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# Shared Supply Chain: Strategy Selection and Optimization for Blockchain Technology Implementation Methods

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ABSTRACT

Upon the arrival of the sharing consumption model, guaranteeing the authenticity of products and the transparency of transactions has emerged as fundamental challenges hindering the industry's progression. This paper explores the selection and optimization of blockchain technology implementation methods within the shared supply chain. Through a comparative analysis of non-blockchain, private blockchain, and distributed application models, our findings reveal that distributed application generates higher profits when consumers exhibit high sensitivity to blockchain performance and when such performance adheres to specific standards. Conversely, the private blockchain is more suited to customized requirements. Blockchain technology not only increases prices and transparency but also enhances consumer trust, particularly within the distributed application framework. Performance plays a crucial role in decision-making, with the private blockchain relying on corporate investment for optimization and distributed application being constrained by the limitations of the public chain. Based on these findings, it is recommended that enterprises adopt a flexible approach in selecting the most appropriate mode according to their unique needs. Additionally, they should prioritize technological innovation, strive to improve blockchain performance, consider fostering consumer trust, and promote collaborative development throughout the supply chain. These strategies will collectively contribute to the healthy and sustainable growth of the industry.

*Keywords:* shared supply chain, blockchain, pricing, equilibrium strategy

## 1. Introduction

The shared goods supply chain, an emerging yet burgeoning sector, encounters a myriad of challenges that hinder its growth and development. Among these, product authentication issues, consumer trust deficits stemming from information asymmetry, and inadequate transaction transparency pose significant obstacles. Blockchain technology, with its distributed ledger, immutability, and

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decentralized nature, presents a transformative solution. By offering a secure, transparent, and verifiable platform, blockchain can address these challenges, thereby fostering a more efficient, trustworthy, and resilient shared goods supply chain.

The sharing economy, as an innovative approach to consumption, has sparked widespread interest and attention within the academic community. Hossain [1] provided a comprehensive review of the sharing economy, addressing definitional dilemmas, theories, stakeholders, and impacts. Chi et al. [2] investigated sustainable behaviors in bicycle-sharing, emphasizing environmental stimuli. Christodoulides et al. [3] contributed to luxury consumption literature, revealing new consumption forms. Huang et al. [4] studied optimal strategies for firms in the B2C sharing model, emphasizing profit potential. Haynes and Hietanen [5] highlighted blockchain's challenges to traditional marketing roles and its promotion of capitalized sociality. Lu and Yi [6] focused on institutional trust's influence on repurchase intentions. Davlembayeva and Papagiannidis [7] examined platform-provider relations and providers' perspectives on negative incidents. Muharam et al. [8] found user empowerment key to acceptance of blockchain-based sharing systems.

Blockchain technology has been applied across industries, addressing various challenges. Fiorentino and Bartolucci [9] proposed blockchain-based smart contracts to improve governance in the sharing economy. Ye et al. [10] analyzed competition between manufacturers and sharing platforms, advocating for collaboration. Rožman et al. [11] proposed a scalable framework for blockchain-based shared manufacturing, emphasizing cross-chain solutions. Hamledari and Fischer [12] discussed integrating physical and financial supply chains in the construction industry with blockchain-based crypto assets. Zhang et al. [13] analyzed blockchain's potential to solve SME financing dilemmas in supply chain finance. Wan et al. [14] found blockchain enhances collaborative innovation in the manufacturing industry. In Industry 4.0, Javaid et al. [15] and Nuttah et al. [16] reviewed blockchain applications, identifying management issues and solution features. Abdallah and Nizamuddin [17] presented a blockchain solution for the pharma supply chain, enhancing transparency and security. Klöckner et al. [18] explored data management challenges in luxury watch industry blockchain applications. Giganti et al. [19] analyzed blockchain's impact on agri-food sector sustainability, while Acciarini et al. [20] studied its effects on food industry purchase intentions. Duan et al. [21] systematically reviewed blockchain adoption in supply chain management, highlighting drivers, barriers, and future prospects. Yi et al. [22] examined battery recycling and information leakage prevention in the new energy vehicle supply chain with blockchain.

In summary, the sharing economy has transformed traditional sales models, and blockchain technology holds great promise in addressing supply chain challenges such as information asymmetry, centralized data storage, and data credibility. However, research on blockchain technology implementation methods in shared goods supply chains is limited. Two main models exist: private blockchain and distributed applications on public blockchains. Private blockchains offer customization and performance optimization but at a higher cost, potentially eroding consumer trust due to centralized control. Conversely, distributed applications provide lower costs and higher consumer trust through transparency and decentralization, though performance may be constrained by public blockchain limitations. Businesses must weigh factors like cost, performance requirements, and consumer trust to make informed decisions. Consequently, this research focuses on examining decisions between private blockchain and distributed applications in shared supply chains, analyzing decision-making processes related to retail pricing, sharing prices, and blockchain investments.

