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Rewarding Honesty: An Incentive Mechanism to Promote Trust in Blockchain-Based E-commerce

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Abstract
Building trust is a difficult task among strangers over a network. This is because fraud happens when the temptation to cheat becomes greater than the rewards of staying honest. The enormous growth of e-commerce has resulted in cheating and fraud becoming increasingly important issues. Advocates for blockchains argue that this new technology can effectively eliminate misconduct and promote trust among participants. However, recent field experimental studies show that fraud still exists in the blockchain-based marketplace. This article suggests a new design for the arbitration process. A trusted third party is given the right to resolve disputes and reward blockchain cryptographic tokens to honest users. We show that the optimal strategies of individual users involve delivering quality items as described and leaving honest reviews about purchased items.

Keywords: *Arbitration, Bayesian Nash Equilibrium, Fraud, Utility Tokens*

JEL Classifications: *G32, E51, F30*

1. Introduction

With the expansion of e-commerce, the importance of online trust has heightened. This electronic marketplace, although providing a wealth of business opportunities and a convenient shopping model, introduces significant uncertainties and risks. Blockchains, as an emerging technology, have garnered the attention of e-commerce users. Advocates of blockchains assert that this technology, in tandem with self-enforcing "smart contracts," enables decentralized marketplaces by eliminating counterparty risk without reliance on intermediaries. However, [1] reported that 33% of subjects engaged in deceptive practices during a trading game on a blockchain-based marketplace. Furthermore, their questionnaire survey revealed that participants tend to rely on government entities or corporations to provide trust in resolving disputes rather than individuals. Given these facts, our objective in this article is to effectively mitigate fraud issues without compromising the decentralization property in the arbitration process.

Certain blockchains feature cryptographic tokens. We propose a mechanism to be implemented on the blockchain-based e-commerce platform in which virtuous participants are rewarded with utility tokens. Economically speaking, agents are likely to act virtuously when the rewards of honesty surpass the benefits of cheating. We envision a scenario wherein Alice is the buyer, Bob is the seller, and both participate on the platform operated by the trusted authority, Charlie (representing a government entity). For each dispute-free transaction, Alice and Bob will receive tokens from Charlie. Interestingly, even if Alice receives a low-quality product and chooses not to initiate arbitration, both she and Bob would still receive tokens. However, this is not an optimal strategy for Alice, as we will discuss later. In the event of a dispute, Charlie will reward either Alice for reporting a low-quality item sent by Bob or Bob for reporting a dishonest review left by Alice. Notably, neither Alice nor Bob needs to reveal their identities to any other parties throughout the process. Our analysis reveals that such an incentive mechanism achieves a unique Bayesian Nash equilibrium in which both buyer and seller act honestly.

A. Related work

Over the past decade, due to the popularity of blockchain, it has received considerable attention from both industrial scientists and academic researchers. To date, a growing body of literature has provided a comprehensive survey on blockchain. Various streams of survey papers exist in the literature. In particular, the survey in [2] focuses on the introduction of Bitcoin from a technical perspective. The survey in [3]-[5] provides a comprehensive discussion of security and privacy issues in the blockchain ecosystem. The blockchain applications on the Internet of Things (IoT) are surveyed in [6]. The integrated blockchain and edge computing systems are summarized in the survey [7], focusing on the research issues and challenges. The survey on blockchain from a game theoretical perspective is reviewed in [8].

Customer reward systems, such as bonus points or miles, are widely employed by both online and offline merchants. However, these systems fail to ensure customers' privacy and anonymity. By harnessing blockchain technology, our incentive mechanism ensures anonymity and also rewards honest sellers, thereby fostering trust among participants.

Token economics, though not a new concept, has been proposed in [9]. Research on cryptographic tokens primarily revolves around the creation of value, as discussed in [10] and [11], and the integration of tokens within existing institutions [12] and [13]. A noteworthy development is the use of tokens to incentivize network nodes to relay traffic. In [14] and [15], tokens are used to incentivize self-interested transceivers to provide relay service.

