A Smart Contract Solution to Exercise Habit Building via Commitment Devices

Applications of Blockchain to Improve Traditional Supply Chains

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How can blockchain and internet of things technologies be developed to increase supply chain efficiency and transparency?

In the summer of 2015 Chipotle had two major E. coli outbreaks in Seattle and California. Between the two incidents over 200 people were infected with E. coli (Food Poisoning News, 2022). In a comprehensive review of the incident, Chipotle could not identify the source of contamination because they could not trace their own convoluted supply chains (Law, 2010, p.42). The integration of blockchain technology with smart contracts that act on observations made by Internet of Things (IoT) sensors has the potential to increase the efficiency and transparency of supply chains (Hasan, 2019, p.150). If this supply chain infrastructure had existed in 2015, Chipotle and regulators at the FDA could have identified storage conditions that lead to contamination from IoT data on blockchain records. I will research how relevant stakeholders – consumers, businesses, and regulators – have interests that are aligned and misaligned in the development of such smart contract supply chain infrastructure.

Blockchain is a publicly viewable digital ledger that allows for a distributed peer-to-peer computer network to keep an immutable record of accounts. Distributed means no one computer system governs it, rather many computer systems agree to append new records to the ledger via rules defined by open-source code that anyone can read, run or make approved revisions to. Immutable records are data that once the distributed network agrees to adopt will always exist sequentially on the blockchain. In cryptocurrencies like Bitcoin, these records would contain information about payments. Other blockchains like Ethereum have enhanced functionality that allows these records to contain executable programs called smart contracts. The goal of smart contracts is to automate legal contracts in whole or in part as code (Zou, 2021, p.1). Internet of

things (IoT) devices are low-power computer devices such as digital sensors that can record their readings in blockchain records. I will demonstrate the feasibility of smart contract-enabled supply chains with a proof-of-concept technical project.

Applications of Blockchain to Improve Traditional Supply Chains

What interests are aligned and misaligned between majority stakeholders in the sociotechnical system? How will this motivate the development and adoption of smart contract-enabled supply chains?

Technologies seldom reach their final form purely due to the designers' intentions. Instead, different societal institutions, norms, and stakeholder groups compete for the development of emerging technologies to best suit their interests. Smart contract-enabled supply chains, smart supply chains, are no different. For example, design choices that prioritize transparency may make information public that businesses would rather keep private to maintain a competitive advantage. I wish to examine how different components of the sociotechnical system will compliment and compete with one another in the development of smart supply chains.

Background: A Motivating Example

The startup *seafoodsouq*, headquartered in Dubai has built a seafood supply chain network for international seafood markets with blockchain. In their fish-packing facilities, when products are packaged, QR codes are attached to the packaging to display in a user-friendly manner: where the seafood is from, the timeline from catch to delivery, and adherence to international laws.

