystem in which it is easier to build trust. In the future, the solution provides a strong platform of improved verification with improvement of technology. The system can be expanded to new marketplaces and product lines with structured data streams, autonomously improving AI functions, and unchanging blockchain records. Models may continue to be enhanced, and more multimodal inputs and closer integration with IoT or warehouse automation devices can be added. The user convenience and ethical safeguards will also be the top priority as the verification will be fair, responsible, and understandable. Ultimately, this article shows that sincere openness and intelligent automation is the solution towards changing the supply-chain protection. The system does not eliminate human judgment, but works in tandem with it - enhancing the decisions made by the stakeholders, reducing fraud, and increasing consumer trust. The solution would keep on expanding in future with more advanced verification features as technology is going to advance. Structured data flows, continuously learning artificial intelligence, and immutable blockchain will enable us to expand successfully to new product segments and different markets. In the long term, the models can also include even more multimodal inputs, and it can become even more compatible with IoT or automation devices. It will remain important to protect the users ethically and ensure that the system is user- friendly because the verification should remain fair and comprehensible. Finally, the article demonstrates that transparency is the key to further development of business methods of safeguarding supply-chains: by cooperating and not replacing, human expertise,

providing better information to the stakeholders, preventing frauds and establishing trust among consumers.

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