



Optimizing the digital gold bullion supply chain to enhance efficiency, security, and public trust

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Received Date: December 22, 2024

Revised Date: February 5, 2025

Accepted Date: February 26, 2025

ABSTRACT

Background: The rapid growth of digital bullion services in Indonesia has transformed gold bullion management from a purely physical supply chain into a hybrid system integrating physical logistics and digital financial infrastructure. This transformation positions PT Pegadaian as a key factor in managing high-value gold assets while facing increasing demands for efficiency, security, and public trust. Although prior studies indicate that digitalization can enhance supply chain performance, high transaction volumes and asset values also create operational complexity and security risks, particularly in synchronizing physical and digital systems. This study aims to analyze the digital bullion supply chain of PT Pegadaian and formulate optimization strategies to improve efficiency, security, and public trust. **Methods:** A qualitative descriptive approach is applied using secondary data from official publications, regulatory documents, and relevant literature. Supply chain mapping is used to identify material, information, and financial flows, followed by problem analysis to determine critical performance areas. **Findings:** The results indicate that the digital bullion supply chain exhibits hybrid characteristics, where performance is influenced by transaction settlement efficiency, synchronization between physical gold stocks and digital balances, system security, physical gold distribution, and cost transparency. Increasing transaction volumes and asset values intensify system load and risk exposure, making these factors critical to supply chain reliability and public trust. The findings support supply chain integration theory, emphasizing coordinated material, information, and financial flows in managing high-value digital-physical systems. **Conclusion:** An integrated optimization model that balances operational efficiency, strengthened security, and transparency is essential to ensure the sustainability of Pegadaian's digital bullion services and enhance public trust. **Novelty/Originality of this article:** This study proposes an integrated conceptual optimization model linking physical gold logistics, digital transaction systems, and public trust within a unified digital bullion supply chain framework, an area that remains limited in existing research.

KEYWORDS: digital bullion; gold bullion supply chain; operational efficiency; public trust; system security.

1. Introduction

The development of digital financial services has driven significant changes in the management of investment assets, including high-value commodities such as gold. Traditionally, gold is known as a safe haven asset and an inflation hedging instrument (World Gold Council, 2026). However, along with the integration of digital technology in the financial system, gold is no longer only traded physically, but also through digital platforms that offer easy access, transaction efficiency and transparency for the wider community (World Gold Council, 2023).

Cite This Article:

Barus, W. H. R. (2025). Optimizing the digital gold bullion supply chain to enhance efficiency, security, and public trust. *Strengthening Dynamic System: e-Government and Public Services*, 2(1), 20-36. <https://doi.org/10.61511/sdseps.v2i1.2025.3434>

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In Indonesia, developing bullion business activities is an important part of efforts to deepen the financial sector and optimize the economic value of gold as a strategic commodity. PT Pegadaian (Persero) has a central role in developing digital bullion services that integrate gold trading, storage and financing activities (Pegadaian, 2024). From a supply chain management (supply chain management) perspective, the success of this service depends largely on the ability to manage the flow of materials, information and finances in an integrated manner to achieve operational efficiency and service reliability (Chopra, 2019; Mukhuty et al., 2022).

The bullion industry in Indonesia is experiencing significant development along with the strengthening of PT Pegadaian's role as a gold bank (bullion bank) business actor. The existence of PT Pegadaian as a major player in the bullion business confirms the institutional transformation from a conventional pawnshop institution to a financial institution that supports integrated and legal gold investment. This role is becoming increasingly strategic in the context of national gold management, particularly in promoting the stability of the financial system and expanding public access to gold-based investment products (Askandar et al., 2025).

In line with these developments, the practice of Sharia Pawnshops shows a convergence between sharia finance, service digitalization and socio-economic resilience. The synergy between gold as a hedge asset, digital financial inclusion, and sharia principles contributes to expanding community participation and strengthening economic resilience, especially in middle and vulnerable groups (Zainuddin & Mutaqin, 2025). Digitalization of sharia bullion services not only increases operational efficiency, but also strengthens Pegadaian's social function in supporting community economic inclusion and sustainability (Masrur et al., 2025).

On the other hand, the success of Pegadaian bullion services is also influenced by brand trust factors, service quality and competitive price structure, which directly influence purchasing decisions and the loyalty of gold investment customers (Badar & Mandala, 2026). Customer satisfaction acts as a moderating variable that strengthens the relationship between these factors and consumer behavior. However, all bullion business practices must still operate within a clear and structured legal framework, considering the complexity of bullion regulation in Indonesia. Therefore, understanding the bullion legal framework is a crucial aspect in ensuring the sustainability, compliance and credibility of bullion business development by PT Pegadaian (Fadillah et al., 2025).

Old bullion is a high-value commodity (high-value product) with special characteristics, such as strict security needs, accuracy of inventory control, and a relatively high level of logistical risk (Ahsanah, 2022). Inefficiencies in the gold supply chain not only have an impact on increasing operational costs, but also have the potential to reduce the level of public trust in digital bullion services. Previous research emphasized the importance of proactive supply chain risk management in managing high-value commodities, especially to mitigate the risk of loss, distribution delays, and information mismatches (Tang, 2006). One widely used approach is the systematic identification and mitigation of risks from the early stages of the logistical process (Pujawan & Geraldin, 2009)

The development of the digital supply chain (digital supply chain) concept provides opportunities to improve logistics performance through information system integration, increasing end-to-end visibility, and strengthening real-time data-based decision making (Avinadav, 2020). In the context of bullion management, supply chain digitalization has the potential to increase traceability, inventory data accuracy, and transparency of gold flows, which ultimately contributes to increasing operational security and customer trust (OECD, 2025).

In addition, international institutions such as the London Bullion Market Association (LBMA) and the Organization for Economic Co-operation and Development (OECD) emphasize the importance of responsible, transparent and sustainable gold supply chain governance. The Responsible Gold Guidance from LBMA 2021 and the Due Diligence Guidance from OECD 2016 emphasize that gold supply chain management must be supported by a strong risk control and transparency system. However, most of these studies

and standards still focus on the global market context, while empirical research on supply chain optimization of gold bullion in digital bullion services at national financial institutions in Indonesia is still limited (London Bullion Market Association, 2021; OECD, 2016).

Despite the rapid development of digital financial services and digital supply chain concepts, significant gaps remain in the literature. Previous studies have largely focused on manufacturing sectors or low- to medium-value commodities, with limited attention to high-value assets such as gold bullion, which require strict security, accuracy, and risk control. In addition, existing research on supply chain risk management has not sufficiently addressed the integration of physical logistics and digital financial systems within hybrid asset environments. Although international frameworks developed by organizations such as the London Bullion Market Association and the Organisation for Economic Co-operation and Development emphasize transparency and responsible gold supply chain governance, their application is primarily oriented toward global markets and lacks contextualization in national financial institutions, particularly in Indonesia. Furthermore, empirical studies on Pegadaian's digital bullion services remain limited, especially in examining the interrelationship between efficiency, security, digital integration, and public trust within a unified analytical framework.