## 2. Symbolization and problem description

This paper explores the supply chain arrangement between manufacturers and sharing enterprises, where manufacturers sell products directly to consumers at a price of $P_M$ and wholesale to sharing enterprises at a price of $P_W$, which subsequently resell to consumers at a price of $P_S$. The integration of blockchain technology has significantly elevated this system by establishing an immutable product tracing system. This not only substantially enhances the capacity to authenticate product genuineness but also effectively combats counterfeiting, ultimately bolstering consumer confidence.

Manufacturers, tasked with establishing the blockchain infrastructure, must decide between developing a decentralized application and constructing a private blockchain. Private blockchains, while incurring higher development costs due to the extensive resources and manpower required for setup, maintenance, and upgrades, offer a controlled environment where blockchain performance can be tailored to meet specific needs. This allows for the optimization of transaction speeds, confirmation times, and overall network efficiency, crucial for ensuring seamless operations within a shared supply chain. However, the centralized control over the network by the sharing enterprise may raise questions among consumers regarding data privacy and potential conflicts of interest, thereby limiting consumer trust. On the other hand, distributed applications built on public blockchain platforms boast lower development costs as they leverage the existing infrastructure and user base of the public blockchain. The transparency and decentralization inherent in public blockchains enhance consumer trust, as all transactions and data are openly verifiable and not subject to a single entity's control. Nevertheless, the performance of distributed applications is contingent upon the constraints of the underlying public blockchain, including transaction speeds and confirmation times, which can vary and potentially impact the user experience.

Below is a detailed elucidation of the problem.

1) The utility function of consumers is detailed below. It is assumed that consumers' valuations of products are uniformly distributed over the interval [0, 1]. In the scenario where blockchain is not adopted, the utility function for consumers purchasing products is denoted as $F_M^N = \alpha_1 v - p_M$, and for sharing products, it is $F_S^N = \eta\alpha_1 v - P_S$. Here, $\alpha_1$ represents the trust coefficient of consumers in the absence of blockchain technology, with $0 < \alpha_1 < 1$, and $\eta$ signifies the value discount applied to shared products, where $0 < \eta < 1$ [23].

When a private blockchain is adopted, the utility function for consumers buying items becomes $F_M^P = \alpha_2 v + \theta f_P - P_M$, and for sharing, it is $F_S^P = \eta\alpha_2 v + \theta f_P - P_S$. In this context, $\alpha_2$ denotes the trust coefficient of consumers in the private blockchain mode, with $0 < \alpha_1 < \alpha_2 < 1$, and $\theta$ represents the sensitivity of consumers towards blockchain performance.

In the scenario of adopting a distributed application, the utility function for consumers purchasing items is $F_M^D = v + \theta f_D - P_M$, and for sharing products, it is $F_S^D = \eta v + \theta f_D - P_S$. Here, $f_P$ and $f_D$ represent the blockchain performance under private chain and distributed application models respectively, encompassing transaction speed, security, scalability, and data transparency. A high-performance blockchain can expedite transaction confirmation, ensure data security, and enhance user experience. During the consumption and sharing process, consumers benefit from rapid product information lookup, secure payments, and increased trust, all of which directly impact their satisfaction and loyalty.

In the private blockchain scenario, $f_P$ is regarded as an endogenous variable. The financial support of manufacturers for blockchain infrastructure construction, the professional competence of technical teams, and the continuous investment in technological innovation and performance optimization constitute the core driving force behind the performance of private blockchains. Conversely, in the distributed application adoption scenario, $f_D$ is considered an exogenous variable. Its actual performance is not directly controlled by distributed application developers or manufacturers but is primarily constrained by the performance characteristics of the underlying public blockchain platform it relies on. Factors such as the design of the public blockchain's underlying architecture, the efficiency of consensus algorithms, transaction throughput processing capacity, network latency, as well as overall security and stability, all influence the performance of the distributed application.

2) Market Demand Analysis. Our primary goal is to investigate the concurrent operation of retail and sharing markets, To this end, we maintain the assumption that $P_S < \eta P_S + (1-\eta)\theta f_P$. In the absence of

blockchain technology, we designate $F_M^N = 1 - \frac{P_M - P_S}{(1-\eta)\alpha_1}$ and $F_S^N = \frac{P_M - P_S}{(1-\eta)\alpha_1} - \frac{P_S}{\eta\alpha_1}$ as the demands for purchasing and sharing items, respectively. Upon adoption of a private blockchain, these demands shift to $F_M^P = 1 - \frac{P_M - P_S}{(1-\eta)\alpha_2}$ and $F_S^P = \frac{P_M - P_S}{(1-\eta)\alpha_2} - \frac{P_S - \theta f_P}{\eta\alpha_2}$. In the case of a distributed application, the demands for purchasing and sharing items are labeled as $F_M^D = 1 - \frac{P_M - P_S}{1-\eta}$ and $F_S^D = \frac{P_M - P_S}{1-\eta} - \frac{P_S - \theta f_P}{\eta}$, respectively.

