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(REVIEW ARTICLE)

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Blockchain incentive design for transparent supply chain: A Review

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Abstract

Supply chain transparency is essential for ensuring product authenticity, regulatory compliance, sustainability, and building consumer trust. Blockchain technology offers a decentralized and tamper-proof solution for achieving end-to-end supply chain visibility. However, its widespread adoption faces significant technical, economic, and behavioral barriers, including high implementation costs, data privacy concerns, and resistance to change. The review examines the critical role of incentive design in overcoming these barriers and motivating stakeholders to adopt blockchain and share truthful data. We synthesize theoretical approaches, particularly game theory and contract theory, that model stakeholder payoffs and guide the creation of effective reward and penalty mechanisms. Empirical case studies, such as IBM Food Trust and VeChain, illustrate practical benefits and real-world challenges, while simulation-based methods like agent-based modeling and sensitivity analysis provide insights into optimizing incentive strategies. Despite advances, gaps remain in dynamic and context-sensitive incentive structures, cross-cultural enforcement, and integrated frameworks combining economic, behavioral, and technological factors. We propose policy and managerial recommendations and outline future research directions to address these gaps.

Keywords: Block Chain; Optimization; Supply Chain; Game Theory; Sensitivity Analysis

1. Introduction

Supply chains have evolved a lot in recent years since markets are becoming more global and digital at a faster rate [1], [2]. They are now more complex, changing, and spread out all across the world. Supply networks nowadays are not as simple, straight, or local as they used to be [3]. Instead, they involve a lot of people, like suppliers, manufacturers, logistics providers, distributors, retailers, and end customers, who are spread out over different areas and have to obey different standards [4]. This link has made it easier to be productive and grow, but it has also made things more fragile and hard [5], [6].

One of the main challenges with global supply networks is that they aren't transparent [7]. It's hard to observe everything in a traditional supply chain because many people have information about where items come from, how they are created, how they are shipped, and how they are handled [8], [9]. Because of this lack of transparency, it's simpler for frauds, fraudulent goods, unfair labor practices, and not obeying environmental standards to arise. The Organization for Economic Co-operation and Development (OECD) says that the trade in fraudulent and stolen goods around the world accounts up as much as 3.3% of all trade [10]. This highlights how crucial it is to have good processes for keeping track of things [11], [12].

People, government agencies, and non-profits are all clamoring for more transparency, and not simply to stop fraud. People today want to know where and how goods are made, and they want to be confident that the resources are

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sourced ethically, that workers are treated fairly, and that the environment is protected [13]. The European Union's Green Deal, the U.S. Food Safety Modernization Act, and other national laws against counterfeiting make it even more important for supply chains to tighten their reporting and tracking. In this case, being honest is not only the right thing to do; it's also a method to go ahead of your competitors because it builds trust and devotion to your business [14].

Blockchain technology has emerged as a viable approach to overcome these difficulties in a clear way [15]. People first thought of blockchain as the technology that powers cryptocurrencies like Bitcoin. It is a ledger system that is decentralized and can't be changed. It can safely keep track of transactions and data transfers between a group of people [16], [17]. Blockchain can give everyone in a supply chain a full view of the process by enabling them record, check, and get information about transactions and product movements in real time [18]. Blockchain is a unique technique to keep data safe and reliable without needing centralized middlemen. This is because it is decentralized, cryptographically secure, and can't be changed [19], [20].

Integrating Digital Twin and Blockchain technologies creates a secure, transparent, and intelligent framework for real-time system monitoring and decision-making. Digital Twins provide virtual replicas of physical assets, continuously updated with sensor data, while Blockchain ensures the immutability and traceability of that data. Together, they enable secure sharing of operational insights across stakeholders and automate responses through smart contracts. This integration is especially valuable in manufacturing, supply chains, and critical infrastructure. It enhances trust, improves efficiency, and enables predictive and decentralized decision-making [21], [22], [23].

Blockchain has been proved to make supply chains more open in a number of pilot projects and business usage. IBM's Food Trust platform, for example, allows customers and retailers follow the flow of food from farm to table [24]. This makes customers feel safer and minimizes the risk of contamination. Luxury goods companies have also used blockchain to battle fake goods by offering them certificates of authenticity that can be examined and that stay with the goods for their whole lifetimes [24], [25]. These examples highlight how blockchain can help in real-world supply chain challenges.