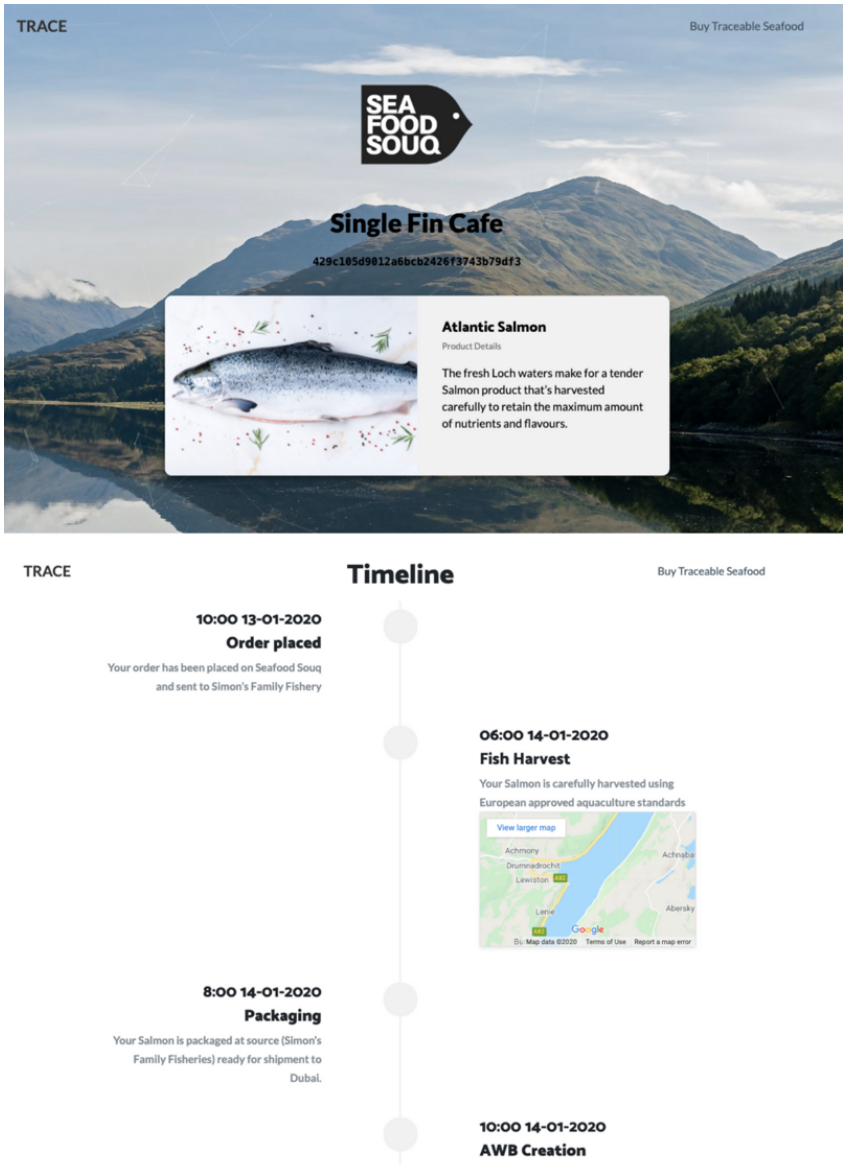

Figure 1: seafoodsouq QR code scan web result

This adoption of smart supply chains makes them more efficient: *seafoodsouq* has "successfully delivered multiple times Maine Coast Lobster to Dubai within 24 hours, 100% live = zero wastage" (Sophie, 2021). Also, this smart supply chain system provides transparency that allows consumers to purchase seafood based on personal ethical preferences like adherence to sustainable fishing or time from catch to table. These are choices consumers do not have in traditional seafood supply chains. Regulators can monitor the *seafoodsouq* blockchain to ensure

food quality and freshness are maintained. Regulators may hope to require *seafoodsouq* supplier companies to report hourly temperature to the blockchain so that regulators can better fulfill their mandate. However, *seafoodsouq* may resist such a measure as it could expose the identities of their suppliers which in turn may hurt their business as *seafoodsouq* competitors poach off *seafoodsouq's* suppliers.

Literature Review

Smart contracts have three main advantages over conventional contracts according to Zheng. First, they reduce risk because once issued they are immutable making malicious behaviors like financial fraud much more difficult. Second, they reduce administrative and service costs by replacing a central broker, and the costs that come with one, with a decentralized network to perform similar capabilities. Third, they improve the efficiency of the business process by significantly reducing turnaround time once contract conditions are met (Zheng, 2019, p.476).

It is not just the food supply chain that benefits from blockchain, IoT, and smart contract integration. Dr. Satyabrata Aich and a team of South Korean researchers conducted a case study of smart supply chains' impacts on the automotive, pharmaceutical and retail industries. Most interesting is that smart supply chains decrease instances of counterfeit drugs by providing transparency to the lifecycle of drugs. This is accomplished with global trade item numbers that when referenced before giving a drug to a patient can display information about each step in the production and distribution pipeline all the way back to the raw material supplier (Aich, 2019, p.140). The Cobalt mining industry is another example that would benefit from increased transparency. A smart supply chain system would provide traceability for companies to measure and be held accountable for social, environmental, and sustainability concerns (Hastig and Sodhi,

2020, p. 942). The increased transparency from supply chains allows consumers to make more informed and sustainable choices. Such as avoiding the purchase of "blood diamonds", diamonds from supply chains that involve child labor and unethical supply processes (Park, 2021, p.8).

The Australian National University's Center for Asia & the Pacific Policy Studies (APPS) produced a report commenting on how blockchain supply chains integrate with different regulatory states. 40% of Asian Pacific Economic Cooperation member countries require that domestic regulatory reports of international trade be conducted with paper methods. APPS notes a need to quickly collaborate on standard blockchain protocols that comply with each country's domestic policies for trade imports (Allen, 2019, p. 375). This figure demonstrates how ambitious smart supply chain integration would be on an international stage.

Theoretical Framework

The outlined sociotechnical system subscribes well to the Actor-Network Theory (ANT). The ANT framework allows for humans, technologies, and institutions to all be full participants in the socio-technical system. Consider the food supply chain example: all the IoT sensors in supply chain systems would effectively take on the role of a human enforcer monitoring the temperature of all shipments during each stage of transport and would have the ability to alert stakeholders to hazardous conditions. If necessary, there could be a ban on an unsafe shipment, preventing contaminated food from being served. This system could inexpensively expand the power of regulatory institutions such as the FDA because they can monitor the blockchain to carry out their mission while simultaneously deploying human enforcers. Likewise, smart supply chains empower court systems with abundant information to rapidly resolve disputes between businesses within supply chains.