3) The costs associated with different blockchain implementation modes are as follows. Firstly, consider the costs of constructing a private blockchain. Assuming the development and maintenance cost function is $\frac{1}{2}kf_p^2$, this signifies that as performance improves, costs increase, with the difficulty of enhancing performance escalating progressively. Therefore, in developing a private blockchain, it is crucial to strike a balance between performance and cost to ensure the investment's rationality. Secondly, let's discuss the costs of developing and utilizing distributed applications. Unlike building a blockchain from scratch, developing distributed applications distributed applications on existing blockchains generally incurs lower development and maintenance costs. This is because distributed applications can leverage the existing infrastructure and ecosystem of the blockchain, reducing development expenses. We hypothesize that the development and maintenance cost of distributed applications is a fixed value, independent of blockchain performance, and that distributed applications' performance is primarily determined by the underlying public blockchain. Additionally, item manufacturers and sharing enterprises must consider the blockchain interaction costs per transaction, which include fees for invoking smart contracts, executing transactions, and uploading information. We denote the unit interaction cost as ci.

## 3. Models

This section presents three distinct models: a non-blockchain model, a private blockchain model, and a decentralized application model.

### 3.1. *The non-blockchain model*

Drawing from the market demand analysis in Section 2, the profit function of the manufacturer, in the absence of blockchain technology, can be formulated as

$$\Pi_m^N = \left(P_M - c\right)\left(1 - \frac{P_M - P_S}{(1-\eta)\alpha_1}\right) + \left(P_W - c\right)\left(\frac{P_M - P_S}{(1-\eta)\alpha_1} - \frac{P_S}{\eta\alpha_1}\right) \tag{1}$$

where $\left(P_M - c\right)\left(1 - \frac{P_M - P_S}{(1-\eta)\alpha_1}\right)$ represents the profit earned by the manufacturer through the sale of products directly. $\left(P_W - c\right)\left(\frac{P_M - P_S}{(1-\eta)\alpha_1} - \frac{P_S}{\eta\alpha_1}\right)$ denotes the profit generated by the manufacturer through wholesale distribution of products to the sharing enterprise.

Furthermore, the profit of the sharing enterprise is denoted as

$$\Pi_p^N = \left(P_S - P_W + s\right)\left(\frac{P_M - P_S}{(1-\eta)\alpha_1} - \frac{P_S}{\eta\alpha_1}\right). \tag{2}$$

$p_r - w + s$ represents the profit acquired by the sharing enterprise from each unit of product shared. $\frac{p_b - p_r}{(1-\lambda)\beta_1} - \frac{p_r}{\lambda\beta_1}$ is the demand for shared products among consumers.

Proposition 1 In the non-blockchain model, the equilibrium retail price, the equilibrium wholesale price, and the equilibrium sharing price are

$$P_M^{N*} = \frac{\alpha_1 + c}{2} \tag{3}$$

$$P_W^{N*} = \frac{c + s + \alpha_1 \eta}{2} \tag{4}$$

$$p_S^{N*} = \frac{c + \eta c + 2\alpha_1 \eta - s}{4} \tag{5}$$

### 3.2. *The private blockchain model*

Drawing from the market demand analysis presented in Section 2, the profit function of the manufacturer for the private blockchain model is formulated as

$$\Pi_m^P = \left(P_M - c\right)\left(1 - \frac{P_M - P_S}{(1-\eta)\alpha_2}\right) + \left(P_W - c\right)\left(\frac{P_M - P_S}{(1-\eta)\alpha_2} - \frac{P_S - \theta f_P}{\eta\alpha_2}\right) - \frac{1}{2}kf_P^2. \tag{6}$$

Where $\frac{1}{2}kf_p^2$ represents the expenses incurred in establishing and sustaining the private blockchain framework, these costs are borne by the item-sharing manufacturer.

