Blockchain Adoption and Empowerment in Competing E-tailers with Information Disclosure and Sharing

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Abstract. This paper examines the adoption of blockchain technology and the role of blockchain-enabled data empowerment in information sharing between two oligopolistic e-tailers. It analyzes three strategic scenarios: no use, single use, and dual use of blockchain technology for information verification. Findings reveal that data empowerment through blockchain plays a critical role in outcomes; high data empowerment capability leads to positive impacts from information sharing, while low empowerment can produce adverse effects. E-tailers are more inclined to adopt blockchain in low-cost scenarios, whereas in high-cost scenarios, they are likely to forgo it. In cases of moderate costs, e-tailers may adopt a mixed strategy.

Keywords: Blockchain; Information Disclosure; Information Sharing; Data Empowerment; Competition.

1 Introduction

Faced with intense market competition and growing consumer demand, e-tailer continuously innovate products and increase added value, with blockchain technology gaining increasing attention. Due to its distinctive characteristics of decentralization, transparency, immutability, and high security, blockchain has become an important tool for improving information disclosure, and it is gradually being recognized and accepted by consumers and various industries [1][2]. For example, Walmart uses blockchain for product verification and electronic payments, boosting efficiency and customer satisfaction. Information disclosure strategies influence consumer behavior—sometimes more information attracts consumers, while at other times, it may deter them. In serial supply chains, dual moral hazard often discourages upstream suppliers from improving product quality. Traceability technology, however, can effectively mitigate dual moral hazard within supply chains by providing effective information sharing. Consequently, blockchain offers higher cost-efficiency, better information quality, reduced moral hazard, and the ability to automate existing contracts through smart contracts, ultimately improving product quality, increasing profits for all enterprises, and achieving a win-win outcome [3][4]. This study examines three blockchain application scenarios and

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their impact on information sharing, analyzing how data empowerment influence disclosure strategies and information sharing between e-tailers, especially among information-sensitive consumers.

2 Literature Review

Blockchain offers immutability, traceability, and irreversibility, enabling e-tailers to verify disclosed information and thereby enhancing consumer trust and product demand [5]. Compared to traditional databases, blockchain is the most advanced distributed technology available, capable of validating every transaction and eliminating consumer doubts about retailer-provided information. Bumblauskas [6] identified opportunities to enhance tracking and supply chain analysis through blockchain, while Wang [7] collaborated with JD.com to study its impact on consumer behavior. While consumer beliefs have a lesser impact on information disclosure than blockchain costs, the technology can still provide more reliable information for e-tailers [8]. Blockchain increases product transparency and traceability by tracking key information such as pricing and quality, facilitating faster, more cost-effective transactions [9]. In the market, there are both information-sensitive and insensitive consumers, and e-tailers typically raise their level of information disclosure when competitive risks or demand increase [10][11]. Blockchain is still in the early stages of commercialization [12], Current research pays less attention to its application in e-tailers' competition to boost consumer demand.

3 Model

This model examines the strategic interaction between two e-tailers selling substitutable products, focusing on each e-tailer's equilibrium information disclosure strategy. E-tailer i sells product i, where $i = 1,2$, and the amount of information disclosed is represented by τ_i. Consumer trust in the e-tailer's information is denoted by δ, with $0 \leq \delta \leq 1$. When blockchain is implemented, consumer trust reaches its maximum, $\delta = 1$. Consumers are categorized into two types: information-sensitive and information-insensitive. The proportion of information-insensitive consumers is $\lambda(0 < \lambda < 1)$, and they are only sensitive to price. Assume the market potential is a, influenced by both price and disclosed information, with β representing cross-price sensitivity and φ representing cross-information sensitivity. Specifically, the demand for e-tailer i's product increases as the price of e-tailer j's product rises, but decreases in proportion to the amount of information disclosed by e-tailer j. Considering whether the e-tailer adopts blockchain and engages in information sharing, and $i = 1,2, j = 3 - i$, the corresponding demand function is expressed as follows:

(1) The market demand when both e-tailers do not use blockchain for information authentication is:

$$H_i^{NN} = \lambda\left(a - p_i + \beta p_j\right) + (1 - \lambda)\left(a - p_i + \beta p_j + \delta\left(\tau_i - \varphi\tau_j\right)\right) \qquad (1)$$