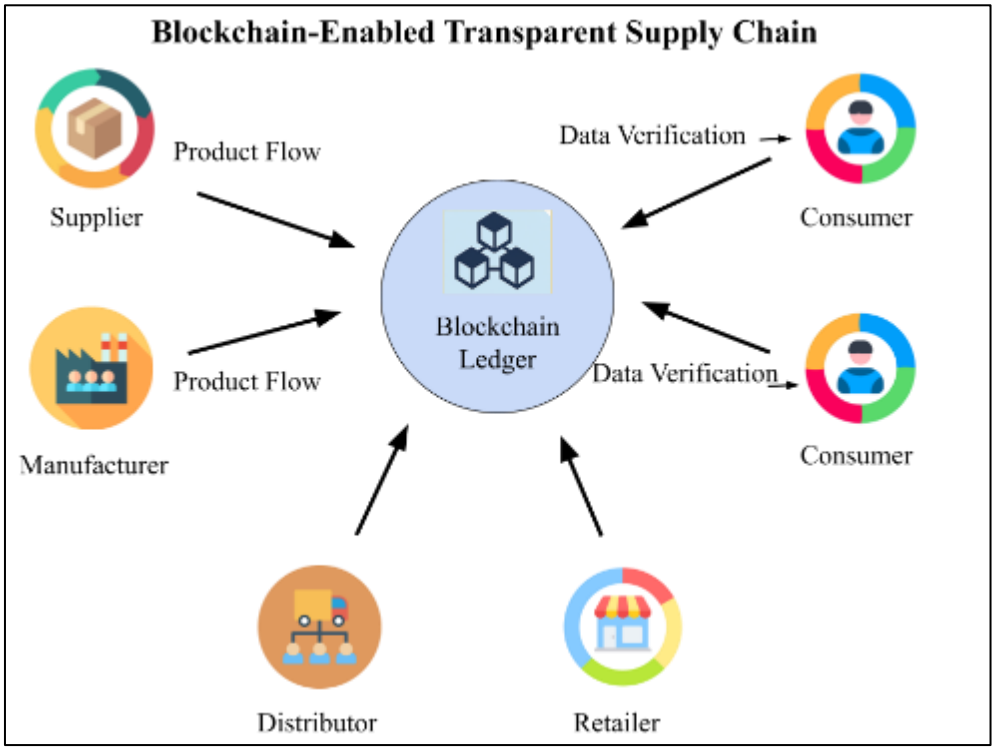

Figure 1 End-to-end product and data flows via a shared ledger

Blockchain has a lot of promise, but it hasn't been used much in supply chains yet. A number of studies have shown that there are a number of problems that make it challenging to utilize broadly [26], [27]. A lot of money is needed up front and to integrate (Ci), which is a huge challenge for small and medium-sized firms (SMEs) who don't have a lot of money. Stakeholders are also apprehensive about the privacy of sensitive business information because they worry that putting all of their operational information on a public ledger could show faults in their competitors or trade secrets [28]. Also,

the benefits of using blockchain (Bi), such a higher brand reputation or access to high-end marketplaces, might not appear clear or direct enough to make the costs worth it [29].

Barriers to behavior and organization are also quite essential. Supply chain actors may not want to change because they don't know enough about technology, are anxious about how it will affect their work, or don't want to follow new rules and norms [30]. Also, each segment of a supply chain has its own goals, priorities, and willingness to take risks. This makes it hard to update technology such that it works well with other technology [31], [32].

Setting up and using incentive systems that link each person's goals to the goals of open communication is the best way to get beyond these obstacles. Some examples of incentives are financial payouts, fewer taxes, exclusive access to a market, or better terms on a contract [33]. On the other hand, penalties (Pi) like fines, getting kicked out of supply networks, or harm to one's reputation could keep people from breaching the rules and make them more honest. Rewards and penalties can influence how people feel about their choices. This is why it makes sense and is good for company to adopt blockchain and be honest about exchanging data [33], [34], [35].

Game theory and contract theory can be utilized to come up with and think about these kinds of incentives [36]. Researchers can tell if working together is the best choice by understanding stakeholders as people who seek to make the most of their own position. By figuring out what rewards and punishments are needed to get different sorts of supply chain networks to use blockchain, theoretical models can assist make regulations in the actual world.

There is a lot of study on how to use blockchain in supply chains, but not much on how to encourage people to use it by giving them incentives. Most of the study that has been done so far has been on whether the technology is possible, how pilot programs work, or the big benefits. It hasn't gone into much detail regarding the most significant issue, which is why stakeholders act the way they do. We need to fill this gap so that small experiments can be used on a large scale over a lengthy period of time.

This review article seeks to fill this gap by collecting together all the research that has already been done on using blockchain to improve supply chains. It does this by looking at both theoretical and real-world ways to create incentives and pointing out areas where more research is needed. This study uses ideas from economics, behavioral science, and operations management to enable blockchain technology make supply chains that are open, robust, and moral by creating powerful, beneficial incentive structures.

2. Blockchain in Supply Chain Management

2.1. Applications and Benefits

Blockchain technology offers a range of applications and benefits that have the potential to transform traditional supply chain operations. Blockchain fixes a lot of problems that have been around for a long time in the supply chain, like information asymmetry, a lack of traceability, and a lack of trust among stakeholders. It does this by providing a safe, open, and decentralized ledger. Here are several significant uses and the benefits that come with them.

2.1.1. Provenance and Traceability

One of the best things about blockchain for supply chains is that it makes it easier to find out where products came from and how they got there. It's not always easy for traditional supply chains to have clear, verifiable records of how a product gets from the source to the final user. This lack of openness makes it simpler for phony items, improper labeling, and unethical sourcing to happen.

Blockchain keeps a record of every transaction or step in a process on a distributed ledger that can't be modified. At every step, each stakeholder can see where things originated from, where they went, and how they changed. In the food business, for example, blockchain lets you trace ingredients back to the farm where they came from. This helps quickly locate the sources of contamination during food safety issues. Blockchain helps the pharmaceutical industry maintain track of medications safely so they can fight fraudulent drugs and make sure they meet laws like the Drug Supply Chain Security Act (DSCSA) [36].

2.1.2. Authentication and Anti-Counterfeiting

It is claimed that the world market for phony goods is worth more than $500 billion a year. This has an effect on firms that sell electronics, drugs, luxury goods, and car components. Giving items unique digital identities is a strong approach to check them out with blockchain.

These digital IDs can be linked to tags or smart labels that can't be modified or copied to make sure that product information stays the same. Blockchain-based apps make it easy for customers and supply chain partners to confirm the legality of products, which cuts down on fraud and promotes trust in the brand.

2.1.3. Smart Contracts and Process Automation

Smart contracts are agreements that automatically carry out their conditions, which are already set on the blockchain. When certain circumstances are met, smart contracts in supply chains automatically carry out transactions. This saves the individuals in charge time and money and cuts down on paperwork.

For instance, the terms of payment may depend on gaining confirmation of delivery and the results of a quality inspection. The smart contract can automatically pay the supplier once the shipment has been examined and proven to be in order. This automation makes things go more smoothly, speeds up the flow of cash, and stops fights.

2.1.4. Enhanced Supply Chain Collaboration

Blockchain makes it secure and easy for everyone in the supply chain, from suppliers of raw materials to end merchants, to share information. In the past, supply chain data was split up and kept in different areas, which led to poor decision-making and inefficiencies.

Blockchain allows everyone involved access to a single, tamper-proof source of truth. This makes it easier to plan production, estimate demand, and optimize stocks. More open data helps people trust one other and make decisions together. This is very helpful in supply chains with several levels and many separate enterprises [37] , [38].

2.1.5. Sustainability and Ethical Compliance

People and governments demand more and more proof that businesses are doing the right thing, like providing fair working conditions, getting their supplies in a way that doesn't hurt the environment, and having a lower carbon footprint[37]. Blockchain assists these projects by keeping track of sustainability factors that can be examined and validated.

Blockchain can keep track of whether or not someone is following certifications like Fair Trade, Organic, or Forest Stewardship Council (FSC). By being honest about how they get their resources ethically, businesses may stand out in the market and meet tight regulatory demands.