Based on these gaps, this study aims to analyze the current structure and performance of the gold bullion supply chain in Pegadaian's digital bullion services, identify key inefficiencies and logistical risks, and evaluate the role of digitalization in enhancing integration, transparency, and operational performance. In addition, this study examines how supply chain performance influences public trust and proposes an integrated and adaptive optimization model to improve efficiency, security, and reliability in managing digital-physical gold assets. Through this approach, the research is expected to contribute both theoretically—by extending digital supply chain and risk management perspectives to high-value commodities—and practically, by providing strategic insights for financial institutions in developing sustainable and trustworthy digital bullion services.

2. Methods

2.1 Research paradigms and approaches

This study employs a descriptive-analytical qualitative approach supported by simple quantitative analysis. Ontologically, the gold bullion supply chain is viewed as a real and observable system consisting of actors, processes, and logistics flows. Epistemologically, knowledge is constructed through the interpretation of empirical data derived from official documents and observations, which are then analyzed using supply chain management, digitalization, and risk management perspectives. This approach is appropriate as the study does not aim to test causal relationships statistically, but rather to analyze, evaluate, and develop an optimization model for the gold bullion supply chain in the context of digital bullion services.

2.2 Research objects

This research focuses on Pegadaian's Digital Bullion Service and its associated gold bullion supply chain processes, including procurement, storage, distribution, and digital transaction systems. The selection of this object is based on its strategic role in Indonesia's financial ecosystem, particularly in integrating physical gold logistics with digital financial services, which has significant implications for efficiency, security, and public trust. In addition, the rapid growth of digital financial services in Indonesia has increased the importance of developing secure, transparent, and efficient bullion management systems to support sustainable financial innovation.

2.3 Research method flow

This study employs a systematic research procedure to ensure that the analysis is conducted in a structured and comprehensive manner. The research process begins with data collection and literature review, followed by data analysis and interpretation based on the selected analytical framework. The flow of research methods used in this study is shown in the following Fig. 1. This methodological flow is designed to support transparency, consistency, and reliability throughout the research process.

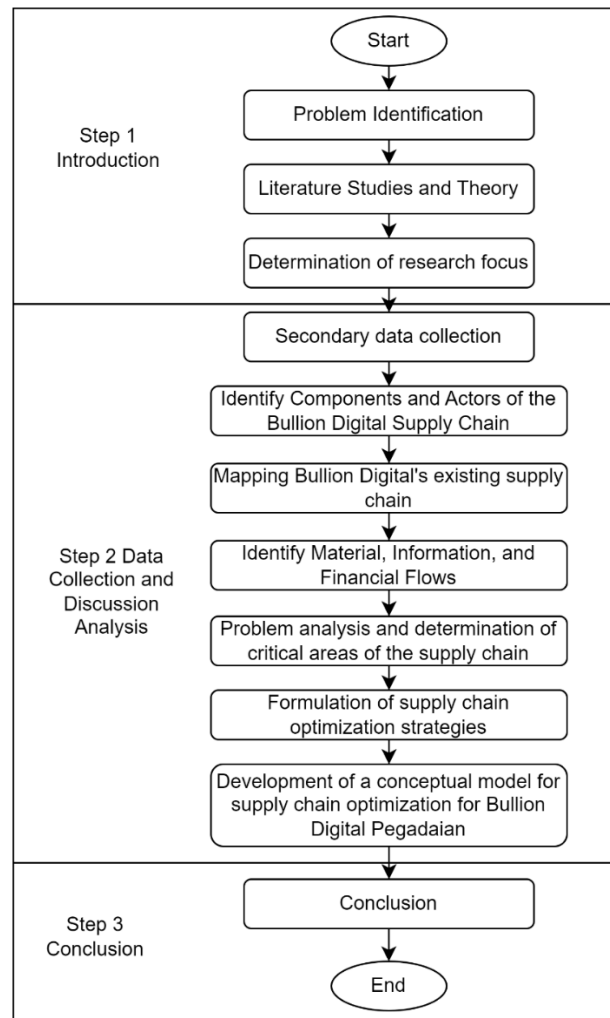


Fig. 1 Research method flowchart

2.4 Data sources and selection criteria

This study relies entirely on secondary data obtained from credible and publicly accessible sources, including Pegadaian annual reports, official press releases and corporate publications, regulatory documents related to bullion and financial services, as well as relevant academic literature and industry reports. The selection of these data sources is based on several important criteria. First, the data must meet the criterion of credibility, meaning that it originates from official, institutional, or peer-reviewed sources. Second, the data must be relevant to bullion services, supply chain processes, or digital financial systems. Third, priority is given to data published within the last five to seven years to ensure the analysis remains current and up to date. Finally, the data must provide sufficient and comprehensive information to support the mapping of supply chain processes and the

identification of risks and performance factors. These considerations ensure transparency and reliability throughout the analytical process.

2.5 Research variables and analytical focus

The main analytical focuses of this study include supply chain efficiency, which is evaluated through process flow structure, bottlenecks, and potential waste. In addition, the study examines logistics and operational risks, including security risks, delays, and data inconsistencies that may affect operational performance. Another important focus is supply chain digitalization, which covers system integration, data synchronization, and transparency within operational processes. Furthermore, public trust is assessed as an important outcome of supply chain performance, particularly in relation to the security and reliability of transactions.

2.6 Analytical framework

This study adopts an integrated analytical framework that combines Supply Chain Management (SCM) principles, including flow management, integration, and operational efficiency, with Digital Supply Chain concepts that emphasize system integration and real-time information flow. In addition, the study incorporates a Risk Management Framework focusing on risk identification, assessment, and prioritization. This integrated framework is applied to systematically evaluate the interaction between physical logistics systems and digital financial infrastructure, particularly in hybrid asset management systems such as digital bullion services.

3. Results and Discussion

3.1 Identification of components and actors of the digital bullion supply chain

This section aims to identify the main components as well as actors involved in the Pegadaian digital bullion supply chain as a basis for understanding the structure of the analyzed system. The identification process is carried out through reviewing official publications of PT Pegadaian (Persero), Financial Services Authority (OJK) regulations that regulate bullion business activities, as well as scientific literature that discusses high-value asset supply chain management. In the context of digital bullion, the supply chain not only includes the physical movement of gold, but also involves a digital system that represents the ownership and economic value of gold. The components and actors identified therefore reflect the integration between physical logistics systems and digital financial infrastructure (OJK, 2025).