(2) When one e-tailer uses blockchain for information authentication, the disclosed information is verified and traceable, resulting in full consumer trust ($\delta = 1$). However, trust in the information disclosed by e-tailer j remains at δ, and the corresponding demand is:

$$H_i^{BN} = \lambda\left(a - p_i + \beta p_j\right) + (1-\lambda)\left(a - p_i + \beta p_j + \tau_i - \delta\varphi\tau_j\right) \tag{2}$$

$$H_j^{BN} = \lambda\left(a - p_j + \beta p_i\right) + (1-\lambda)\left(a - p_j + \beta p_i + \delta\tau_j - \varphi\tau_i\right) \tag{3}$$

(3) When both e-tailers implement blockchain for information authentication, the authenticity of the information disclosed by each is verified and traceable, resulting in full consumer trust ($\delta = 1$) for both e-tailers. The corresponding demand function is:

$$H_i^{BB} = \lambda\left(a - p_i + \beta p_j\right) + (1-\lambda)\left(a - p_i + \beta p_j + \tau_i - \varphi\tau_j\right) \tag{4}$$

(4) When both e-tailers adopt information sharing, they automatically default to using blockchain technology. In this scenario, demand is influenced by the combined information disclosed by both e-tailers, with the goal of improving business efficiency. Assuming the level of data empowerment is $\xi(\xi > 0)$, both e-tailers achieve the same level of data empowerment after sharing information. However, due to potential redundancy in shared information, the total amount of disclosed information may decrease, necessitating an adjustment to the demand function.

$$H_i^{BBI} = \lambda\left(a - p_i + \beta p_j\right) + (1-\lambda)\left(a - p_i + \beta p_j + \xi(1-\varphi)\left(\tau_i + \tau_j\right)\right) \tag{5}$$

To attract consumers, the e-tailer discloses favorable information to increase consumer utility, with the assumption that the cost is $k_\tau \tau_i^2/2$, where $k_\tau \geq 1$ is the information disclosure coefficient. The unit production cost is c. To address consumer distrust in the disclosed information, blockchain is employed to ensure the authenticity of information, incurring an additional unit cost ε. Additionally, information sharing enhances the e-tailer's benefits, assuming that the cost of data empowerment investment is $k_\xi \xi^2/2$, where $k_\xi > 0$ is the cost coefficient, and the level of data empowerment ξ reflects the e-tailer's investment effort. The profit functions for e-tailer i, both without and with blockchain, as well as in scenarios of data empowerment, are as follows:

$$\pi_i^N = (p_i - c)H_i^N - k_\tau \tau_i^2/2 \tag{6}$$

$$\pi_i^B = (p_i - c - \varepsilon)H_i^B - k_\tau \tau_i^2/2 \tag{7}$$

$$\pi_i^{BI} = (p_i - c - \varepsilon)H_i^{BI} - k_\tau \tau_i^2/2 - k_\xi \xi^2/2 \tag{8}$$

4 Analysis

4.1 Game Analysis under Different Blockchain Adoption Strategies

This section explores the optimal pricing and information disclosure strategies of two e-tailers under different blockchain adoption strategies, as well as the expected profits for each scenario. When neither e-tailer uses blockchain to verify the credibility of information (denoted by superscript NN), information-sensitive consumers may doubt the product information disclosed. In this case, the profit function for e-tailer i ($i = 1,2$) is:

$$\pi_i^{NN} = \pi_j^{NN} = (p_i - c)H_i^{NN} - k_\tau \tau_i^2/2$$

When only one e-tailer uses blockchain to authenticate its disclosed information (denoted by superscript BN), consumers fully trust the e-tailer using blockchain $\delta = 1$. The profits of both e-tailers can be expressed as:

$$\pi_i^{BN} = (p_i - c - \varepsilon)H_i^{BN} - k_\tau \tau_i^2/2$$

$$\pi_j^{BN} = \left(p_j - c\right)H_j^{BN} - k_\tau \tau_j^2/2$$

When both e-tailers use blockchain to verify the authenticity of their disclosed information (denoted by superscript BB):

$$\pi_i^{BB} = \pi_j^{BB} = (p_i - c - \varepsilon)H_i^{BB} - k_\tau \tau_i^2/2$$

Theorem 1. The equilibrium decisions and profits under different blockchain adoption scenarios are shown in Tables 1 and 2.

Table 1. Equilibrium Decisions for E-tailers.

