# Stakeholder Conflict in Shaping of Smart Supply Chains

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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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## Introduction

Our modern globalized world allows us access to many products from all over the world. Facilitating the shipment and fulfillment of all these products requires a highly complex interaction of supply chains. The composition of these supply chains is opaque which reduces the ability of final consumers, businesses, and governments to make informed and reasoned decisions. Consumers know little about the origin or sourcing of their products. Businesses must trust suppliers are transporting products in the correct conditions rather than proving that they do. Finally, governments, specifically regulators, can have issues preventing unsafe products from reaching consumers as they often must take retroactive actions rather than proactive measures.

What can be done to improve the outcomes of supply chains for businesses, consumers, and regulators? Supply chain management "is a process that encompasses the entire process of transporting, storing, and delivering products from the place of raw materials to production and to the final consumers" (Park & Li, 2021, p.3). One metric that can improve supply chains is transparency because the increase in available information will enable each stakeholder group to make more informed choices, thus providing benefits to society overall. Transparency can refer to the conditions of goods as well as the path and timing from the origin of the inputs to the final product destination. Blockchain is a technology that promotes transparency and traceability.

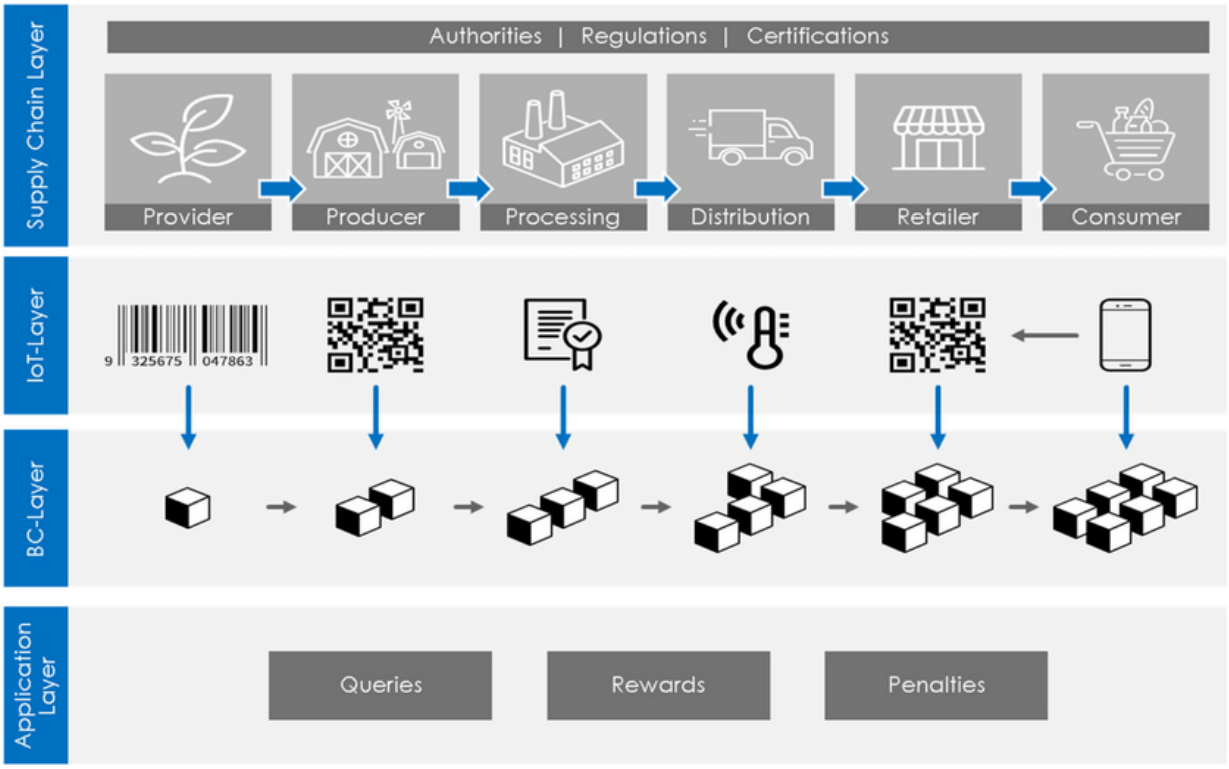
Blockchain is a publicly viewable digital ledger that allows for a distributed peer-to-peer computer network to keep an immutable record of accounts. Distributed means no one computer system governs it, rather many computer systems agree to append new data to the ledger. A blockchain is a way of structuring data in discrete segments called blocks, which are ordered sequentially to form a 'chain'. All blocks and their ordering are identically maintained on every computer in the distributed network. Blockchains can be thought of as append-only databases.