Furthermore, the profit of the sharing enterprise is denoted as

$$\Pi_p^p = \left(P_S - P_W + s\right)\left(\frac{P_M - P_S}{(1-\eta)\alpha_2} - \frac{P_S - \theta f_p}{\eta\alpha_2}\right) \tag{7}$$

Proposition 2 In the private blockchain model, the equilibrium retail price, the equilibrium wholesale price, the equilibrium sharing price and the equilibrium blockchain's performance are

$$P_M^{P*} = \frac{1+\alpha_2}{2\alpha_2} + \frac{\theta^2\left(2\eta + \alpha_2 s - \alpha_2 c - \eta\alpha_2 c\right)}{2\left(4\eta k - \alpha_2\theta^2 - \eta\alpha_2\theta^2\right)} \tag{8}$$

$$P_W^{P*} = \frac{\eta + \alpha_2 c + \alpha_2 s}{2\alpha_2} + \frac{\theta^2\left(2\eta + \alpha_2 s - \alpha_2 c - \eta\alpha_2 c\right)}{2\left(4\eta k - \alpha_2\theta^2 - \eta\alpha_2\theta^2\right)} \tag{9}$$

$$P_S^{P*} = \frac{\eta + \alpha_2 c}{\alpha_2} + \frac{\alpha_2\theta^2\left(\alpha_2 s + 2\eta\right) + \eta k\left(\eta\alpha_2 c - \alpha_2 s - 3\alpha_2 c - 2\eta\right)}{\alpha_2\left(4\eta k - \alpha_2\theta^2 - \eta\alpha_2\theta^2\right)} \tag{10}$$

$$f_P^* = \frac{\theta\left(2\eta + \alpha_2 s - \alpha_2 c - \eta\alpha_2 c\right)}{4\eta k - \alpha_2 m^2 - \eta\alpha_2 m^2} \tag{11}$$

### 3.3. *The distributed application model*

Drawing from the market demand analysis presented in Section 2, the profit function of the manufacturer for the distributed application model is formulated as

$$\Pi_m^D = (P_M - c)\left(1 - \frac{P_M - P_S}{1-\eta}\right) + (P_{iV} - c)\left(\frac{P_s - P_S}{1-\eta} - \frac{P_S - \theta f_D}{\eta}\right) \\ - c_i\left(1 - \frac{P_s - \theta f_b}{\eta}\right) - G \quad (12)$$

Where $1-\frac{p_r - md_T}{\lambda}$ represents the total volume of transactions executed by the item-sharing manufacturer, whereas $c_f\left(1-\frac{p_r - md_r}{\lambda}\right)$ encapsulates the transaction fees paid by the manufacturer for conducting these transactions via a distributed application, primarily due to the utilization of a public blockchain. Specifically, $c_i\left(1-\frac{p_r - md_t}{\lambda}\right)$ comprises fees such as gas costs, transaction validation fees, and any other associated costs incurred when interacting with the public blockchain network. Additionally, G denotes the expenses incurred in developing the distributed application, which leverages an existing blockchain infrastructure, encompassing costs related to software development, integration, and any necessary customization to align with the item-sharing enterprise's operational requirements.

The profit of the sharing enterprise, denoted as

$$\Pi_p^D = (P_S - P_W + s - c_i)\left(\frac{P_M - P_S}{1-\eta} - \frac{P_S - \theta f_P}{\eta}\right) \quad (13)$$

Proposition 3 In the distributed application model, the equilibrium retail price, the equilibrium wholesale price, and the equilibrium sharing price are

$$P_M^{D^*} = \frac{c + c_i + \theta f_D + 1}{2} \quad (14)$$

$$P_W^{D^*} = \frac{c + \eta + s + \theta f_D}{2} \quad (15)$$

$$p_S^{D*} = \frac{c + 2c_i + 2\eta + \eta c + \eta c_i - s + (3-\eta)\theta f_D}{4} \quad (16)$$

## 4. Analytical analysis

Inference 1 In the private blockchain mode, $P_M^{P^*} \geq P_M^{N^*}$; whereas in the distributed application mode, $P_M^{D*} < P_M^{N*}$.

Inference 1 highlights the finding that the implementation of blockchain technology, whether within a private blockchain framework or as a component of the distributed application mode, has resulted in an upward adjustment of the optimal retail price. This can be attributed to blockchain's capacity to markedly improve the authentication of products' genuineness, thereby bolstering consumer confidence and, consequently, increasing consumers' readiness to pay a higher price for such items.

Inference 2 In the private blockchain mode, when $0 < \alpha_1 \leq A$, it holds that $P_S^{P^*} \geq P_S^{N^*}$; and when $A < \alpha_1 < 1$, it follows that $P_S^{P*} < P_S^{N^*}$. Here, $A = \frac{3\alpha_2^2 c\theta^2 + 4\eta^2\alpha_2\theta^2 - 8\eta^2 k - 4\alpha_2^2\theta^2 s - 4\eta\alpha_2\theta^2 + 3\eta\alpha_2^2 c\theta^2 - \alpha_2^3\theta^2 sc - \eta\alpha_2^3\theta^2 sc + \alpha_2^3\theta^2 s^2}{2\eta\alpha_2^2\theta^2 + 2\eta\alpha_2^3\theta^2 s - 8\eta^2\alpha_2 k}$. In the distributed application mode, $P_S^{D^*} > P_S^{N^*}$.