Methods

To collect evidence on how incentives are aligned and misaligned in the shaping of this emerging technology I will perform a review of the academic literature on how the judicial and regulatory systems are anticipating and preparing for this shift. As well as interview experts like Alexander Tabarrok – director of the Center for the Study of Public Choice at George Mason University. Additionally, I will research and critique existing proposals for proposed distributed smart supply chain protocols leveraging research articles like "Configuring blockchain architectures for transaction information in blockchain consortiums: The case of accounting and supply chain systems" by Daniel E. O'Leary. Lastly and perhaps most importantly to understand how businesses are planning to implement such systems I will review cooperate marketing materials and 3rd party reviews and overviews of existing and experimental smart supply chains. Finally, I will interview people who have worked on projects like IBM's Supply Chain Solution used in vaccine production & distribution as well as the German automotive industry (Transformation is a journey - IBM, 2015).

A Smart Contract Solution to Exercise Habit Building via Commitment Devices

How to develop a smart contract to enforce commitment deceives for exercise habits while protecting users' sensitive data?

For my proof-of-concept project, I will be developing a decentralized application for users to issue "commitment device" smart contracts with themselves or groups. A commitment device is an economic concept to incentivizes an action by forcing an explicit cost for failure to exhibit the desired behavior. For example, to incentivize my exercise every day a smart contract could take $5 from my personal Ethereum wallet (similar to a traditional bank account) at the

beginning of the day. Then the programmatic trigger to return the $5 back to me would be an event broadcasted to the blockchain by my fitness tracker stating I had more than 60 minutes of an elevated heart rate in the day. Otherwise, the money is lost to me forever.

In this proof-of-concept, I will model two key aspects of smart blockchain-enabled supply chains. First, a smart contract requires actions to be taken in the real and tangible world before payment is made. In real supply chains, this is a vendor transporting the specified good in a measurable time and condition. My proxy for this is daily health data supplied from a fitness tracker Application Program Interface (API) such as Apple HealthKit or Fitbit Developer API.

The second major problem blockchains in supply chains would solve is creating a decentralized source of trust between untrustworthy parties. Meaning a vendor does not have to take the supplier at their word that goods have been properly transported. Rather, the supplier can prove to the vendor via data on the blockchain from IoT sensor readings that the conditions and transport times of goods were within specific parameters of the smart contract. This prompts the smart contract the automatically release the agreed-upon funds. This second problem is trickier to demonstrate in my proof of concept, however, one possible way to conduct this would be to organize “exercise habit-changing groups” that are collectively punished if a threshold of users does not achieve 60 minutes of elevated heart rate in a day. This system creates a decentralized source of trust because the distributed peer-to-peer blockchain securely holds and then releases the group's funds when the number of users meets the threshold and the group proves they have accomplished their fitness goals. The alternative would be to trust some person to not run off with the group's money and strictly enforce the repayment conditions.

This project could be accomplished by using a programming language called Solidity which was developed by the creators of the Ethereum blockchain network. This allows me to

deploy and test my smart contract on an existing blockchain network rather than creating my own. However, executing code on the Ethereum blockchain requires payment to the distributed network, called gas fees, in the cryptocurrency Ether. A possible solution to circumvent this unnecessary development cost would be to leverage a free Ethereum test network or create my own using AWS Managed Blockchain.

This proof-of-concept would be a useful contribution to the development of smart supply chains because it would present a solution for the two major issues previously mentioned. Additionally, because health data is considered very sensitive in this society my project would have to protect the data. The security challenge is how to securely store API keys that allow access to all health data stored by a fitness tracker provider on a publicly viewable ledger. This will likely involve some cryptographic tricks to protect these API keys; I will borrow techniques used by Dr. Hongjiao Wu in the paper "Security and Privacy of Patient Information in Medical Systems Based on Blockchain Technology", 2021. This problem is similar to how can businesses use smart supply chains while protecting sensitive data like supplier names and negotiated prices.

Conclusion

In the STS research, I will explore and analyze how stakeholders are likely to work together and contribute to a shared vision for smart supply chains. More importantly, however, I will be looking at how to solve issues when incentives are misaligned, attempting to find technological and non-technological solutions to aid in the realignment of incentives so that future production-grade smart supply chain infrastructure can serve the needs of many stakeholders rather than the technology being informed by and developed to serve the needs of only one powerful stakeholder. In the technical project, I will be attempting to solve one of these major misalignments in that businesses are hesitant to embrace blockchains because of fear they

would expose valuable private information. The STS work will contain an assortment of others' ideas to realign misaligned incentives. Hopefully, the resulting work will contribute to the accelerated development of smart supply chains that would have a maximized positive impact on society.

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