The main actors in the digital bullion supply chain include gold suppliers as physical gold providers, Pawnshops as bullion service managers and providers, gold storage facilities (vault) as logistics components that ensure the security and availability of physical assets, and customers as end users of digital bullion services (Irawan & Christianto, 2025). Apart from that, the payment and settlement system which is integrated with Pegadaian digital services acts as a supporting actor in ensuring smooth financial flows. In terms of system components, the digital bullion supply chain consists of physical gold as the underlying asset, the Pegadaian digital platform as a medium for transactions and recording ownership, as well as information technology infrastructure that ensures data integration between digital balances and physical gold stocks (Owoade et al., 2024).

The identification of components and actors at this stage confirms that the digital bullion supply chain has hybrid characteristics, where the reliability of the system is determined not only by the management of materials, but also by the accuracy and integrity of the digital information that connects all actors in the ecosystem (Rachmad, 2025). The following image presents an overview of the main actors and main components involved in the digital bullion supply chain at PT Pegadaian.

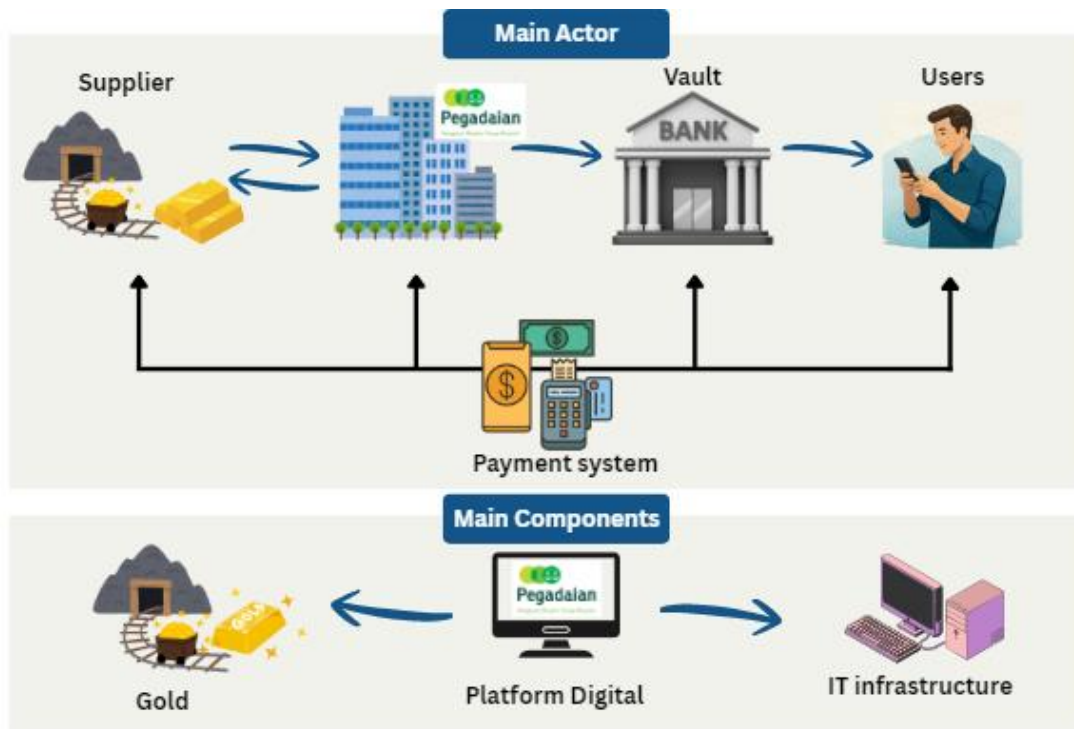


Fig. 2 Main actors and system components in PT Pegadaian's digital bullion supply chain

In the PT Pegadaian digital bullion system, the main actors consist of gold suppliers, PT Pegadaian as the main manager, bank vault as the storage facility provider, and users as the final party, all of whom are connected via an integrated payment system (Ghode et al., 2025). The flow of gold material moves from suppliers to Pawnshops to then be stored in vaults, while the flow of information and transactions is facilitated through digital platforms supported by information technology infrastructure. This integration between actors and components plays an important role in ensuring security, transparency, operational efficiency, and increasing public trust in digital gold investment services (Khan et al., 2023).

3.2 Mapping bullion digital's existing supply chain

Analysis of the digital bullion supply chain system begins with mapping operational flows based on PT Pegadaian (Persero) public data and regulatory documents. Pegadaian, after obtaining permission from the Financial Services Authority (OJK) to carry out bullion business activities through POJK No. 17 of 2024, operates several core services such as gold deposits, corporate gold deposits, gold-based working capital loans, and bullion trading (OJK, 2024). As of April 2025, the total volume of gold transactions managed through the Pegadaian bullion business line reached 5.31 tons, consisting of 1.06 tons of gold deposits, 2.95 tons of corporate gold deposits, 150 kilograms of working capital loans and 1.15 tons of gold trading (ANTARA News, 2025a). In terms of retail services, the digital gold deposit balance recorded at the beginning of 2025 reached 118 kilograms, showing the public's positive response to gold storage via the Pegadaian digital platform (Jakarta Globe, 2025). This mapping describes the structure of the Pawnshop digital bullion ecosystem where centrally stored physical gold functions as the underlying asset, while ownership transactions, balances and value movements are carried out through a digital system connected to financial flows. The following image summarizes the system integration and main flows in PT Pegadaian's digital bullion operations.

Overall, this scheme shows that PT Pegadaian acts as an integration center that connects gold suppliers, storage facilities (vault), digital platforms, payment systems and users in one digital bullion ecosystem. The integration of material, information and financial flows through digital platforms enables increased operational efficiency, strengthened

storage and transaction security and transparency with an impact on increasing public trust (Bilkisti et al., 2025). Thus, the integrated implementation of digital bullion is an important foundation in supporting the sustainability of gold investment services and strengthening PT Pegadaian's role in the national bullion industry (Taghizadeh & Taghizadeh, 2021).