Inference 2 highlights the pivotal role of the consumer trust coefficient in influencing the sharing price of products. Specifically, in the context of the private blockchain mode, a low trust coefficient necessitates the authenticity verification capabilities of blockchain technology, which subsequently elevates the sharing price. Conversely, when the trust coefficient is high, the potential for price increases in the non-blockchain model widens, while the distributed application mode, owing to its cost-effectiveness, offers advantages that lead to relatively lower prices in comparison to the private blockchain mode. Furthermore, the distributed application mode excels in scenarios where consumer trust is high, as it leverages blockchain to further bolster trust while mitigating cost burdens. Consequently, the sharing price under the distributed application mode surpasses that of non-blockchain technologies. In summary, the intricate interplay between consumer trust and blockchain technology exerts a nuanced and complex influence on the sharing prices of products across diverse scenarios, collectively influencing market pricing strategies.

Inference 3 When $B < f_D < 1$, where $B = \frac{\theta\left(2\eta + \alpha_2 s - \alpha_2 c - \eta\alpha_2 c\right)}{4\eta k - \alpha_2\theta^2 - \eta\alpha_2\theta^2} + \frac{1 - \alpha_2 c - \alpha_2}{\beta_2\theta}$, it is observed that $P_M^{P*} < P_M^{D*}$. Conversely, when $B < f_D < 1$, resulting in $P_M^{P*} < P_M^{D*}$.

Inference 4 When $0 < f_D \le C$, where $C = \frac{4\left(2\eta^2 k - \alpha_2^2 c\theta^2 - \eta^2\alpha_2\theta^2 + \alpha_2^2\theta^2 s + \eta\alpha_2\theta^2 - \eta\alpha_2 ks + \eta^2\alpha_2 ck - \eta\alpha_2^2 c\theta^2 + \eta\alpha_2 ck\right)}{(3-\eta)\alpha_2\theta\left(4\eta k - \alpha_2\theta^2 - \eta\alpha_2\theta^2\right)} + \frac{s - c - 2c_i - 2\eta - \eta c - \eta c_i}{(3-\eta)\theta}$, it is observed that $P_S^{P^*} \ge P_S^{D^*}$. Conversely, when $C < f_D < 1$, resulting in $P_S^{P^*} < P_S^{D^*}$.

Inference 3 and Inference 4 elucidate the intricate relationship between pricing and blockchain performance within the distributed application and private blockchain mode. Specifically, when distributed application blockchain performance is suboptimal, the private blockchain mode tends to establish higher prices in both retail and sharing markets, attributable to its comparative ease in achieving superior performance and the investment costs associated with blockchain development. Conversely, if distributed application blockchain performance is robust and the private model falls short in competition, the distributed application mode gains an edge in both retail and sharing pricing. In essence, the comparative analysis of blockchain performance directly shapes the pricing strategies of these two modalities. A high-performing blockchain mode, capable of delivering more efficient and secure services, becomes a pivotal consideration for manufacturers and sharing enterprises when determining pricing, thereby underpinning higher retail and sharing prices.

Inference 5 $\frac{\partial P_M^{N*}}{\partial\alpha_1} > 0$, $\frac{\partial P_S^{N*}}{\partial\alpha_1} > 0$, $\frac{\partial P_M^{N*}}{\partial\eta} = 0$, $\frac{\partial P_S^{N*}}{\partial\eta} > 0$, $\frac{\partial P_M^{N*}}{\partial\theta} = 0$, $\frac{\partial P_S^{N*}}{\partial\theta} = 0$.

Firstly, as demonstrated by Inference 5, in the non-blockchain mode, there exists a positive correlation between both the optimal retail price and the optimal sharing price of products, and the consumer trust coefficient. This stems from the fact that as the consumer trust coefficient increases, indicating a greater level of consumer confidence in products, their willingness to pay for these items also rises, prompting manufacturers to inherently raise both retail and sharing prices for products. Secondly, an observation reveals that the optimal retail price of products is decoupled from the value discount offered on shared products, whereas the optimal sharing price of products displays a positive correlation with the magnitude of this value discount. This implies that the pricing strategy for retail products is not influenced by sharing discounts, whereas sharing pricing is sensitive to such incentives. Lastly, it is evident that neither the optimal retail price nor the optimal sharing price of products exhibits a relationship with the sensitivity coefficient of blockchain performance. This suggests that, within the context examined, blockchain performance does not directly influence the pricing of products in the non-blockchain mode.

Inference 6 $\frac{\partial P_M^{D^*}}{\partial\alpha_2} = 0$, $\frac{\partial P_S^{D^*}}{\partial\alpha_2} = 0$, $\frac{\partial P_M^{D^*}}{\partial\eta} = 0$, $\frac{\partial P_S^{D^*}}{\partial\eta} > 0$, $\frac{\partial P_M^{D^*}}{\partial\theta} > 0$, $\frac{\partial P_S^{D^*}}{\partial\theta} < 0$.