Blockchain is frequently discussed in the context of cryptocurrencies because they first popularized the technology. Blockchain enables users to prove how much cryptocurrency they own by showing all transactions they have ever been involved in on a public ledger. In the context of supply chains, blockchain provides transparent data to prove where things came from, where they went, and in what condition were they transported there on a public ledger.

Internet of Things (IoT) devices are cheap, low-power computer devices such which perform very specific tasks. Examples of IoT devices in your home may include smart thermostats, lightbulbs, serge breakers, doorbells, and security cameras. They perform very simple automated tasks that often interact with the physical world. In the context of supply chains, IoT devices primarily facilitate data collection as they are temperature, humidity, pressure, GPS, etc. sensors. These measurements can be aggregated and associated with specific shipping containers when provided as new data for a blockchain. The combination of blockchain distributed ledger and IoT sensor devices will be referred to as a *smart supply chain*.

**Figure 1**

*Cyber-physical system of smart supply chain (Aich, 2019, p.3)*




Smart supply chains store immutable data about food through each step of the supply chain process and store it on a public ledger. For example, a shipment of apples can be given from the producer to the processing and distribution partner in the supply chain. The quantity and type of apples is recorded in addition to a GPS measurement which indicates which orchard the apples came from. During transport the temperature and humidity are recorded on the blockchain so that retailers and consumers can verify that the apples are of good quality before they purchase!

The potential of smart supply chains to disrupt supply chain information problems motivated the following research question. How can blockchain and IoT technologies be developed to increase global supply chain transparency in the food sector?

The food industry benefits from smart supply chain adoption by providing transparency about the following three constraints of food supply chain logistics. One is *time constraints* - food spoils, blockchain records on the digital ledger must be able to prove that it was transported in a timely manner. Second, *transportation condition constraints* – food must be sealed and often stored consistently at specific temperatures and humilities. Lastly, *sustainable & ethical sourcing* - food can be produced in ways that harm society. Examples are overfishing depleting future sustainable supply or deforestation to produce additional arable land. It can be argued that most if not all major industries are subject to some if not all of these three constraints. So, the findings and recommendations in this paper will be applicable to all supply chains more broadly.

**Methods**

This discussion considers stakeholders in three groups: businesses, regulators, and consumers. This is a simplification as there are real entities that are a mix of these groups. For example, non-government organizations (NGOs) would access the blockchain like a consumer but perform the functions of regulators. Or state-owned enterprises (SOEs) which function as a business yet internally regulate.

This research aims to study how transparency is designed in smart supply chains, and what consequences these design choices have on society. In the results section, secondary sources are analyzed to understand what the transparency of smart supply chains can enable for different societal stakeholder groups. Then, business case studies from early adopters of the technology inform what the consequences of different smart supply chain designs are for each stakeholder. There will be an emphasis on identifying misaligned incentives between stakeholder groups which create conflicts. The goal is to inform a discussion of how stakeholders involved in

smart supply chain systems have power over the design of these systems and how that power enables them to shape the technology in alignment with their interests.

## Results

The structure of the results section is first explaining the motivation for why each stakeholder group has incentives to contribute to the shaping of the sociotechnical system of smart supply chains. This will explore what capabilities smart supply chains may provide or enhance benefits for different stakeholders. Second, a presentation of two business case studies. These cases represent two extremes of how smart supply chains may be designed and utilized. There is also a small section on issues of blockchain robustness and security.

### *Consumer Perspective*

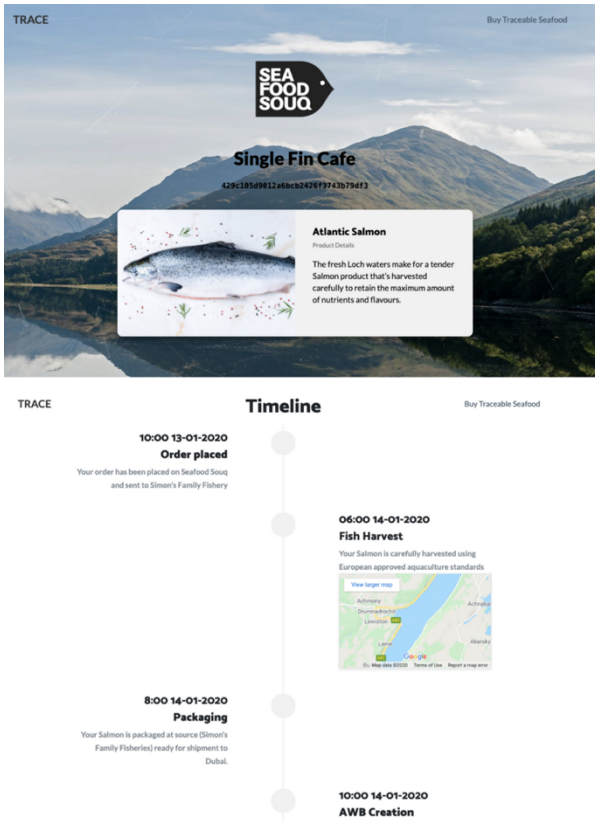
There exist *food groups* that are essentially community-organized food wholesalers, their purpose is to bring demanded products that otherwise would not exist in their area. These groups are formed for reasons in addition to reducing per unit cost, "food is transformed into a vector which carries with it additional signals of beliefs, motives, and ethics that are conveyed through the purchase of the goods" (Little et. al, 2010, p. 1807). These groups organize around a specific intention, some of which include purchasing locally grown organic, ethically sourced, or exotic foods (Little et. al, 2010, p. 1804). Food Groups would be aided by transparency enabled by smart supply chains because it would make discovering food suppliers simpler. Data on the smart supply chain blockchain could include supplier's products and location which can be searched and filtered to find partners suitable for a given food group's function.