Strategy	p_i	p_j	τ_i	τ_j
NN	$\frac{(a+c)k_\tau + (\varphi-1)(1-\lambda)^2 c\delta^2}{(2-\beta)k_\tau + (\varphi-1)(1-\lambda)^2\delta^2}$	$p_i^{NN} = p_j^{NN}$	$\frac{\delta(1-\lambda)(a+(\beta-1)c)}{(2-\beta)k_\tau + (\varphi-1)(1-\lambda)^2\delta^2}$	$\tau_i^{NN} = \tau_j^{NN}$
BN	$c + \varepsilon + \frac{k_\tau}{(1-\lambda)}\tau_i^{BN}$	$c + \frac{k_\tau}{(1-\lambda)\delta}\tau_j^{BN}$	$(1-\lambda)\frac{M_1N_2 + M_2K_2}{K_1K_2 - N_1N_2}$	$(1-\lambda)\delta\frac{M_2N_1 + M_1K_1}{K_1K_2 - N_1N_2}$
BB	$\frac{(a+c+\varepsilon)k_\tau - (c+\varepsilon)(1-\lambda)^2(1-\varphi)}{(2-\beta)k_\tau - (1-\lambda)^2(1-\varphi)}$	$p_i^{BB} = p_j^{BB}$	$(1-\lambda)\frac{a+(\beta-1)(c+\varepsilon)}{(2-\beta)k_\tau - (1-\lambda)^2(1-\varphi)}$	$\tau_i^{BB} = \tau_j^{BB}$

Table 2. Equilibrium Profits of E-tailers.

Strategy	π_i	π_j
NN	$\frac{k_\tau(2k_\tau - \delta^2(1-\lambda)^2)(a+(1-\beta)c)^2}{2((2-\beta)k_\tau + (\varphi-1)(1-\lambda)^2\delta^2)^2}$	$\pi_i^{NN} = \pi_j^{NN}$
BN	$k_\tau K_1 \frac{(M_2K_2 + M_1N_2)^2}{2(K_1K_2 - N_1N_2)^2}$	$k_\tau K_2 \frac{(M_1K_1 + M_2N_1)^2}{2(K_1K_2 - N_1N_2)^2}$
BB	$t(2t - (1-\lambda)^2)\frac{(a+(c+\varepsilon)(\beta-1))^2}{2((2-\beta)t - (1-\lambda)^2(1-\varphi))^2}$	$\pi_i^{BB} = \pi_j^{BB}$

Note:$M_1 = a + (\beta-1)c + \varepsilon\beta$, $M_2 = a + (\beta-1)c - \varepsilon$, $N_1 = \beta k_\tau - \varphi(1-\lambda)^2$, $N_2 = \beta k_\tau - \varphi\delta^2(1-\lambda)^2$, $K_1 = 2k_\tau - (1-\lambda)^2$, $K_2 = 2k_\tau - \delta^2(1-\lambda)^2$.

Previous studies have provided relevant insights for similar scenarios, so this study does not focus extensively on equilibrium solutions or comparisons of blockchain adoption strategies. Instead, it centers on the potential impact of blockchain enabled data empowerment (see next section). A brief comparative analysis of blockchain adoption strategies follows.

In the vertical comparison between BN and NN scenarios, if blockchain technology is mature, e-tailer i discloses more "true information" to expand blockchain influence, benefiting only if the technology's maturity level is adequate. When technology is less developed, however, e-tailer i opts for conservative disclosure, resulting in losses. In a mature blockchain environment, e-tailer i may initially benefit from sharing "disguised information," though this benefit diminishes as the technology advances. For the horizontal comparison, if blockchain technology is immature, the market may become flooded with "disguised information," reducing e-tailers' incentive to leverage blockchain. As the technology matures, this situation reverses. The existence interval $\varepsilon_1^n < \varepsilon < \varepsilon_1^*$ demonstrates that within this range, blockchain technology benefits both its users and those opting out, highlighting its externalities.

When comparing BN and BB scenarios, as well as NN and BB scenarios, a mature blockchain landscape encourages e-tailers to provide more accurate information, thereby increasing demand, profits, and brand reputation. This creates pressure for e-tailer j to disclose more true information to remain competitive. If costs are high, e-tailer j need not disclose beyond what is needed in non-blockchain scenarios, since high costs offset demand impacts. At moderate costs, if e-tailer j adopts blockchain, its profits dip below non-blockchain periods, which could create barriers to technology adoption, leading to market monopolization. On this basis, it can be further noted that when blockchain is mature, both e-tailers benefit from accurate and truthful information, which is favorable for consumers. However, high costs elevate the entry barrier, discouraging e-tailers from adopting new technologies, indicating that the technology is still experimental.