Currently, a functional blockchain-based platform, OpenBazaar (OB), uses multi-signature escrow transactions to manage counterparty risks in online trading. If a buyer or seller encounters issues with the transaction, they can initiate the dispute resolution process. The moderator examines the situation and co-signs with the victorious party to release the funds. This preventive strategy, however, does not completely eradicate counterparty risk. Technically, anyone can impersonate a moderator, or even create multiple pseudonymous accounts to act as several moderators.

In an effort to safeguard users' privacy and curb information fraud, scholars have concentrated on redesigning reputation systems in the blockchain era. In [16]–[18], the focus is on investigating reputation systems relating to blockchain technology and applications, primarily from a technology-focused perspective intertwined with engineering, programming, and computer science.

To the best of our knowledge, this article is the first to introduce incentive tokens in a blockchain-based e-commerce platform and to use tokens to encourage honesty among participants, thereby promoting trust. Our approach to fraud prevention differs from previous methods in several respects. Firstly, we use tokens to reward participants. Secondly, we examine users' strategic behavior using a Bayesian game-theoretic model. Thirdly, we introduce a third party as a central authority to arbitrate in fraud cases. In the event of a dispute, this authority has the right to cancel the transaction, issue refunds, and reward honest users with tokens.

Our study confirms the importance of trust service providers in providing a reliable blockchain ecosystem. In [19], the fundamental role of trust service providers is comprehensively discussed in essential aspects of systemic trust, law compliance, adequate technical performance, confidentiality of transactions, and long-term preservation of data.

This research also resonates with the mechanism design literature in economics. In [20], it is suggested that the planner's task of implementing the social choice rule can be achieved using a planning mechanism. If the planner adheres to the designed mechanisms, the outcome will be desirable (incentive compatible for individuals).

B. Main contributions

In this article, we primarily introduce a utility token scheme to reward self-interested users for their honesty on a blockchain-based e-commerce platform. In our design, users are primarily driven to maximize their utility and are not compelled to remain honest if they find opportunities for fraud. In essence, the crux of the problem is the marketplace's lack of incentives for individual users to remain honest when the rewards for cheating outweigh those of honesty. Unlike prior solutions, we introduce an authority capable of canceling transactions and rewarding honesty with tokens. This incentive token mechanism can increase the utility of honesty for users, thereby promoting trust among participants in the decentralized peer-to-peer marketplace.

More importantly, we offer a rigorous analysis of our proposed incentive mechanism and substantiate its efficacy. Using a Bayesian game, we affirm that honest behavior is the unique equilibrium and provides the highest payoff for self-interested users. Despite its simplicity, our model offers insightful implications for using tokens as an incentive and can be applied to various market structures.

Consequently, our findings can aid organizations in making strategic and organizational decisions about emerging blockchain technology. Our research also uncovers comprehensive insights that could prove crucial during the technology adoption process of blockchain applications. These insights can guide future blockchain-related research and help practitioners develop robust blockchain applications that are likely to be accepted by users and build trust with them.

C. Structure

The remainder of this article is organized as follows: In Section 2, we detail our incentive mechanism and prove the existence of a unique equilibrium. In Section 3, we conclude the article and suggest directions for future research.

2. Incentive mechanism

In this section, we first conceptualize the incentive mechanism. The objective is to ascertain whether this mechanism encourages users to deliver items of quality as advertised and to leave accurate product reviews. Secondly, we establish that our model ensures the rewards of honesty exceed the benefits of deception, leading agents to conclude that cheating is not optimal, thereby promoting trust among participants.

A. Environment

We analyze a single-instance transaction within an e-commerce platform. Subsequently, we demonstrate that repeating this game results in identical outcomes. A single buyer, Alice, decides whether to transact with a single seller, Bob. Once Bob receives a purchase request from Alice, he delivers the product, after which Alice leaves a review. We assume that Alice cannot ascertain the product's quality beforehand and can only evaluate it upon delivery. Moreover, Alice and Bob aim to maximize their utility and might provide substandard products or fake reviews given the opportunity.

When Alice receives a subpar product, she can initiate a dispute or choose to remain silent. In this scenario, an authority, Charlie, will reward Alice with tokens for reporting. We focus on the incentive mechanism here, leaving the origin and value of the tokens for future work. Similarly, Bob can also appeal to Charlie if Alice provides a malicious review of the transaction. Charlie will again reward Bob for his report. Lastly, both Alice and Bob will be granted tokens automatically if no dispute arises.