Firstly, as indicated by Inference 6, within the distributed application mode, there is no discernible relationship between the optimal retail and sharing prices of products and the consumer trust coefficient. This finding highlights the unique pricing dynamics at play in the Distributed application mode. Secondly, it is observed that the optimal retail price of products remains unaffected by the value discount applied to shared products, whereas the optimal sharing price positively correlates with the extent of this discount. However, the rationale previously provided for this phenomenon seems less applicable to the distributed application mode. Instead, the explanation that consumers' trust in products influences their willingness to pay, which in turn affects pricing, is generally more relevant to the non-blockchain mode. Lastly, in the Distributed application mode, it is evident that the optimal retail price of products positively correlates with the sensitivity coefficient of blockchain performance. This implies that as consumers' expectations for blockchain performance increase, product manufacturers invest more in blockchain development and subsequently set higher retail prices to leverage this advanced technology. Conversely, the optimal sharing price of products exhibits a negative correlation with the sensitivity coefficient of blockchain performance, suggesting that heightened demands for blockchain performance may not directly translate into higher sharing prices, possibly due to competitive pressures or differing cost structures within the sharing market.

Inference 7 $\frac{\partial f_P^*}{\partial k}<0$, $\frac{\partial P_M^{P*}}{\partial k}<0$, $\frac{\partial P_S^{P*}}{\partial k}<0$.

Firstly, Inference 7 elucidates that under the private blockchain model, the optimal performance of the blockchain is inversely correlated with the blockchain's development and maintenance cost coefficient. This phenomenon stems from the fact that the manufacturer, faced with a higher cost coefficient, encounters greater financial pressures to improve blockchain performance. Consequently, he chooses to reduce blockchain performance as a cost-saving measure. Secondly, the analysis further reveals that within the private blockchain framework, both the optimal retail and sharing prices of products negatively correlate with the blockchain's development and maintenance cost coefficient. This relationship can be attributed to the impact of blockchain performance on consumer behavior. Specifically, as the cost coefficient increases, the manufacturer decreases investments in blockchain development, leading to decreased blockchain performance. Since blockchain performance is a significant factor influencing consumers' purchasing and sharing experiences, its decline can diminish their willingness to pay, ultimately prompting product companies to adjust their pricing strategies downwards.

## 5. Numerical analysis

The main objective of this section is to analyze the impact of key parameters on the manufacturer and the sharing enterprise's profits, as well as to compare the profits under different models. According to the literatures [24-26], $c=0.03$, $s=0.2$, $k=4$, $c_i=0.000001$, $\alpha_1=0.3$, $\alpha_2=0.9$, $\eta=0.05$, $G=0.15$.

As depicted in Figure 1, as the sensitivity parameter $\theta$ increases, the profits of manufacturers employing blockchain technology exhibit a pronounced upward trend. This is attributed to the fact that consumers who are more discerning about blockchain performance favor products utilizing high-performance blockchain technology, as it confers a superior and more secure shopping experience. Consequently, as $\theta$ escalates, manufacturers harnessing blockchain technology can draw a larger consumer base, resulting in augmented profits. Furthermore, the graph underscores the particularly significant profit growth observed in the distributed application mode. This stems from the notable cost advantages of the distributed application approach over the private blockchain model in terms of development and maintenance. By leveraging the preexisting infrastructure and ecosystem of public blockchain platforms, distributed application can mitigate development costs, affording them a competitive pricing edge in the market. This enables distributed application to captivate a wider consumer base and, in turn, realize a more substantial profit growth. Lastly, within the distributed application mode, it is discernible that as blockchain performance ( $fD$ ) enhances, the manufacturer's profits also undergo a modest but significant increase. This occurs because, in the distributed application mode, blockchain performance is directly proportional to the consumer's user experience and trust. A high-performance blockchain accelerates the response speed and processing capabilities of the distributed application, delivering a smoother and more efficient service to consumers, thereby boosting overall profitability.