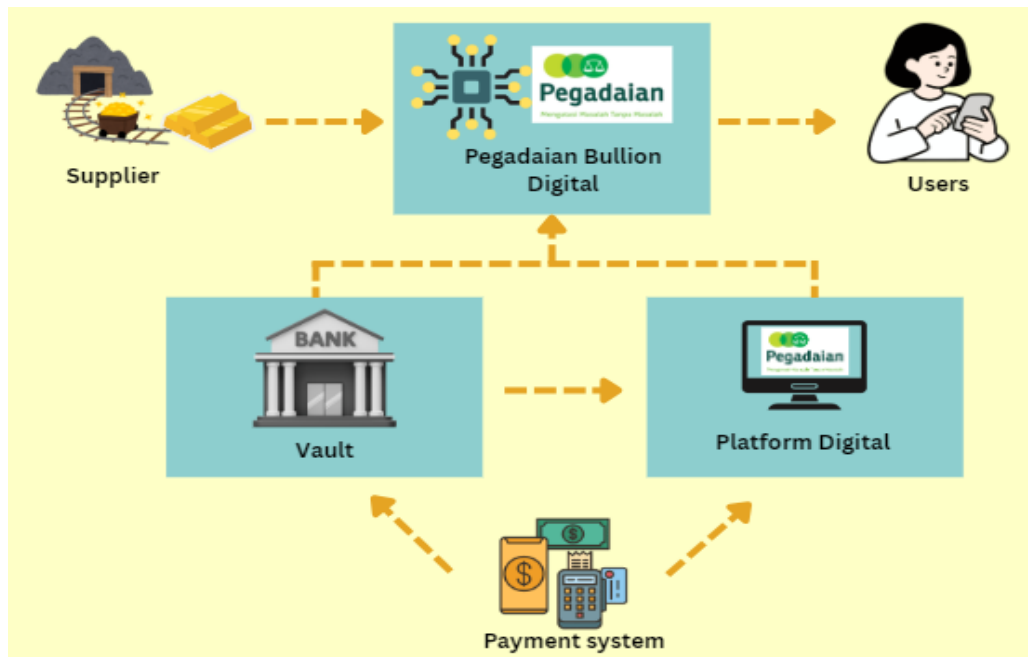


Fig. 3. Mapping of existing supply chain of digital bullion

3.3 Identify material, information, and financial flows

Based on the above mapping of supply chain flows, the study identified three main flows on which the assessment focused: materials, information and finance. Material flows in the context of digital bullion include physical ownership of gold stored in Pegadaian's vault facility and available as a basic inventory of customers' digital balances, where physical movement of gold occurs mainly in the condition of physical withdrawal or delivery of gold bullion requested by the customer. Information flow involves the movement of digital transaction data, including gold balance updates, buying and selling history, and recording changes in customer ownership via the Pegadaian Digital application (Rushton, 2014).

Financial flows include payment and settlement processes carried out through digital payment systems integrated with bullion services, such as payment for gold purchases or disbursement of gold value. These three streams are interlinked and form a unique digital bullion supply chain mechanism of action, distinct from conventional physical goods supply chains due to the predominance of digital representation over relatively static physical assets (Chopra, 2019; Tang, 2006). The following figure depicts the interconnectedness and integration of material flows, information flows, and financial flows in digital bullion systems.

The scheme asserts that the effectiveness of digital bullion systems depends largely on synchronization between the flow of gold materials, the flow of proprietary information and digital transactions, and the financial flow from payment to settlement of gold value. The integration of these three streams through digital systems and centralized storage facilities allows for improved operational efficiency, data accuracy and transaction security. Thus, synchronization and integration of supply chain flows are key factors in ensuring transparency, system reliability and increasing public trust in digital bullion services (Xiao et al., 2026).

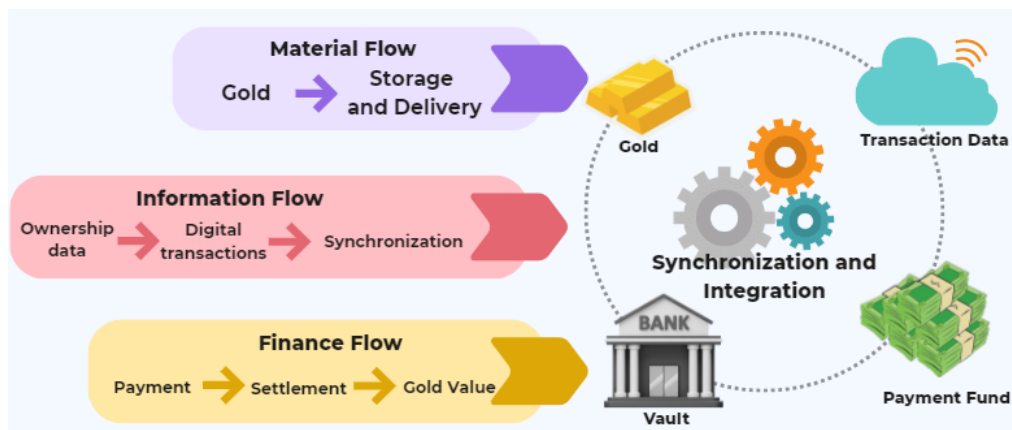


Fig. 4. Integration of material, information and financial flows in digital bullion systems

Furthermore, the tight interdependence between material, information, and financial flows creates a critical need for real-time data integration within the digital bullion supply chain. Any discrepancy between physical gold availability and digitally recorded balances may lead to operational risks, including settlement delays and inconsistencies in customer ownership records. Therefore, continuous reconciliation mechanisms and system monitoring are essential to maintain alignment between physical inventories and digital representations, particularly as transaction volumes increase and customer participation expands (Kshetri, 2018).

In addition, the integrated flow structure highlights the strategic role of digital platforms as coordination mechanisms rather than mere transaction interfaces. By enabling end-to-end visibility across supply chain actors, digital systems support proactive risk management, faster decision-making, and improved service responsiveness. This enhanced visibility not only reduces operational uncertainty but also strengthens transparency perceived by customers, which is crucial in maintaining trust when managing high-value assets such as gold bullion within a predominantly digital environment (Sanni, 2024).

3.4 Problem analysis and determination of supply chain critical areas

The growth of Bullion Digital Pegadaian services shows a very significant escalation of supply chain activity. Based on data from Pegadaian publications and national economic news, the number of Pegadaian digital transactions increased from around 8.02 million transactions to more than 34 million transactions, or experienced growth of around 324% in one reporting period. This increase is in line with the increase in the number of digital customers which has exceeded 4.6 million active users. On the other hand, the gold trading volume in Pegadaian's bullion business was recorded at around 6.37 tons of gold with a transaction value of close to IDR 11 trillion, indicating the large value of assets that must be managed safely and efficiently (ANTARA News, 2025b; Jakarta Globe, 2025).

The surge in transactions and the value of managed gold directly increases the complexity of the digital bullion supply chain. In terms of operational efficiency, very fast transaction growth has the potential to create bottlenecks in the backend system, especially in the transaction settlement process, recording digital gold balances, and synchronizing data between the digital system and the availability of physical gold. The imbalance between system capacity and transaction volume risks causing service delays and data errors, which can ultimately reduce customer satisfaction and trust levels (Masrur et al., 2025).

From a security aspect, the increasing tonnage of gold managed and transaction value reaching trillions of rupiah make the Bullion Digital system an object with high risk. Risks not only come from the physical security side of gold storage, but also from the digital security side, such as potential cyber-attacks, manipulation of transaction data, and leaks of customer information. Considering the character of gold as a high-value asset, failures in securing digital and physical supply chains can have a systemic impact on service reputation

and sustainability (Athi’ulhaq, 2023). The following image presents the conceptual framework of PT Pegadaian’s digital bullion system which emphasizes the integration of gold sources, digital processes and market needs.