4.2 Data Empowerment Strategies Based on Blockchain Information Sharing

As competition between the two e-tailers evolves, with blockchain technology employed, e-tailers tend to increase the proportion of information-sensitive consumers to enhance their utility. In this phase, relying solely on blockchain to boost demand utility is limited, making information sharing and data empowerment strategies viable. At this point, consumer trust in e-tailer-disclosed information is 1 ($\delta = 1$), and the level of data empowerment $\xi > 0$. The profit function for the e-tailers can be expressed as:

$$\pi_i^{BBI} = (p_i - c - \varepsilon)H_i^{BBI} - k_\tau \tau_i^2/2 - k_\xi \xi^2/2$$

Solving for equilibrium leads to equilibrium prices and profits for both e-tailers:

$$p_i^{BBI} = p_j^{BBI} = -\frac{ak_\tau + (c+\varepsilon)\left(k_\tau - 2(\varphi-1)^2(\lambda-1)^2\xi^2\right)}{2(\varphi-1)^2\xi^2(\lambda-1)^2 + (\beta-2)k_\tau}$$

$$\tau_i^{BBI} = \tau_j^{BBI} = -\frac{(\varphi-1)(\lambda-1)\xi\left(a+(\beta-1)(c+\varepsilon)\right)}{2(\varphi-1)^2(\lambda-1)^2\xi^2 + (\beta-2)k_\tau}$$

$$\pi_i^{BBI} = \pi_j^{BBI} = \frac{k_\tau\left(a+(\beta-1)(c+\varepsilon)\right)^2\left(2k_\tau - (\varphi-1)^2(\lambda-1)^2\xi^2\right)}{2\left(2(\varphi-1)^2(\lambda-1)^2\xi^2 + (\beta-2)k_\tau\right)^2} - \frac{k_\xi \xi^2}{2}$$

Corollary 1. (1) When a e-tailer's data empowerment capacity is low, $\partial p_i^{BBI}/\partial\varepsilon > 0$, $\partial\tau_i^{BBI}/\partial\varepsilon < 0$, and $\partial\pi_i^{BBI}/\partial\varepsilon < 0$; when high, $\partial p_i^{BBI}/\partial\varepsilon > 0$, $\partial\tau_i^{BBI}/\partial\varepsilon > 0$, and

$\partial \pi_i^{BBI}/\partial \varepsilon > 0$. Notably, as the e-tailer's data empowerment capacity approaches a certain threshold ξ^*, $\partial p_i^{BBI}/\partial \varepsilon < 0$ becomes significantly smaller. (2) $\partial p_i^{BBI}/\partial \xi > 0$, $\partial \tau_i^{BBI}/\partial \xi > 0$, $\partial \pi_i^{BBI}/\partial \xi > 0$, and as blockchain costs decrease, the trends with data empowerment capacity become more pronounced.

Corollary 1(1) suggests that when an e-tailer has weak data empowerment capabilities, sharing information through blockchain lacks sufficient incentive to offset the associated costs. This leads to higher (or lower) product prices and reduced (or improved) information quality as costs rise. The negative impact intensifies as data capabilities improve. Corollary 1(2) indicates that optimal disclosure strategies and profits are positively correlated with data empowerment capacity. As empowerment improves, the benefits of information increase; however, at high costs, this effect diminishes. If technological integration is immature, applying such strategies may be unwise. Conversely, when costs decrease, data empowerment becomes a key driver of profits, promoting greater information disclosure and allowing for price increases to maximize benefits.

Lemma 1. (1) If $0 < \lambda < \lambda^*$, when $0 < \xi < \xi^1$, $\tau_i^{BBI} < \tau_i^{BB}$, $\pi_i^{BBI} < \pi_i^{BB}$; when $\xi^1 < \xi < \tilde{\xi}$, $\tau_i^{BBI} < \tau_i^{BB}$, $\pi_i^{BBI} > \pi_i^{BB}$; when $\tilde{\xi} < \xi < \bar{\xi}$, $\tau_i^{BBI} > \tau_i^{BB}$, $\pi_i^{BBI} > \pi_i^{BB}$; (2) If $\lambda^* < \lambda < \lambda^+$, $\pi_i^{BBI} > \pi_i^{BB}$; when $0 < \xi < \tilde{\xi}$, $\tau_i^{BBI} < \tau_i^{BB}$; when $\tilde{\xi} < \xi < \bar{\xi}$, $\tau_i^{BBI} > \tau_i^{BB}$; (3) If $\lambda^+ < \lambda < 1$, $\pi_i^{BBI} < \pi_i^{BB}$; when $0 < \xi < \tilde{\xi}$, $\tau_i^{BBI} < \tau_i^{BB}$; when $\tilde{\xi} < \xi < \bar{\xi}$, $\tau_i^{BBI} > \tau_i^{BB}$.