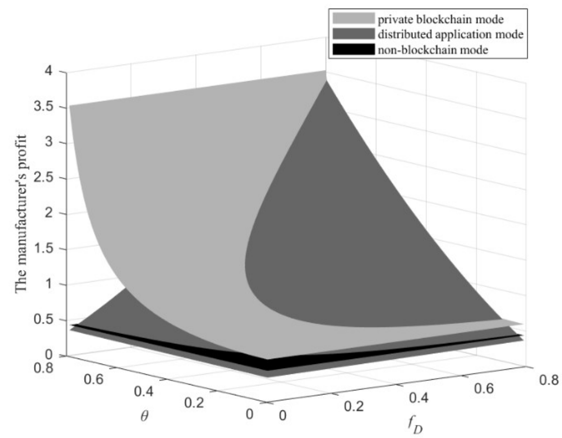


**Fig. 1.** Variation of the manufacturer's profit with $\theta$ and $fD$

As evident from Figure 2, the manufacturer's profit under the distributed application mode attains its peak when both the blockchain performance ( $fD$ ) and consumer sensitivity to blockchain performance ( $\theta$ ) are relatively high. This is due to the fact that, when both these factors are pronounced, the distributed application mode can fully capitalize on its advantages of cost-effectiveness and high performance, thereby attracting a substantial consumer base and achieving the highest profit margins. Conversely, when either consumer sensitivity to blockchain performance is low or blockchain performance under the distributed application mode is insufficient, the private blockchain mode, with its customization capabilities and flexibility, can better cater to the needs of specific consumer segments, resulting in higher profits. Lastly, the non-blockchain mode, being devoid of the benefits offered by blockchain technology, including traceability, anti-counterfeiting measures, and enhanced trust, finds itself at a competitive disadvantage in the market. Consequently, the manufacturer's profit remains the lowest in this mode.

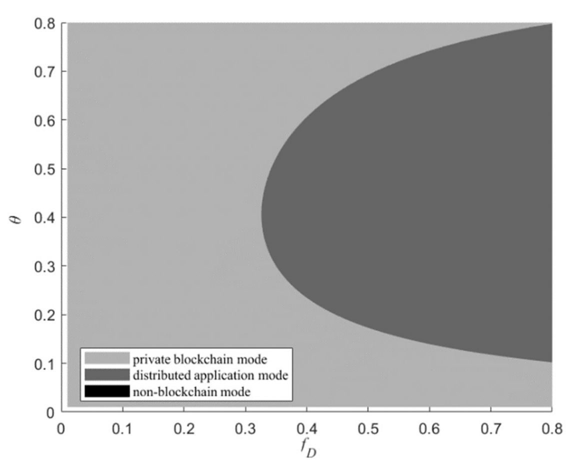


**Fig. 2.** Comparison of the manufacturer's profits in different modes

As illustrated in Figure 3, the profit of sharing enterprise that adopt blockchain technology exhibits an upward trend as the consumer sensitivity to blockchain performance ($\theta$) increases. Specifically, under the distributed application mode, as the blockchain performance ($fD$) improves, the profit of these sharing enterprises undergoes a modest growth. This phenomenon aligns with the analysis presented in Figure 1, where it is noted that high-performance blockchains can augment the processing capabilities and stability of distributed application, ultimately offering consumers a relatively superior leasing service experience. Consequently, with the enhancement of $fD$, the profit of sharing enterprise operating under the distributed application mode experiences a corresponding, albeit slight, increase.

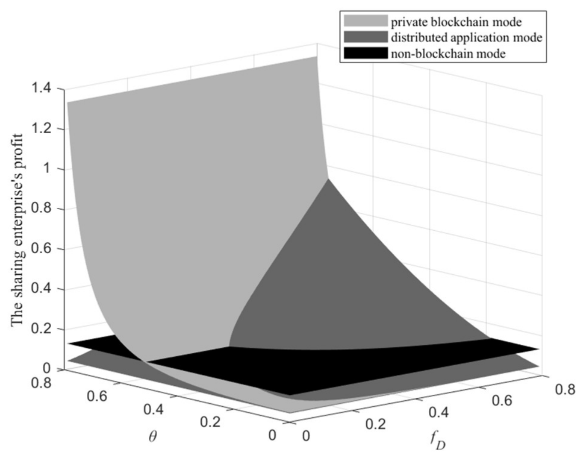


**Fig. 3.** Variation of the sharing enterprise's profit with $\theta$ and $fD$

As depicted in Figure 4, when consumer sensitivity to blockchain performance ($\theta$) is relatively high, the profit of sharing enterprise operating under the private blockchain mode attains the highest level. This is attributed to the fact that consumers with a pronounced sensitivity to blockchain performance prioritize transparency and security in leasing services. The private blockchain mode, by offering customized blockchain services tailored to meet consumers' demands for high-performance blockchains, enhances the trustworthiness and competitiveness of sharing enterprise, thereby maximizing profits. Conversely, when m is low, the profit of sharing enterprise that do not adopt blockchain technology surpasses others. This is because consumers with a lower sensitivity to blockchain performance are more price-conscious when selecting leasing services. In such scenarios, the non-blockchain mode, which does not incur additional blockchain development and maintenance costs, offers more price-competitive leasing services, attracting a larger consumer base. However, when blockchain performance ($fD$) under the distributed application mode is high, it emerges as the most profitable option for sharing enterprise. This is due to the smooth and efficient leasing service experience provided by high-performance blockchains under the distributed application mode, which attracts a significant number of consumers. Despite potential limitations imposed by public blockchain platforms on the distributed application mode's performance, its profitability remains the highest when supported by high performance.