2.2. Adoption Barriers

Blockchain technology has a lot of promise and can help with supply chain management in many ways, but not many people are using it currently. It's necessary to know about these problems in order to create successful incentive structures that connect the goals of all stakeholders with the goals of collective transparency. People don't use it because of three main sorts of problems: technological, economic, and behavioral.

2.2.1. Technical Barriers

One of the foremost challenges to blockchain adoption is its technical complexity and integration difficulties. Many supply chains rely on outdated systems that have been established and upgraded over time. Adding blockchain to these systems usually entails a lot of redesigning, custom development, and moving data, all of which can get in the way of business as usual.

There are still concerns about how well blockchain can grow. Modern supply chains that process millions of transactions every day demand very fast networks, and public blockchains may not be able to handle that. Even permissioned blockchains, which are supposed to make things more scalable, can have trouble with performance when more users and data are added.

Interoperability is also a difficulty with technology. People in supply chains often use diverse software platforms, standards, and data formats. Making a blockchain solution that works effectively with diverse systems in different firms and countries is hard from a technical point of view, and it usually takes a lot of work to make things the same. The quality and accuracy of data make it even harder to accept new technology. Blockchain makes sure that data can't be modified, but it doesn't check to see if the data that enters in is accurate or reliable in the first place. The "garbage in, garbage out" problem is what this is called. IoT sensors, RFID tags, and tight validation criteria are needed to make sure that data inputs are accurate and can't be modified.

2.2.2. Economic Barriers

Setting up blockchain is also very expensive at first, which is another huge difficulty with it. Buying new equipment, building new software, putting in place cybersecurity measures, and organizing training programs are needed to set up blockchain infrastructure. Small and medium-sized firms (SMEs) may not be able to afford these initial costs, especially if they don't know how long it will take to get their money back.

Also, the costs and benefits are not always evenly distributed out among everyone in the supply chain. Retailers and end consumers may benefit a lot from enhanced traceability and brand trust, but upstream suppliers may have to pay a lot of the costs without seeing any immediate benefits. This difference could make people higher up the chain less likely to put money into adopting blockchain [40].

People are also cautious since they don't know how much money they would save in the long run. Supporters say that there could be benefits including fewer fraud, speedier settlements, and lower administrative costs. However, these benefits are often simply theoretical until they are validated through large-scale deployments. People are considerably more worried about the economy since they can lose money on failing pilot ventures.

Companies may also be cautious to invest in a technology that is still changing swiftly because they are scared that the systems they use now may become obsolete or not work with new standards. Companies might not want to invest in blockchain projects since they don't know how the technology will work.

2.2.3. Behavioral and Organizational Barriers

Aside from technical and economic problems, behavioral and organizational concerns are also very crucial in keeping blockchain from being adopted. It's a well-known problem that people don't want to shift as technology changes. Both workers and managers may feel intimidated by new systems that change how things are done, introduce automation, or need new skills.

It's even harder for supply chain partners to work together because they don't know how to use technology. Implementing blockchain demands not only IT expertise but also a fundamental understanding of decentralized systems, cryptographic security, and smart contracts. A lot of organizations, especially those in traditional manufacturing and logistics, might not have the expertise they need to deal with all of these issues.

People are considerably less likely to use data when they are worried about its privacy. People are worried about providing competitors or other supply chain members access to important operational data because blockchain is open. This is beneficial for trust and traceability. People that are involved in the project may be apprehensive that providing data could disclose how the company makes money, how it functions, or where it is weak and could be taken advantage of [41], [48].

Adoption is also harder because everyone has to work together. The more people who use blockchain in a supply chain, the more useful it gets. Its benefits are best when all or most of the people in the supply chain take part. But it's always challenging to get a bunch of autonomous groups with various aims and levels of risk to work together. Everyone might be stuck, waiting for someone else to go first if there isn't a central coordinating authority.

2.2.4. Importance of Incentive Design

Incentives are highly crucial for motivating people in the supply chain to use new technology and work together to make the overall system better. When using blockchain in a supply chain, incentives are highly crucial because everyone needs to work together, exchange data, and make substantial investments at the beginning.

2.2.5. Aligning Individual and Collective Interests

There are a lot of different people who work in supply chains, like raw material suppliers, manufacturers, logistics businesses, distributors, and retailers. Each actor usually does what's best for them, which means minimizing costs, raising revenue, and lowering risk. Blockchain works best when a lot of people are involved and all parts of the supply chain contribute data that is accurate and consistent.

People may not want to use blockchain if they don't see the benefits immediately away and don't see it as an investment that would create value. For example, a supplier would have to pay to adopt blockchain, but they might not see a return right away from the increased transparency downstream, which mostly assists customers or retailers. Incentive systems help close this gap by making sure that everyone who uses blockchain gets a fair share of the benefits [43].

2.2.6. Historical Precedents in Supply Chain Incentives

It's a well-known idea to use prizes to urge individuals to work together in supply chains. A lot of people have looked into and employed standard contracts like revenue-sharing agreements, buyback contracts, and cost-sharing arrangements to make sure that everyone in the supply chain is on the same page.

For instance, revenue-sharing contracts can fix the double marginalization problem in supply chains by making sure that choices about prices and inventories are in sync. These boosts shared revenues [44], [45]. Buyback agreements function the same way: they enable suppliers promise to buy back unsold goods to get merchants to order more. This makes it less likely that demand will change.

These examples show that carefully planned incentives may help people work together better, make the whole system work better, and make sure that everyone gets a fair share of the advantages of working together. These traditional ways of doing things can teach us a lot about how to design incentive systems that work with blockchain.

2.2.7. Designing Effective Incentive Mechanisms for Blockchain

Designing incentives for blockchain adoption requires a nuanced understanding of stakeholder motivations, cost structures, and benefit distribution. Rewards must be substantial enough to offset adoption costs (Ci) and perceived risks, while penalties must be enforceable and severe enough to deter non-compliance without driving actors out of the supply chain entirely.

Penalties should be harsh enough to keep people from breaking the rules, but not so strong that they have to leave the supply chain. Also, incentives should be able to alter with the market and the growth of technology. People that employ new technology early on could need bigger awards because the dangers and costs are higher at initially. People who embrace it later may need lower rewards because the technology has been around longer and the benefits are more known.