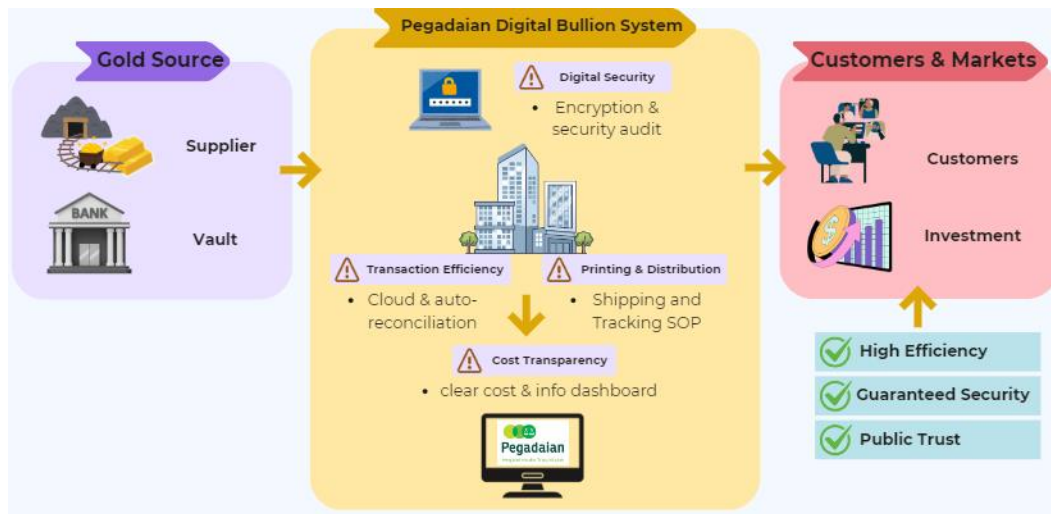


Fig. 5. PT Pegadaian digital bullion system model

Furthermore, even if transactions are carried out digitally, the demand for digital gold to physical form is still present. This places the physical printing and distribution process as a critical point in the supply chain. Inefficiencies at this stage, such as delays in printing or delivery, can create a gap between customer expectations and actual service performance. Another aspect that also influences is transaction cost transparency. Lack of customer understanding of cost structures, price spreads and administrative costs has the potential to lower the perceived value of services even if the system has worked technically well.

Table 1. Summary of data and critical areas of the pawnshop digital bullion supply chain

Aspect	Public quantitative data	Implications for supply chains	Critical areas
Digital transaction volume	>34 million transactions (up ±324%)	High load on backend and settlement systems	Transaction efficiency
Number of digital customers	>4.6 million active users	Real-time system and service reliability demands	Public trust
Bullion gold volume	±6.37 tons of gold	High risk on asset storage and recording	Security
Gold transaction value	±Rp11 trillion	Potential for major losses in the event of disruption	Security
Printing & distribution process	Physical demand remains	Risk of delays and logistical inefficiencies	Physical distribution
Cost structure	Spreads & fees vary	Cost perception can affect loyalty	Cost transparency

(ANTARA News, 2025a, 2025b; Pegadaian, 2024)

Moreover, the rapid escalation of transaction volume and asset value reinforces the necessity for an integrated optimization approach that simultaneously addresses efficiency, security, and transparency within the digital bullion supply chain. As transaction intensity increases, fragmented improvements in either digital systems or physical logistics alone are insufficient to sustain service reliability. Instead, a holistic supply chain perspective that aligns system capacity planning, risk management mechanisms, and customer-oriented transparency policies becomes essential. Such integration not only mitigates operational and security risks but also serves as a strategic instrument to maintain public trust and

support the long-term sustainability of PT Pegadaian's digital bullion services in an increasingly competitive and technology-driven bullion market. Based on this analysis, the critical area of the Bullion Digital Pawnshop supply chain can be identified and mapped quantitatively as summarized in the following Table 1.

3.5 Formulation of supply chain optimization strategies

Based on the results of problem analysis and identification of critical areas in Phase 4, optimization of the Bullion Digital Pegadaian supply chain needs to be carried out through an integrated approach that includes aspects of operational efficiency, system security and increasing public trust. The optimization strategy is not only focused on improving one point of the process, but on the entire supply chain flow that connects physical gold management with digital transaction systems.

On the operational efficiency aspect, the surge in digital transaction volume to more than 34 million transactions show the need for increased capacity and flexibility of the backend system. Optimization can be carried out through the application of a scalable and automated digital system, especially in the process of settling and reconciling gold balances. With an automatic reconciliation system, the risk of recording errors can be significantly suppressed even if the transaction volume increases. This efficiency is important to maintain service speed and data consistency between stored physical gold and customers' digital gold balances.

In terms of security, the large value of gold managed by —, reaching around 6.37 tons or IDR 11 trillion —, puts Bullion Digital Pawnshop at a high level of risk. Therefore, the optimization strategy is directed towards strengthening multi-layered security, both in digital infrastructure and in the physical management of gold. The implementation of international security standards, periodic audits and the separation of data storage and operational functions are important steps to minimize systemic risks. Strong security serves not only as an asset protection mechanism, but also as a key foundation in building public trust.

Furthermore, the physical gold printing and distribution process needs to be more closely integrated with digital systems. Transparency of printing and delivery status through real-time tracking systems can reduce customer uncertainty and increase service satisfaction. Optimization at this stage aims to reduce distribution lead times and minimize delivery errors, so that consistency between digital and physical services can be maintained.

The aspect of cost transparency is also an important part of the optimization strategy. Clear cost information, including price spreads and administration fees, needs to be presented openly on digital platforms. This transparency plays a role in building perceptions of price fairness and reducing potential customer distrust, especially retail investors who have just switched to digital bullion services. Overall, Bullion Digital Pegadaian's supply chain optimization strategy is directed at creating an efficient, safe and transparent system, so that it is able to support rapid transaction growth without sacrificing service quality and public trust.

Table 2. Critical area mapping, optimization strategy, and pawnshop digital bullion supply chain performance indicators

Critical areas	Optimization strategy	Key Performance Indicators (KPIs)	Expected impact
Digital transaction efficiency	Scalable backend system and automatic reconciliation	Transaction settlement time, balance error rate	Fast and accurate transactions
System & data security	Layered security and periodic audits	Number of security incidents	The risk of loss & fraud decreases
Physical storage & distribution	Logistics integration and real-time tracking	Delivery lead time, distribution accuracy	Customer satisfaction increases
Cost transparency	Cost dashboard and transaction simulation	User satisfaction score	Public trust increases

In addition, the successful implementation of these optimization strategies requires strong coordination between organizational units, technology providers, and external partners involved in the digital bullion ecosystem. Governance mechanisms, standard operating procedures, and performance indicators must be aligned to ensure that operational efficiency, security controls, and transparency initiatives are implemented consistently across the supply chain. By institutionalizing these optimization measures, PT Pegadaian can strengthen the resilience of its digital bullion supply chain, enhance adaptability to future transaction growth, and reinforce its strategic role as a trusted and sustainable national bullion service provider.