Lemma 1 indicates that when the proportion of consumers indifferent to information is low ($0 < \lambda < \lambda^*$), and the e-tailer's data empowerment is weak ($\xi < \xi^1$), the e-tailer has little motivation to share information, as sharing costs exceed potential benefits. Conversely, if data empowerment is high ($\xi > \bar{\xi}$), although sharing can yield some profit, exceeding a threshold ($\xi > \xi^+$) may lead to diminishing returns, as the technology reaches maturity and impedes profit-sharing, causing the e-tailer to behave monopolistically to prevent new entrants. At a moderate empowerment level ($\xi^1 < \xi < \tilde{\xi}$), the e-tailer tends to cooperate in sharing information to boost demand while disclosing less to lower costs. When the empowerment level is high ($\tilde{\xi} < \xi < \bar{\xi}$), e-tailers become more interested in sharing benefits, driving them to disclose more information. When a high proportion of consumers are indifferent to information ($\lambda^* < \lambda < \lambda^+$), e-tailers can still increase profits through information sharing, even with low data empowerment. However, if nearly all consumers exhibit low sensitivity to information ($\lambda^+ < \lambda < 1$), the benefits of information sharing fail to mitigate the issue, making it imprudent for e-tailers to adjust information quality to boost sales.

4.3 Equilibrium Information Sharing Strategies

Theorem 2. (1) When $0 \le \varepsilon < \min\{\varepsilon_1^*, \varepsilon_2^*\}$ and $0 < \xi < \xi^1$, the equilibrium strategy is for both e-tailers not to use information sharing technology. (2) When $0 \le \varepsilon < \min\{\varepsilon_1^*, \varepsilon_2^*\}$ and $\xi^1 < \xi < \bar{\xi}$, the equilibrium strategy is for both e-tailers to implement both blockchain and information sharing technologies.

When blockchain costs are low, the optimal decision for both e-tailers is to adopt blockchain technology, with the key being the quantification of their data empowerment capacities. This can be assessed through metrics such as data volume, utilization efficiency, and technological infrastructure, while also accounting for qualitative factors like organizational readiness and partner ecosystems. When empowerment capacity is low, the cost of sharing information is high, leading p e-tailers to lack motivation. Conversely, high empowerment capacity may create market monopolies and barriers to entry. At moderate empowerment levels, e-tailers are more inclined to share information to enhance benefits. This is consistent with real-world scenarios. Walmart, through collaboration with suppliers and leveraging blockchain technology, has reduced the time needed for food tracking, thus increasing the transparency of food safety information and consumer trust. This demonstrates that in markets with high information sensitivity, strong data empowerment enables Walmart to gain greater competitive advantage through information sharing and meets consumer demands for product source information. However, for smaller companies with weaker data empowerment capacities, the high cost of information sharing may deter the adoption of new technologies, making it difficult for them to progress in a competitive market.

Furthermore, the proportion of information-indifferent consumers is crucial for information-sharing strategies. When this proportion is high, despite the increased demand for data empowerment, the high development costs lower the motivation to explore new technologies. Conversely, when the proportion of information-sensitive consumers is high, the appeal of information-sharing technology increases, prompting platform adoption, which in turn drives down blockchain costs and reduces the proportion of indifferent consumers. Such e-tailers thus gain a competitive edge by more aggressively leveraging data-driven experiences to attract consumers and enhance market positioning. Hence, advancing the application and impact of blockchain technology remains a key strategic goal for enterprises.

5 Conclusion

This paper examines the equilibrium strategies for two e-tailers selling substitute products, using Nash game theory to analyze blockchain adoption. It identifies three stages based on fluctuating blockchain costs: first, when costs are below a low threshold, both e-tailers actively adopt blockchain to enhance information authenticity; second, when costs exceed a high threshold, both e-tailers forgo blockchain; and third, when costs fall between these thresholds, mixed strategies may emerge, with blockchain-using e-tailers likely disclosing more truthful information. In terms of information sharing, data empowerment capacity operates between two thresholds, fostering a willingness to share information only under moderate conditions, which leads to cooperative gains. Variations in consumer sensitivity to information and prices further influence the disclosure of truthful information. As consumer trust in unverified information declines, e-tailers using blockchain become more inclined to disclose accurate information, while those not adopting blockchain tend to reduce their information dissemination.

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