Incentive schemes should also consider behavioral factors. Money rewards aren't always enough; recognition, a stronger reputation, and long-term strategic benefits can all be quite motivating. Using both money and non-money incentives can help things work better and reach more people.

3. Theoretical Approaches to Incentive Design

3.1. Game-Theoretic Models

To analyze strategic interactions and cooperative behavior in supply chains game theory has been widely used. It gives a strong way to highlight the choices of self-interested stakeholders that have to choose between working together (like using blockchain and sharing honest data) and not working together (like withholding data or giving misleading information).

As like the game theory, in the blockchain-enabled supply chains, each stakeholder can be viewed as a rational actor trying to maximize their individual payoff. Researchers and lawmakers may be able to develop incentives that connect people's interests with the goal of making the supply chain more open if they understand these reward systems.

For blockchain adoption, the payoff for stakeholder i defined as [38]:

$$Ui(T) = Bi + Ri - Ci$$

Where:
$U_i(T)$: Amount of payoff for stakeholder i for adopting blockchain.
C_i: The cost of implementing blockchain technology, which includes making changes to how things work, training staff, and adding it to existing systems.
B_i: The benefits realized from improved transparency, such as enhanced reputation, access to premium markets, and operational efficiencies.
R_i: External rewards or subsidies provided by governments, industry consortia, or lead firms to encourage adoption.
P_i: Penalty or expected loss from non-compliance, which could include regulatory fines, loss of contracts, or reputational damage.

On the other hand if the stakeholder i does not adopt blockchain then the payoff will be [38],

$$Ui(NT) = -Pi$$

$U_i(T)$: Payoff for stakeholder i for not adopting blockchain.

Pi: Opportunity loss for not adopting (e.g., inefficiency, lost market access)

For truthful adoption to be the rational choice for stakeholder i:

$$Bi + Ri + Pi \geq Ci$$

This requirement makes sure that the total perceived advantages and rewards, as well as the penalties avoided, are more than the costs of adoption. In this instance, the best thing to do is to join a blockchain. In this case, the system enters a Nash equilibrium when no stakeholder can gain more money by changing their strategy on their own. Policymakers and supply chain leaders can make sure that "adopt and share truthfully" becomes a long-term stable outcome by carefully building Ri and Pi.

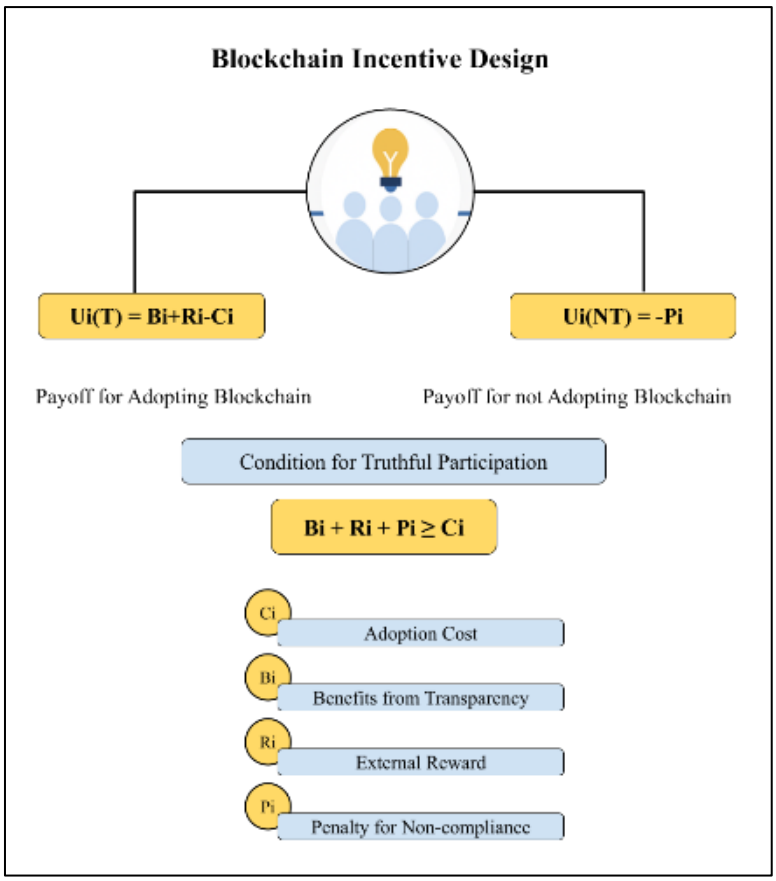

Figure 2 Payoff comparison and adoption condition

In addition, the way rewards and punishments are given out can be changed for different people based on how much they cost and how much they could gain. For instance, upstream providers with higher implementation costs may need bigger Ri to get people to join, while downstream actors may only need minimal changes.

The framework above shows a static, one-shot game, while real-world supply networks work all the time, which suggests a repeating game model. In repeated contacts, the promise of future collaboration and the threat of future sanctions can make stakeholders even more likely to use blockchain and be honest. Reputation effects in repeated games add further informal penalties: stakeholders who don't follow the rules risk losing trust and future business prospects, which makes them much more likely to follow the rules [47].

Positive network effects make it easier for people to use blockchain: the more people who use it, the more useful it becomes. In game theory, coalition formation is when groups of stakeholders work together to achieve benefits that everyone can use. This can then get more folks to join. The "adoption cascade," which is a type of progressive adoption dynamic, is useful for constructing phased incentive systems that start with early adopters and grow to include later participants.

3.2. Contract Theory

Contract theory is better than game theory because it shows how to write contracts that make it apparent what rewards and punishments will happen depending on behaviors that can be seen and checked. People have utilized contract theory in supply chains for a long time to lower moral hazard and get people to do the right thing.

3.2.1. Application in Blockchain-Enabled Supply Chains

Contract Theory lets us make clear rules for how to share data and use new technology when it comes to blockchain. Putting these obligations into formal contracts makes it clear what everyone needs to do, which makes it less likely that someone will try to take advantage of the situation.

3.2.2. Role of Smart Contracts

Smart contracts are self-executing agreements coded on the blockchain that automatically enforce the provisions of the contract when certain criteria are met. This makes contract theory stronger. Smart contracts cut eliminate the intermediaries, minimize the costs of running a business, and make sure that incentives and penalties are carried out on time and without bias.