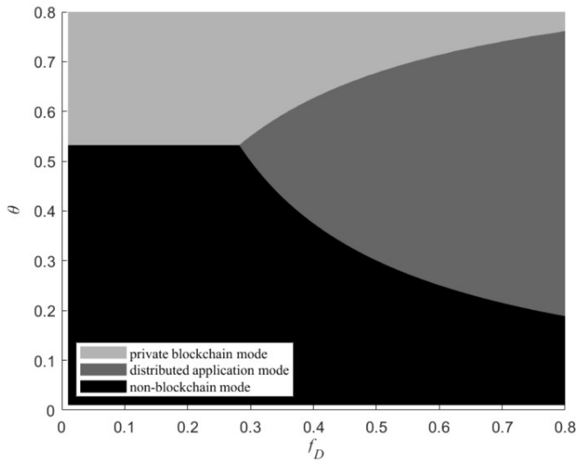


**Fig. 4.** Comparison of the sharing enterprise's profits in different modes

## 6. Conclusions

This paper systematically examines the strategic selection and optimization of blockchain technology implementation methods within the shared supply chain. Through a comparative analysis of three distinct models: a non-blockchain model, a private blockchain model, and the distributed application based on a public blockchain, it delves into the ramifications of each model on transparency, authenticity verification, market demand, and profitability within the goods supply chain. The key findings of the research are as follows:

1) Optimal mode selection based on consumer sensitivity and blockchain performance: in scenarios where consumer sensitivity to blockchain performance is pronounced and the technology's performance reaches a threshold level, the distributed application mode emerges as a preferred choice, owing to its low cost and unparalleled transparency, often resulting in superior profitability. Conversely, when consumer demands for blockchain performance are less stringent or the distributed application's performance is constrained, the private blockchain model, characterized by its high degree of customization and flexibility, can also generate substantial profits.

2) Impact on pricing dynamics: the adoption of blockchain technology significantly elevates the retail and leasing prices of goods. This is primarily attributed to the enhanced consumer trust in product authenticity and transaction transparency facilitated by blockchain. Notably, under the distributed application mode, this trust-boosting effect is accentuated, empowering manufacturers and sharing enterprises to set more premium prices.

3) Blockchain performance as a decision-making criterion: blockchain performance stands as a pivotal factor influencing the strategic decisions of supply chain participants. In the context of the distributed application mode, blockchain performance is largely governed by the limitations and capabilities of the underlying public blockchain platform. Conversely, under the private blockchain model, performance is intimately tied to corporate investments and ongoing optimization efforts. Both models necessitate a careful balance between performance and cost to maximize economic benefits.

Based on the aforementioned research conclusions, this paper provides the following profound managerial insights:

1) Flexible mode selection based on context: Enterprises should adopt a flexible approach in selecting the most suitable blockchain technology implementation method, considering their unique circumstances, market demands, and consumer acceptance of blockchain technology. For enterprises prioritizing cost-effectiveness, the distributed application mode may offer an advantageous solution. In contrast, for those requiring high degrees of customization and flexibility, the private blockchain mode presents more compelling benefits.

2) Emphasize technological innovation and performance enhancement: Enterprises should continually augment their investments in blockchain technology research and development, leveraging technological advancements and ongoing optimization to bolster blockchain performance. Specifically, in the private blockchain mode, enterprises must prioritize the construction and maintenance of robust blockchain infrastructure to ensure that high-performing blockchain services align with market demands.
3) Cultivate consumer trust and elevate brand value: The implementation of blockchain technology markedly fortifies consumer trust in the authenticity and transactional transparency of goods. Enterprises ought to capitalize on this advantage by harnessing blockchain technology to bolster brand credibility and foster consumer loyalty, thereby elevating brand value and market competitiveness.
4) Strengthen supply chain management and foster collaborative development: The shared supply chain for goods encompasses diverse links and participants. Enterprises should fortify communication and collaboration with upstream and downstream supply chain partners to collectively advance the adoption and development of blockchain technology. By integrating resources, sharing information, and engaging in collaborative innovation, enterprises can forge a cohesive force capable of adeptly navigating market shifts and challenges.

This study acknowledges certain limitations, primarily stemming from its focus on analyzing goods manufacturers and sharing enterprises, leaving room for future expansion to encompass other links and participants within the supply chain ecosystem. Furthermore, given the continuous evolution and iteration of blockchain technology, future research endeavors must maintain a sustained focus on the potential impacts and challenges that emerging technologies and applications may pose to the shared supply chain for goods. Such an approach is imperative for fostering the sustained and healthy development of this industry.

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