3.6 Development of a conceptual model for supply chain optimisation bullion digital pegadaian

This stage aims to formulate a conceptual model for Bullion Digital Pegadaian supply chain optimization which is able to answer the main problems in the form of increasing transaction volume, high value of gold assets managed, as well as demands for efficiency, security and public trust. This conceptual model is built by integrating physical gold supply chains and digital service systems in one integrated management framework.

The model starts from managing physical gold as an upstream supply chain, which includes providing, storing and securing gold bullion in designated facilities. This physical gold functions as an underlying asset for digital gold balances traded via the Bullion Digital platform. Consistency between physical gold stocks and digital gold balances is a key prerequisite for the sustainability of the system, so a real-time integrated recording and reconciliation mechanism is needed.

In the middle layer (core process), the Bullion Digital system acts as the main link between physical gold and customers. All transaction activities, from buying, selling, to exchanging digital gold for physical form, are processed through a scalable and secure digital system. Optimization at this layer is focused on settlement speed, balance recording accuracy, and data and transaction protection. With transaction volumes increasing to tens of millions of transactions, digital systems are becoming the most critical point determining the efficiency and reliability of the supply chain as a whole.

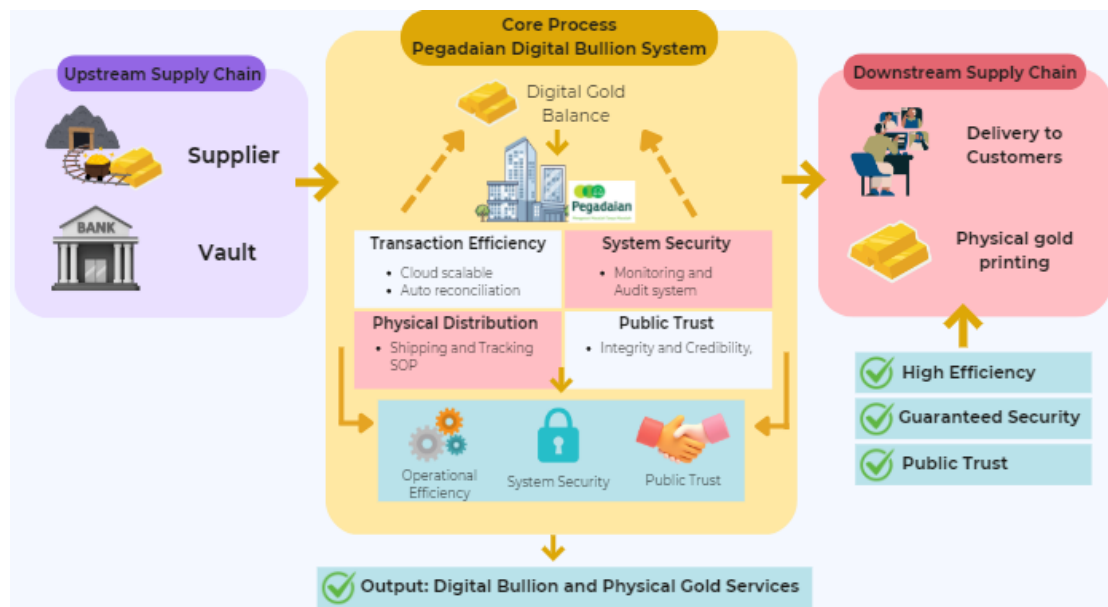


Fig. 6 Pawnsop digital bullion supply chain optimization conceptual model

In the downstream supply chain, the model includes the process of printing and distributing physical gold to customers who choose digital gold exchange. This stage requires close integration between digital systems and logistics operations so that

distribution lead times can be reduced and the risk of delivery errors minimized. Transparency of printing and delivery status through digital systems is an important element to maintain customer satisfaction and trust.

The conceptual model illustrated in Figure X presents an integrated framework that connects the upstream physical gold supply chain, the core process of the Bullion Digital Pegadaian system, and the downstream supply chain within a unified optimisation structure. In the upstream layer, the model highlights the role of gold suppliers and storage facilities as critical sources of physical gold assets. These components ensure the availability and security of gold bullion, which serves as the underlying asset for digital gold balances. Effective inventory control and secure storage at this stage are fundamental to maintaining system credibility and operational continuity.

At the core process level, the Bullion Digital Pegadaian system functions as the central integration platform, as depicted in the model through digital transaction processing and system monitoring mechanisms. The model emphasizes transaction efficiency supported by cloud-based infrastructure, application acceleration, and real-time processing capabilities. In parallel, system security is reinforced through monitoring, auditing, and cybersecurity controls, while inventory reconciliation ensures consistency between physical gold stocks and digital gold balances. This middle layer represents the most critical point of optimisation, as it directly affects system reliability amid increasing transaction volumes (Al-qararah, 2023; Aldeen et al., 2022).

Table 3. Summary of the conceptual model for bullion digital Pegadaian supply chain optimisation

Supply Chain Layer	Main Components	Key Processes	Optimisation Focus	Expected Outcomes
Upstream Supply Chain (Physical Gold Supply Chain)	Gold suppliers, gold storage facilities	Gold procurement, storage, and physical security	Inventory availability, secure storage, asset protection	Availability of physical gold as underlying digital assets
Core Process (Bullion Digital Pegadaian System)	Digital gold platform, transaction system, monitoring and audit system	Buying and selling digital gold, balance recording, real-time reconciliation	Transaction efficiency, system security, data accuracy	Efficient transactions, secure system operations, inventory consistency
Digital Infrastructure Support	Cloud computing, application acceleration, cybersecurity system	Data processing, transaction monitoring, system scalability	System scalability, reliability, and cyber protection	Stable and scalable digital bullion services
Downstream Supply Chain (Customer Delivery)	Gold printing facilities, logistics and delivery services	Conversion of digital gold to physical gold, distribution to customers	Lead time reduction, logistics accuracy, service transparency	Timely and accurate delivery of physical gold
Cross-Cutting Governance Elements	Risk management, transparency mechanisms, internal controls	Monitoring, auditing, and information disclosure	Risk mitigation, transparency, trust building	Increased public trust and customer confidence
Overall Output	Digital gold services and physical gold products	Integrated end-to-end supply chain operations	Efficiency, security, and trust integration	Sustainable Bullion Digital Pegadaian services

The downstream supply chain, as shown in the model, encompasses gold printing, logistics distribution, and delivery to customers who choose to convert digital gold into physical form. Integration between digital systems and logistics operations enables more accurate scheduling, reduced lead time, and minimized delivery errors. Transparency in

printing and shipment status, accessible through the digital platform, enhances service visibility and supports customer confidence in the end-to-end bullion supply chain.