The sequence of our analytical model is as follows: (1) The buyer decides whether to transact with the seller. (2) The seller decides the quality of the product to send to the buyer and receives feedback. (3) The authority rewards tokens to consistent performers.

Unlike games such that players know all relevant information about each other regarding strategies (actions), order of play, and payoff function, in our environment both Alice and Bob have private information that is not known by the other. Specifically, Alice does not know if Bob delivers an authentic product or not while Bob is unsure whether Alice leaves a true review. Therefore, we model the environment using Bayesian games with incomplete information and verify that our designed incentive mechanism guarantees the desirable equilibrium in the following subsections, respectively.

B. Game tree

As stated earlier, if Alice chooses not to transact with Bob, we assume their payoffs are both zero. Conversely, if Alice decides to buy Bob's product, he decides on the quality of the product to deliver. Note that Alice would not know the product's quality until she receives it, hence the dashed line connecting Bob's decision nodes in Figure 1.

We assume that if Bob delivers the genuine item to Alice, Bob's payoff is $V_B^T>0$ and Alice's payoff is $V_A^T>0$; whereas, if Bob delivers a counterfeit to Alice, his payoff is $V_B^F>0$ and hers is $V_A^F<0$.

After Alice receives the genuine item and leaves an honest review, it's clear there's no need for Alice and Bob to arbitrate, and they receive tokens T_A and T_B, respectively. However, if Alice leaves a false review and thus would not report her misconduct, it's optimal for Bob to dispute and receive tokens T_B from Charlie; otherwise, he will receive no tokens, but Alice will be rewarded for malicious behavior.

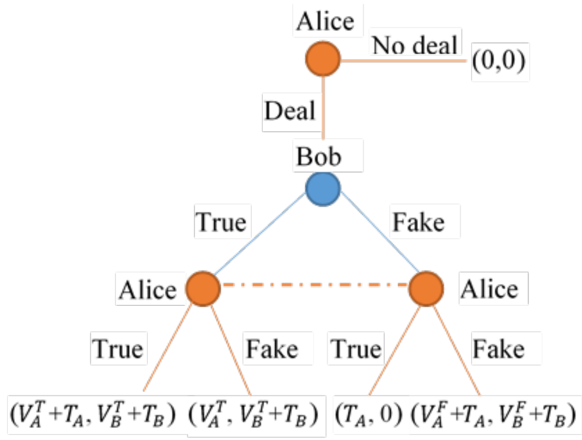

Figure 1. Game tree.

After Alice receives the inferior product and leaves an honest review, what are the optimal strategies for Alice and Bob? Alice will choose to report fraud and Charlie will cancel the transaction (Alice and Bob receive zero payoff) and send T_A tokens to Alice. From Bob's perspective, he's indifferent about reporting or not since Alice must report and he receives zero payoffs and zero tokens in either case.

What will happen if Alice leaves a fake comment after receiving forfeits? Needless to say, Bob will not report Alice's misconduct and obtain T_B tokens from Charlie. Given Bob's strategy, Alice will keep the inferior product and receive T_A tokens, which is better than receiving zero (here, we assume $V_A^F+T_A>0$); but it's easy to demonstrate later that this case cannot occur in equilibrium.

Now, we outline the players' payoffs regarding all possible strategies in this game. Start with Bob, when the transaction is made, if Bob delivers an authentic product (i.e., if Bob is of type true), his payoff would be $V_B^T+T_B$ against any strategy by Alice. In this case, Alice's corresponding payoff would be $V_A^T+T_A$ if she makes a truthful review (i.e., if Alice is of type true); otherwise, it would be V_A^T. On the other hand, if Bob delivers a fake one (i.e., if Bob is of type fake), his payoff would depend on the strategy by Alice. Bob will receive zero payoffs if Alice leaves an honest review and will obtain $V_B^F+T_B$ if Alice decides to leave a false review. In this case, Alice's corresponding payoffs would be T_A and $V_A^F+T_A$, respectively.

From here, we will look for strategies such that one is the best reply against the other and vice versa.