For example:

- Payments can be paid right away when the shipment arrives and meets the quality standards.
- If someone is caught lying about data or not keeping track of it, they can be in trouble straight quickly.
- Tiered incentive structures can be adopted to provide higher rewards for early adopters or for actors who maintain compliance over time.

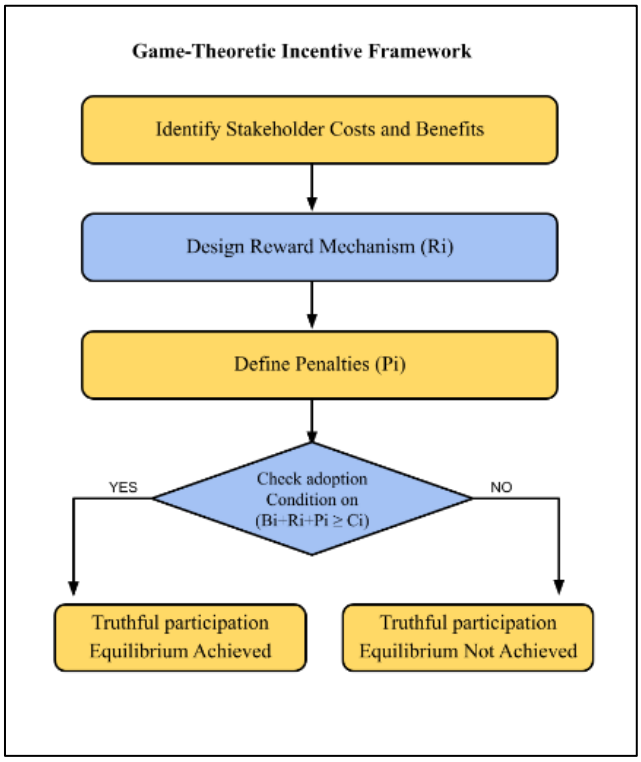

Figure 3 Stepwise design process from cost/benefit analysis to equilibrium

3.2.3. Risk Sharing and Flexibility

There are also ways for the parties to share risk in contracts, which can help keep expenses down when starting out. For instance, cost-sharing agreements can divide the costs of putting blockchain into action among all the supply chain participants. This makes it easier for everyone to work together and decreases their personal risk. Contracts can also be written in a way that lets them change with the market. Dynamic clauses let you adjust the rewards and punishments as the laws change, the costs of technology go down, or the number of individuals who accept something changes[46].

3.2.4. Enforceability and Legal Considerations

Smart contracts are great, but whether or not they can be enforced relies on the laws in the countries where the people in the supply chain operate. Varied countries have varied laws around smart contracts, and when it's not apparent how they will be enforced, they may not be as effective in real life. So, to be sure something is powerful, you often need to employ both the law and technology together.

4. Empirical and Simulation-Based Approaches

4.1. Case Studies

Real-world blockchain pilot projects have taught us a lot about how to use blockchain technologies in supply chains. These case studies help connect what we know about the theory with what we know about the problems that come up in real life. They show both what makes adoption easier and what makes it harder.

4.1.1. IBM Food Trust

The IBM Food Trust project is a good illustration of this. It works with big stores like Walmart and Carrefour to make food safer and easier to trace. Using blockchain, people can see where food comes from and where it goes in almost real time. This openness makes it easier to find and stop foodborne illness outbreaks, helps with inventory management, and builds trust with customers.

Important things from IBM Food Trust consist:

- Advantages of being an early mover: Companies who use blockchain early can help set standards and improve their standing in the industry.
- Trust in the brand and reputation: More openness is a great way to market a product since it makes people feel safe and confident in its quality.
- Cost and complexity: High upfront costs and problems with integration are still big problems, especially for small companies.

4.1.2. VeChain

VeChain's main areas of concentration include stopping counterfeiting and verifying products, especially luxury goods, wine, and car parts. VeChain lets customers and business partners check the authenticity and trace the origin of items by giving them unique digital identities and documenting their lifecycle data on the blockchain.

Outcoms from VeChain include:

- Consumer empowerment: Giving consumers the power to check things directly gives brands a strong reason to use blockchain.
- Value chain distinction: Brands can use openness to explain why their prices are higher and to strengthen their market differentiation.
- Ecosystem partnerships: To make things work, you typically need to work closely with your supply chain partners and technology providers.

Strong leadership commitment, benefits for consumers, and cooperation from regulators are some of the things that make these scenarios possible. On the other hand, impediments often include not being ready for new technology, not sharing benefits evenly, and worries about keeping data private.

4.2. Agent-Based Modeling

Agent-based modeling (ABM) is a great way to examine complicated systems with different actors that interact with each other. In supply chain settings, ABM lets researchers simulate each stakeholder (agent) with different traits, rules for making decisions, and ways of learning.

4.2.1. Benefits of Incentive Design

- Different behaviors: ABM shows how different supply chain actors have varied levels of risk tolerance, adoption costs, and perceived rewards.
- Emergent dynamics: ABM shows how local choices add up to create global system-level patterns, such adoption cascades or resistance clusters.
- Network effects: ABM analyzes network externalities in a clear way, showing how the value of using blockchain goes up as more people use it.

4.3. Sensitivity Analysis

Sensitivity analysis is the process of changing important parameters in a model in a planned way to see how they affect the results. When designing blockchain incentives, sensitivity analysis can help find the aspects that have the biggest effect on stakeholders' decisions and the overall adoption rate.

4.3.1. Applications in Designing Incentive

- **Reward and penalty thresholds**: Set minimum reward levels or maximum acceptable penalties that will encourage people to adopt.
- **Cost-benefit ratios**: Analyze how changes in adoption cost (Ci) and perceived benefits (Bi) affect the success of incentive programs.
- **Network structure impacts**: Assess how the structure of the network (for example, centralized vs. decentralized) affects how well incentives operate.

4.3.2. Policy Implications

Policymakers and supply chain leaders can use sensitivity analysis to:

- Decide how to best use resources for the most effective incentives.
- Create rules that can change if costs or market conditions change.
- Finding strong strategies that work well in a variety of uncertain future situations.

There are still big gaps in both academic and practical literature when it comes to using theoretical models like game theory and contract theory to figure out how to encourage people to use blockchain. These gaps make it hard to go from ideas to broad, effective use in the real world.