The model explicitly positions operational efficiency, system security, and public trust as interconnected performance outcomes, consistent with the outputs illustrated in the conceptual diagram. Improvements in transaction efficiency and logistics coordination reduce operational risk, while robust security and monitoring mechanisms protect high-value assets and data integrity. These elements collectively reinforce public trust, resulting in a sustainable Bullion Digital service that delivers both digital gold and physical gold outputs. Thus, the conceptual model provides a comprehensive and visually aligned framework for optimizing the Bullion Digital Pegadaian supply chain.

Overall, this conceptual model contributes by providing a holistic perspective on digital bullion supply chain optimization that explicitly integrates physical asset management and digital transaction systems within a single framework. Unlike conventional supply chain models that emphasize material flow dominance, this model highlights the critical role of digital systems as coordination and control mechanisms for high-value, low-mobility assets such as gold. By structurally linking upstream asset security, core digital processing, and downstream physical fulfillment, the model demonstrates how synchronization across supply chain layers can simultaneously enhance efficiency, security, and public trust. Consequently, the proposed framework serves not only as an analytical tool for evaluating current system performance but also as a strategic reference for guiding future development of PT Pegadaian's digital bullion services amid increasing transaction intensity and asset value.

4. Conclusions

This research shows that the gold bullion supply chain in the Bullion Digital Pegadaian service has grown significantly along with the increase in transaction volume and number of customers. Analysis of existing conditions indicates that the integration between physical gold management and digital systems has made a positive contribution to increasing transaction efficiency and ease of access for the public. Nevertheless, the complexity of supply chains involving high-value assets and large-scale digital systems also poses challenges in the form of potential operational inefficiencies, logistical risks and the need for strengthened system security and transparency.

The results of the analysis further identified that the main source of supply chain inefficiency and risk is the process of data integration between physical gold stocks and digital gold balances, increasing system load due to transaction growth, as well as the process of distributing physical gold to customers which still requires more coordinated logistics management. Security risks, both in physical and digital aspects, are a critical factor that directly influences the level of public trust in digital bullion services.

Digitalization has been found to have a strategic role in improving the efficiency, safety and transparency of the gold bullion supply chain. Digital bullion systems enable faster, more accurate and integrated transaction recording, while increasing process visibility for customers. Transparency of transaction information and the status of gold assets is a key element in strengthening public trust in Pegadaian digital bullion services.

As a major contribution, the research proposes an integrated and adaptive bullion supply chain optimization model, linking physical gold management, digital systems and services to customers in a single conceptual framework. This model emphasizes a balance between operational efficiency, strengthening security, and increasing public trust as the foundation for the sustainability of bullion business activities. By implementing this model, the Pegadaian Digital Bullion service is expected to be able to continuously improve supply chain performance and strengthen its position as a trusted digital bullion service provider in Indonesia.

Acknowledgement

The authors acknowledge PT Pegadaian (Persero) for the financial support provided for the publication of this research. The authors also express their gratitude to all parties who contributed to the completion of this study, including those who provided academic input, technical assistance, and constructive feedback throughout the research and writing process.

Author Contribution

The author was responsible for the conception and design of the study, data collection, data analysis and interpretation, manuscript preparation, and approval of the final version of the manuscript.

Funding

This research received financial support from PT Pegadaian (Persero) for the publication of this study.

Ethical Review Board Statement

Ethical review and approval were waived for this study because the research did not involve human participants, animals, or any primary data collection. The study exclusively utilized publicly available secondary data obtained from official publications and reports issued by PT Pegadaian (Persero). Therefore, ethical clearance was not required, as the research does not raise concerns related to public health, personal data protection, or human subject research.

Informed Consent Statement

Not available. This study did not involve human participants and did not collect any primary data requiring informed consent.

Data Availability Statement

The data supporting the findings of this study are derived from publicly available sources, including official publications, annual reports, and publicly disclosed information released by PT Pegadaian (Persero). No new datasets were generated during the current study. The data used are available from the corresponding sources upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Declaration of Generative AI Use

During the preparation of this work, the author used ChatGPT (OpenAI) to assist in language editing, structuring academic arguments, and improving clarity and coherence of the manuscript. After using this tool, the author reviewed and edited the content as needed and took full responsibility for the content of the publication.