C. Equilibrium

In the previous subsection, we discussed and ensured the reporting strategies of Alice and Bob. We now verify their decisions about delivery and feedback, working backward. Given the choice has already been made by Bob, leaving a true comment is a dominant strategy for Alice since we assumed

V_A^T >0 and V_A^F <0 (in fact it is consistent with reality). Specifically, when Bob delivers an authentic product, the payoff of leaving an honest review is equal to $V_A^T + T_A$ which is higher than the payoff of leaving a false one for Alice, that is, $V_A^T + T_A > V_A^T$. It means that the best response of Alice is to leave an honest review if Bob delivers the genuine item. Similarly, Alice's best reply to Bob's misconduct is also to leave a truthful review because $T_A > T_A + V_A^F$. In other words, Alice will leave a true comment regardless of the type of item she received.

Now given Alice plays such a strategy, what is the best response of Bob? Apparently, Bob will deliver the genuine item given Alice's optimal strategy (leaving honest feedback) because the payoff is equal to $V_B^T + T_B$ if Bob delivers the authentic product when Alice selects the action of leaving a truthful review; otherwise, the payoff is zero if Bob delivers a counterfeit when Alice chooses to leave an honest review.

Now, look at the initial decision node. It is straightforward to show that transacting with Bob will yield Alice $V_A^T + T_A$ while she obtains zero if she decides not to make an offer, which suggests that Alice will buy Bob's product. Therefore, we have the equilibrium strategy: (transact and leave consistent feedback; deliver genuine item) and they achieve the highest payoff level ($V_A^T + T_A$; $V_B^T + T_B$) intended.

D. Applications

We now discuss some applications of our theoretical model for security issues and mining management in blockchains, respectively. Firstly, our model can analyze strategies of attackers regarding selfish mining, majority attack, and/or denial of service (DoS), and verify the designed mechanism such that the best response of each player is not attacking. Secondly, our methodology can be effectively applied to model the interaction between miners in computational power allocation, chain selection, and pool selection. At equilibrium, the maximum utility of participants can meet.

3. Limitation and future work

In Section 2, we provide an in-depth analysis of the theoretical model and verify that rewarding peers with tokens for reporting malicious behaviors can mitigate misconduct. However, we assume that the size and value of such a token are predetermined, which allows us to focus on the rewarding mechanism and simplify the presentation of the mechanism.

There are some interesting problems that we have not addressed in this work. As future work, in particular, it would be interesting to examine the fundamental concepts of token economics: the demand and the supply sides of the cryptographic token market. Specifically, we would first explore how tokens are created, distributed, and used within our proposed blockchain platform. We would further analyze the complex dynamics in the supply and demand sides to create a sustainable and thriving ecosystem. On the demand side, it is critical to understand what benefits the token provides and to what extent these benefits will grow, which drives people to use or hold tokens. On the supply side, we would discuss what is the appropriate size of the initial lunch of tokens, and what is the desirable token policy to incentivize participants to circulate and trade tokens. What is more important, we would investigate how to match both sides to achieve the design of honest behavior.

Additionally, this mechanism could be shown to be more robust compared to finite repeated games. Finally, potential future work could consider incorporating our optimal token scheme into existing market institutions.

4. Conclusion

Blockchain technology, as found in [1], is a double-edged sword. It safeguards users' privacy while also raising challenges—issues of trust among users. This new technology is advantageous when removing a centralized third party that possesses users' data. Conversely, new mechanisms are necessary to foster trust among strangers. Some peers might not provide the same services as they advertise, and some might be malicious by providing fake reviews. As there is no central authority to supervise peers' behaviors and incentivize them to act rightfully, blockchain technology can help address these issues.

In this article, we examined whether blockchain can serve as the technology underpinning decentralized marketplaces to promote trust. By utilizing tokens as an incentive mechanism, we demonstrated that rewarding peers for reporting malicious behaviors can mitigate misconduct. Despite its simplicity, our innovative token rewarding mechanism can be used to incentivize users to behave consistently and tackle trust issues.

Competing Interests:
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval:
Not applicable.

Author's contribution:
DC conceived of the study and helped to draft the manuscript. YL developed the theory, performed the analysis and wrote the manuscript. WX participated in the design of the study and verified the methods. All authors discussed the results and approved the final version of the manuscript.

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