5. Limited Research on Dynamic Incentives

Most of the research that has been done thus far has looked at static, one-time incentive structures. But supply networks are continually evolving because of new rules and regulations, new technology, and changing market needs. The costs of using blockchain (Ci) generally decrease down over time as technology gets better and people learn more about it. On the other side, the benefits (Bi) may go up if individuals want more transparency [42].

There is a clear need for research into dynamic, time-dependent incentive mechanisms that adapt to these changes. Making incentives that alter as people go along the adoption curve keeps people motivated and gets people who are late to the party to join in.

5.1. Insufficient Analysis of Cross-Cultural and Jurisdictional Differences

Supply chains often go across borders, and each country has its own norms, culture, and laws. The way that penalties are implemented (Pi) can be highly different from one place to another, depending on the local laws, the strength of the institutions, and how people feel about following the rules and being open.

Most of the research that has been done so far has not looked at how these differences in jurisdiction affect how well incentive schemes work. We need to perform comparative study in other locations to find out how local conditions affect stakeholder behavior and to come up with the optimal incentive systems for those conditions.

5.2. Lack of Integrated, Multi-Dimensional Approaches

Most studies just look at economic incentives on their own and don't fully consider how behavior and technology affect them. Stakeholders' choices are affected by a number of factors, including financial incentives, perceived risks, cultural norms, organizational readiness, and technical skills.

A comprehensive framework combining economic, behavioral, and technological incentives is necessary to address these interdependent factors holistically. For example, giving someone money together with technical training and public recognition might be more effective than just giving them money.

5.3. Limited Empirical Validation

Models based on theory and simulation are helpful, but there isn't enough real-world research to back them up. We need to undertake additional field tests, long-term studies, and huge pilot projects to see how effective the theories are in the actual world and make them more accurate.

6. Future Research Directions

6.1. Empirical Validation

Future research should focus on integrating empirical data to validate theoretical incentive models. Field studies, controlled experiments, and large-scale pilot programs can provide insights into real-world effectiveness and uncover context-specific challenges and enablers.

6.2. Hybrid Modeling Approaches

Developing hybrid frameworks that combine agent-based simulations with optimization and econometric models can provide more robust predictions. Such approaches can capture both micro-level behaviors and macro-level system dynamics, offering more comprehensive guidance for policy and managerial decisions.

6.3. Incorporating Sustainability and Social Responsibility Incentives

Beyond economic incentives, future studies should explore how environmental and social responsibility incentives can motivate blockchain adoption. For example, linking blockchain adoption to carbon credits, sustainability certifications, or ethical sourcing labels may align with broader corporate strategies and attract environmentally conscious consumers.

6.4. Investigating Coalition and Network Effects

Research should also examine the role of coalition formation and network dynamics in blockchain adoption. Understanding how alliances among early adopters or industry consortia influence broader supply chain adoption can inform strategies for achieving critical mass and maximizing network effects.

6.5. Behavioral Economics Insights

Integrating insights from behavioral economics, such as framing effects, loss aversion, and social norms, into incentive design can further enhance effectiveness. Future work can explore how psychological and social factors interact with economic incentives to shape stakeholder decisions.

7. Conclusion

Blockchain technology has made supply networks more transparent, honest, and reliable. Blockchain helps to keep track of where goods originate from, make sure they are legal, and build trust with customers in ways that were never possible before. Right now, it's not practical to use blockchain in supply chains because of a number of problems with the technology, the firm, and how people work.

This review has showed how important it is to provide people rewards to fix these problems. We used ideas from game theory and contract theory to show that people can work together to make the community more open if they get the correct rewards and punishments. Incentive systems can help everyone in the supply chain make the right choice by making sure that the perceived benefits and incentives are greater than the costs of following the rules and the chance of being punished for not doing so.

IBM Food Trust and VeChain are two instances from the real world of how blockchain technologies may work. It underscore the importance of strategic incentives, including early mover advantages, brand differentiation, and enhanced consumer trust. In addition, simulation approaches like agent-based modeling and sensitivity analysis offer valuable tools for evaluating and optimizing incentive strategies before large-scale implementation.

Even with these adjustments, the study still has a number of flaws. There hasn't been enough research on things like dynamic and adaptive incentives, differences in culture and laws, and integrated multi-dimensional approaches that look at economic, behavioural, and technological factors. We need to patch in these holes so that we can make complete solutions that will let a lot of people use blockchain for a long period.

This study shows policymakers how important it is to have centralised monitoring, pooled transparency financing, and incentive structures that change with the market and technology. Managers need to make little adjustments, get stakeholders involved, and relate to people in the correct way to develop trust and commitment in a company.

Researchers should spend more time testing theoretical models in the real world, looking into hybrid simulation frameworks, and making sure that incentives are designed with social responsibility and sustainability in mind. Learning more about coalition effects and how networks work will also help us find more ways to reach critical mass and make the most of blockchain through network effects.

Setting the right incentives is not just one component of constructing technology; it is the most critical thing that will help blockchain change supply chains. If people think that their own goals are in harmony with the group's goals, they can transition to open, strong, and socially responsible global supply chains. This can help with rewards that are strong and well thought out. Blockchain technology can help develop supply chains that are completely open and reliable. This is feasible because of research that crosses fields and policies and actions that operate together.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] O. Esan, F. A. Ajayi, and O. Olawale, "Supply chain integrating sustainability and ethics: Strategies for modern supply chain management," https://wjarr.co.in/sites/default/files/WJARR-2024-1259.pdf, vol. 22, no. 1, pp. 1930–1953, Apr. 2024, doi: 10.30574/WJARR.2024.22.1.1259.

[2] L. Chen, Y. Lu, and R. Zhao, "Analysis and application of modern supply chain system in China," Modern Supply Chain Research and Applications, vol. 1, no. 2, pp. 106–119, May 2019, doi: 10.1108/MSCRA-01-2019-0004.

[3] R. Wiedmer and S. E. Griffis, "Structural characteristics of complex supply chain networks," Journal of Business Logistics, vol. 42, no. 2, pp. 264–290, Jun. 2021, doi: 10.1111/JBL.12283.