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References

- Ahsanah, D. N. (2022). Emas sebagai instrumen investasi jangka panjang. *Shar-E: Jurnal Kajian Ekonomi Hukum Syariah*, 2, 177–187. <https://lib.unnes.ac.id/20002/>
- Al-Qararah, E. A. S. (2023). An empirical study of the effect of FinTech infrastructure on competitive advantage and performance. *International Journal of Information Technology and Language Studies (IJITLS)*, 7, 1–9. <https://ijitls.com/index.php/ijitls/article/view/333>
- Aldeen, B., Fraihat, M., & Al-Afeef, M. A. M. (2022). The moderating effect of financial technology (FinTech) innovation between knowledge management infrastructure and institutions performance. 8, 91–95. <https://doi.org/10.17605/OSF.IO/NMKVH>
- ANTARA News. (2025a, January 14). OJK catat usaha bullion Pegadaian capai 5,31 ton emas per April 2025. <https://www.antaranews.com/berita/4877453/ojk-catat-usaha-bullion-pegadaian-capai-531-ton-emas-per-april-2025>
- ANTARA News. (2025b, November 12). Pegadaian catat total emas kelolaan capai 129 ton hingga Oktober 2025. <https://www.antaranews.com/berita/5238137/pegadaian-catat-total-emas-kelolaan-capai-129-ton-hingga-oktober-2025>
- Askandar, A., Reihansyah, M., & Kusuma, R. L. (2025). Understanding the legal framework of bullion in Indonesia. *Journal of Financial Sector Law & Policy*, 1(1), 55–69. <https://jurnal.hkhsk.id/index.php/jfslp/article/view/112>
- Athi'ulhaq, A. (2023). *Pengaruh pengetahuan, keamanan, dan persepsi risiko investasi terhadap minat generasi Z dalam berinvestasi emas digital: Studi pada E-Mas BSI Mobile* [Undergraduate thesis]. Universitas Islam Indonesia. <https://dspace.uui.ac.id/handle/123456789/43487>
- Avinadav, T. (2020). The effect of decision rights allocation on a supply chain of perishable products under a revenue-sharing contract. *International Journal of Production Economics*, 225, 107587. <https://doi.org/10.1016/j.ijpe.2019.107587>
- Badar, M. Y. Y., & Mandala, S. (2026). The existence of PT Pegadaian as a bullion bank business player in Indonesia. *Jurnal Greenation Sosial dan Politik*, 3(4), 1280–1288. <https://doi.org/10.38035/jgsp.v3i4.553>
- Bilkisti, N., Wahyuningtias, J., Anatasha, G. E., Amilia, M. S., Selviana, I., Ihwan, K., & Malik, A. (2025). Peran Pegadaian Syariah dalam pemberdayaan UMKM di Indonesia. *Jiic: Jurnal Intelek Insan Cendikia*, 2(5). <https://jicnusantara.com/index.php/jiic>
- Chopra, S. (2019). *Supply chain management: Strategy, planning, and operation*. Pearson Education Limited.
- World Gold Council. (2023). *Responsible gold mining principles*.
- World Gold Council. (2026). *Gold outlook 2026: Push ahead or pull back*. <https://www.gold.org/goldhub/research/gold-outlook-2026>
- Fadillah, F., Suhud, U., & Rizan, M. (2025). Analysis of brand trust, service quality, and price on purchase decisions and customer loyalty in gold bullion investment at PT Pegadaian: The moderating role of customer satisfaction. *Greenation International Journal of Tourism and Management*, 3(1), 89–99. <https://doi.org/10.38035/gijtm.v3i1.373>
- Ghode, D. J., Yadav, V., Jain, R., & Soni, G. (2025). Integrated framework for supply chain with blockchain technology: A manufacturers' perspective. *Journal of Innovation and Entrepreneurship*, 14(1), 1–22. <https://doi.org/10.1186/s13731-025-00553-1>
- Irawan, G. Y., & Christianto, H. (2025). Legal regulations on gold banks post-UUP2SK and POJK17/2024: Normative review and comparison with international practices. *Journal of Social Research*, 4(8), 2133–2143. <https://doi.org/10.55324/josr.v4i8.2726>
- Jakarta Globe. (2025, January 14). Pegadaian Digital's gold deposit balance hits 118 kilograms. <https://jakartaglobe.id/special-updates/pegadaian-digitals-gold-deposit->

- [balance-hits-118-kilograms](#)
- Khan, M., Alshahrani, A. N., & Jacquemod, J. (2023). Digital platforms and supply chain traceability for robust information and effective inventory management: The mediating role of transparency. *Logistics*, 7(2). <https://doi.org/10.3390/logistics7020025>
- Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, 39, 80–89. <https://doi.org/10.1016/j.ijinfomgt.2017.12.005>
- London Bullion Market Association. (2021, November). *LBMA responsible gold guidance*. <https://www.lbma.org.uk>
- Masrur, A. R., Holis, M., & Musoffan. (2025). Digitalisasi emas dalam perspektif syariah: Studi pada ekosistem bullion bank Indonesia. *Jurnal Ilmiah Ekonomi Islam*, 11(05), 282–291. <https://jurnal.stie-aas.ac.id/index.php/jei/article/view/18358>
- Mukhty, S., Upadhyay, A., & Rothwell, H. (2022). Strategic sustainable development of Industry 4.0 through the lens of social responsibility: The role of human resource practices. *Business Strategy and the Environment*, 31(5), 2068–2081. <https://doi.org/10.1002/bse.3008>
- Organisation for Economic Co-operation and Development. (2016). *OECD due diligence guidance for responsible supply chains of minerals from conflict-affected and high-risk areas* (3rd ed.). OECD Publishing. <http://dx.doi.org/10.1787/9789264252479-en>
- Organisation for Economic Co-operation and Development. (2025). *OECD economic outlook* (Vol. 2025, Issue 117). OECD Publishing. <https://doi.org/10.1787/83363382-en>
- Otoritas Jasa Keuangan. (2024). *Peraturan Otoritas Jasa Keuangan Republik Indonesia Nomor 17 Tahun 2024*. <https://ojk.go.id/id/regulasi/Documents/Pages/POJK-17-Tahun-2024-Penyelenggaraan-Kegiatan-Usaha-Bulion/POJK%2017%20Tahun%202024%20Penyelenggaraan%20Kegiatan%20Usaha%20Bulion.pdf>
- Otoritas Jasa Keuangan. (2025). *SP 42/GKPB/OJK/II/2025*. <https://ojk.go.id/id/berita-dan-kegiatan/siaran-pers/Pages/Kegiatan-Usaha-Bulion-Layanan-Bank-Emas-di-Indonesia--.aspx>
- Owoade, S., Abayomi, A. A., Uzoka, A. C., Odofin, O. T., Adanigbo, O. S., & Ogeawuchi, J. C. (2024). Predictive infrastructure scaling in fintech systems using AI-driven load balancing models. *International Journal of Advanced Multidisciplinary Research and Studies*, 4(6), 2393–2401. <https://doi.org/10.62225/2583049X.2024.4.6.4356>
- Pegadaian. (2024). *Laporan tahunan 2024 (Annual report)*. <https://pegadaian.co.id/kinerja-keuangan/laporan-tahunan>
- Pujawan, I. N., & Geraldin, L. H. (2009). House of risk: A model for proactive supply chain risk management. *Business Process Management Journal*, 15(6), 953–967. <https://doi.org/10.1108/14637150911003801>
- Rachmad, Y. E. (2025). Bank emas in Indonesia: Regulations, challenges, and future prospects. United Nations Department of Global Communications. <https://doi.org/10.17605/osf.io/jmvbw>
- Rushton, A. (2014). *The handbook of logistics and distribution management: Understanding the supply chain*. Kogan Page Limited.
- Sanni, B. (2024). *Role of coordination platforms in high-tech and electronics e-supply chains*.
- Taghizadeh, E., & Taghizadeh, E. (2021). The impact of digital technology and Industry 4.0 on enhancing supply chain resilience. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2021, 2021–2029. <https://doi.org/10.46254/an11.20210379>
- Tang, C. S. (2006). Perspectives in supply chain risk management. *International Journal of Production Economics*, 103(2), 451–488. <https://doi.org/10.1016/j.ijpe.2005.12.006>
- Xiao, M., Zhao, C., Feng, Z., Xiao, M., & Zhao, C. (2026). Supply chain finance in blockchain-based digital asset platform. *March 2022*. <https://doi.org/10.1145/3532640.3532650>
- Zainuddin, M., & Mutaqin, A. (2025). Konvergensi finansial syariah: Sinergi emas, inklusi digital, dan ketahanan sosial-ekonomi dalam praktik Pegadaian Syariah. *Al-Muhasib*:

Journal of Islamic Accounting and Finance, 5(1), 1–20. <https://doi.org/10.30162/al-muhasib.v5i1.2233>

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