[4] "Performance Benefits of Supply Chain Logistical Integration on JSTOR." Accessed: Jul. 10, 2025. [Online]. Available: https://www.jstor.org/stable/20713491

[5] R. H. Ballou, S. M. Gilbert, and A. Mukherjee, "New Managerial Challenges from Supply Chain Opportunities," Industrial Marketing Management, vol. 29, no. 1, pp. 7–18, Jan. 2000, doi: 10.1016/S0019-8501(99)00107-8.

[6] B. Ageron, O. Bentahar, and A. Gunasekaran, "Digital supply chain: challenges and future directions," Supply Chain Forum: An International Journal, vol. 21, no. 3, pp. 133–138, Jul. 2020, doi: 10.1080/16258312.2020.1816361.

[7] R. C. Lamming, N. D. Caldwell, D. A. Harrison, and W. Phillips, "Transparency in supply relationships: Concept and practice," Journal of Supply Chain Management, vol. 37, no. 3, pp. 4–10, Sep. 2001, doi: 10.1111/J.1745-493X.2001.TB00107.X;REQUESTEDJOURNAL:JOURNAL:1745493X;WGROUP:STRING:PUBLICATION.

[8] K. D. Cattani, W. G. Gilland, and J. M. Swaminathan, "Coordinating Traditional and Internet Supply Chains," pp. 643–677, 2004, doi: 10.1007/978-1-4020-7953-5_15.

[9] T. Roy, J. A. Garza-Reyes, V. Kumar, A. Kumar, and R. Agrawal, "Redesigning traditional linear supply chains into circular supply chains–A study into its challenges," Sustain Prod Consum, vol. 31, pp. 113–126, May 2022, doi: 10.1016/J.SPC.2022.02.004.

[10] H. Canton, "Organisation for Economic Co-Operation and Development—OECD," The Europa Directory of International Organizations 2021, pp. 677–687, Jul. 2021, doi: 10.4324/9781003179900-102.

[11] S. Sarpong, "Traceability and supply chain complexity: Confronting the issues and concerns," European Business Review, vol. 26, no. 3, pp. 271–284, 2014, doi: 10.1108/EBR-09-2013-0113/FULL/XML.

[12] A. Moretto, L. Grassi, F. Caniato, M. Giorgino, and S. Ronchi, "Supply chain finance: From traditional to supply chain credit rating," Journal of Purchasing and Supply Management, vol. 25, no. 2, pp. 197–217, Mar. 2019, doi: 10.1016/J.PURSUP.2018.06.004.

[13] V. Roy, "Contrasting supply chain traceability and supply chain visibility: are they interchangeable?," International Journal of Logistics Management, vol. 32, no. 3, pp. 942–972, 2021, doi: 10.1108/IJLM-05-2020-0214/FULL/XML.

[14] M. Chamekh, S. El Asmi, M. Hamdi, and T. H. Kim, "IoT Based Tracking System for Supply Chain Management," Proceedings - 2018 International Conference on Wireless Networks and Mobile Communications, WINCOM 2018, Jul. 2018, doi: 10.1109/WINCOM.2018.8629607.

[15] Md Razibul Islam, "Circular economy leadership for sustainable industrial transformation: A holistic framework for resilient and resource-efficient growth," World Journal of Advanced Engineering Technology and Sciences, vol. 17, no. 3, pp. 253–262, 2025, doi: 10.30574/wjaets.2025.17.3.1540.

[16] R. Cole, M. Stevenson, and J. Aitken, "Blockchain technology: implications for operations and supply chain management," Supply Chain Management, vol. 24, no. 4, pp. 469–483, Jun. 2019, doi: 10.1108/SCM-09-2018-0309/FULL/XML.

[17] A. Gurtu and J. Johny, "Potential of blockchain technology in supply chain management: a literature review," International Journal of Physical Distribution and Logistics Management, vol. 49, no. 9, pp. 881–900, Nov. 2019, doi: 10.1108/IJPDLM-11-2018-0371/FULL/XML.

[18] M. M. Queiroz, R. Telles, and S. H. Bonilla, "Blockchain and supply chain management integration: a systematic review of the literature," Supply Chain Management, vol. 25, no. 2, pp. 241–254, Feb. 2020, doi: 10.1108/SCM-03-2018-0143/FULL/XML.

[19] S. Saberi, M. Kouhizadeh, J. Sarkis, and L. Shen, "Blockchain technology and its relationships to sustainable supply chain management," Int J Prod Res, vol. 57, no. 7, pp. 2117–2135, Apr. 2019, doi: 10.1080/00207543.2018.1533261.

[20] G. Blossey, J. Eisenhardt, and G. J. Hahn, "Blockchain Technology in Supply Chain Management: An Application Perspective," Hawaii International Conference on System Sciences 2019 (HICSS-52), Jan. 2019, Accessed: Jul. 10, 2025. [Online]. Available: https://aisel.aisnet.org/hicss-52/os/impact_of_blockchain/6

[21] Y. A. Bipasha, "Blockchain technology in supply chain management: Transparency, security, and efficiency challenges," International Journal of Science and Research Archive, vol. 10, no. 1, pp. 1186–1196, 2023.

[22] Y. A. Bipasha, "Market efficiency, anomalies and behavioral finance: A review of theories and empirical evidence," World Journal of Advanced Research and Reviews, vol. 15, no. 2, pp. 827–839, 2022.

[23] B. Esmaeilian, J. Sarkis, K. Lewis, and S. Behdad, "Blockchain for the future of sustainable supply chain management in Industry 4.0," Resour Conserv Recycl, vol. 163, p. 105064, Dec. 2020, doi: 10.1016/J.RESCONREC.2020.105064.

[24] Md Hossain and Md Bahar Uddin, "Digital twins in additive manufacturing," World Journal of Advanced Engineering Technology and Sciences, vol. 13, no. 2, pp. 909–918, Dec. 2024, doi: 10.30574/wjaets.2024.13.2.0645.

[25] Md Hossain and Md Bahar Uddin, "Digital twins in additive manufacturing," World Journal of Advanced Engineering Technology and Sciences, vol. 13, no. 2, pp. 909–918, Dec. 2024, doi: 10.30574/wjaets.2024.13.2.0645.

[26] Md Hossain and Md Bahar Uddin, "Digital Twins and Federated Learning for Industrial Internet of Things," International Journal of Science and Research Archive, vol. 16, no. 1, pp. 729–736, Jul. 2025, doi: 10.30574/ijsra.2025.16.1.2087.

[27] M. Wang, Y. Wu, B. Chen, and M. Evans, "Blockchain and supply chain management: A new paradigm for supply chain integration and collaboration," Operations and Supply Chain Management, vol. 14, no. 1, pp. 111–122, 2021, doi: 10.31387/OSCM0440290.

[28] B. G. Smith, "Developing sustainable food supply chains," Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 363, no. 1492, pp. 849–861, Feb. 2008, doi: 10.1098/RSTB.2007.2187.

[29] S. F. Wamba and M. M. Queiroz, "Blockchain in the operations and supply chain management: Benefits, challenges and future research opportunities," Int J Inf Manage, vol. 52, p. 102064, Jun. 2020, doi: 10.1016/J.IJINFOMGT.2019.102064.

[30] V. Paliwal, S. Chandra, and S. Sharma, "Blockchain Technology for Sustainable Supply Chain Management: A Systematic Literature Review and a Classification Framework," Sustainability 2020, Vol. 12, Page 7638, vol. 12, no. 18, p. 7638, Sep. 2020, doi: 10.3390/SU12187638.

[31] M. B. Uddin, Md Razibul Islam, M. N. Uddin, and A. Halim, "Next-generation plastic recycling: Breakthrough developments and the path toward a circular economy," World Journal of Advanced Engineering Technology and Sciences, vol. 16, no. 1, pp. 513–527, 2025.

[32] Z. Chabani, S. Hamouche, and R. Said, "Is Blockchain Technology Applicable in Small and Medium-Sized Enterprises?," Lecture Notes in Networks and Systems, vol. 211 LNNS, pp. 505–514, 2021, doi: 10.1007/978-3-030-73882-2_46.

[33] A. A. Khan, A. A. Laghari, P. Li, M. A. Dootio, and S. Karim, "The collaborative role of blockchain, artificial intelligence, and industrial internet of things in digitalization of small and medium-size enterprises," Sci Rep, vol. 13, no. 1, pp. 1–13, Dec. 2023, doi: 10.1038/S41598-023-28707-9;SUBJMETA=1042,117,639,705;KWRD=COMPUTATIONAL+SCIENCE,COMPUTER+SCIENCE.

[34] Y. A. Bipasha, "Predicting fraud in credit card transactions," International Journal of Science and Research Archive, vol. 15, no. 2, pp. 1167–1177, 2025.

[35] Y. A. Bipasha, "Stock market prediction using LSTM," International Journal of Science and Research Archive, vol. 12, no. 2, pp. 3146–3153, 2024.

[36] S. Singh, A. Gaur, and D. Singh, "Blockchain-Based Governance: Implications for Organizational Boundaries and Structures," British Journal of Management, vol. 35, no. 4, pp. 1692–1699, Oct. 2024, doi: 10.1111/1467-8551.12784.

[37] S. M. Mulaji and S. Roodt, "Factors Affecting Organisations' Adoption Behaviour toward Blockchain-Based Distributed Identity Management: The Sustainability of Self-Sovereign Identity in Organisations," Sustainability 2022, Vol. 14, Page 11534, vol. 14, no. 18, p. 11534, Sep. 2022, doi: 10.3390/SU141811534.

[38] Md Razibul Islam, "Digital leadership and circular economy performance in sustainable supply chains," World Journal of Advanced Engineering Technology and Sciences, vol. 17, no. 3, pp. 503–508, 2025, doi: 10.30574/wjaets.2025.17.3.1583.

[39] V. Varriale, A. Cammarano, F. Michelino, and M. Caputo, "New organizational changes with blockchain: a focus on the supply chain," Journal of Organizational Change Management, vol. 34, no. 2, pp. 420–438, Mar. 2021, doi: 10.1108/JOCM-08-2020-0249/FULL/PDF.

[40] R. Han, Z. Yan, X. Liang, and L. T. Yang, "How Can Incentive Mechanisms and Blockchain Benefit with Each Other? A Survey," ACM Comput Surv, vol. 55, no. 7, p. 136, Jul. 2023, doi: 10.1145/3539604/ASSET/D5BCE603-EB14-4A22-867D-B7137B8910E1/ASSETS/IMAGES/LARGE/CSUR-2021-0132-T05.JPG.

[41] J. Chiu and T. Koeppl, "Incentive Compatibility on the Blockchain," pp. 323–335, 2019, doi: 10.1007/978-3-319-93809-7_20.

[42] Md Razibul Islam, "System dynamics of leadership influence in sustainable supply chains," World Journal of Advanced Engineering Technology and Sciences, vol. 17, no. 3, pp. 509–514, 2025, doi: 10.30574/wjaets.2025.17.3.1584.

[43] Y. Liu, Z. Fang, M. H. Cheung, W. Cai, and J. Huang, "An Incentive Mechanism for Sustainable Blockchain Storage," IEEE/ACM Transactions on Networking, vol. 30, no. 5, pp. 2131–2144, Oct. 2022, doi: 10.1109/TNET.2022.3166459.

[44] Z. Liu et al., "A Survey on Blockchain: A Game Theoretical Perspective," IEEE Access, vol. 7, pp. 47615–47643, 2019, doi: 10.1109/ACCESS.2019.2909924.

[45] Md Bahar Uddin, Md. Hossain, and Suman Das, "Advancing manufacturing sustainability with industry 4.0 technologies," International Journal of Science and Research Archive, vol. 6, no. 1, pp. 358–366, Jun. 2022, doi: 10.30574/ijsra.2022.6.1.0099.

[46] S. Pu and J. S. L. Lam, "A game theoretic approach of optimal adoption time of blockchain: A case of ship operators," Comput Ind Eng, vol. 169, p. 108219, Jul. 2022, doi: 10.1016/J.CIE.2022.108219.

[47] K. K. Mondal, Y. A. Bipasha, S. A. S. M. Naim, and P. Podder, "Hybrid sentiment analysis of drug reviews using ML and lexicon-based methods," in Proc. 6th Int. Conf. on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, 2025, pp. 1090–1095.

[48] Rahman, F., Das, D., Sami, A., Podder, P., & Michael, D. L. (2024). Liver cirrhosis prediction using logistic regression, naïve bayes and KNN. International Journal of Science and Research Archive, 12(1), 2411-2420.