On the individual consumer level, the immense data collected and organized on the blockchain can support applications that present the methods and processes for food production.

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 (Sophie, 2021). Applications like *seefoodsouq* enable consumers to make informed food-purchasing decisions in accordance with their own personal preferences and ethics.

**Figure 2**

*Seafoodsouq QR code scan web result*



*Regulator Perspective*

Transparency from smart supply chains enables regulators to promote public safety and encourage sustainable practices. Public safety is a regulator's role to prevent unsafe foods from reaching consumers. Sustainability will refer to environmental, social, and governance (ESG) goals, which regulators have a role in enforcing to increase public welfare.

Recall the data on smart supply chains blockchain is IoT sensor data associated with specific products. This traceable transparency could be very useful for preventing food born illnesses caused by contamination (Aich et. al, 2019, p.3). This is accomplished in two ways, first, unsafe transport conditions like a temperature being too high and indicating that food has spoiled before it is sold to customers. And in the event of an outbreak, finding the commonality in cases is much simpler with ample blockchain data.

Smart supply chains can play a role in environmental sustainability by more accurately measuring pollution and the interactions between the environment and the economy. From these measurements abatement standards can be set and again measured against the blockchain records to ensure pollution targets are met (Park & Li, 2021). Another type of environmental problem that can be monitored and mitigated with blockchain supply chain records is preventing the over-extraction of resources like fish and lumber. With respect to social sustainability, smart supply chains have been promoted as a method for mediating unethical labor practices that reduce safety and human rights like child labor in the “blood diamonds” trade (Park & Li, 2021). Ideally, the measurement data on the smart supply chain blockchain produce indisputable numerical data about conditions during transport and the duration and location of transport. From this data, inferences can be gathered about if locations produce larger than expected quantities under humane and sustainable practices, which would suggest that these firms are “mixing in” amounts

of material from unethical or unsustainable practices (Hastig & Sodhi, 2020). As for developing countries whose resources are extracted via unethical practices, the transparency provided by smart supply chains may promote economic growth. This is because smart supply chain data may be useful in combating corruption and malignant institutions (Hastig & Sodhi, 2020).

*Business Perspective*

There are varying extents of transparency from fully publicly available to restrictive to select groups of people. Transparency for businesses refers to "the disclosure of information to trading partners, shareholders, customers, consumers, and regulatory bodies" (Hallani et. al, 2021, p.1). Popular blockchains like Bitcoin and Ethereum are decentralized and public, meaning anyone can contribute to the system and anyone can observe the contents of the system. Another class of blockchain is private and centralized blockchains, where the ability to write data to and read data from the blockchain is restricted to entities selected by the blockchain organizers (O'Leary, 2017).

Businesses can increase the efficiency of operations by embracing smart supply chains but it does not come without risks. 77% of industry executives have considered implementing smart supply chains, but only 1% have actually done it. This is because firms want to see the benefits of such technology before investing in research and development (Hastig & Sodhi, 2020). The four dimensions along which operations are improved are error eliminations, process streamlining, visibility, and improved order fulfillment. These operations can be improved because the transparency and traceability of blockchain enable measurements of efficacy that would otherwise not be possible.

Although smart supply chains may increase operational efficiencies, they may also encourage competition which would likely be resisted. Firms that have a substantial market share would discourage the adoption of smart supply chains as a public ledger would result in lost economic rent - profits above the competitive or allocative efficient price. This is because, "removing information asymmetries potentially would provide competitors with access to an entire set of transactions, providing others with a full scope of direct business intelligence insights" (O'Leary, 2017, p.138). The formerly private information revealed on the blockchain can encourage new firms to enter the market, hence encouraging increased competition (Hastig & Sodhi, 2020). One manifestation of this informational asymmetries problem is a firm not wanting to reveal the negotiated rates of suppliers on its blockchain.

As to the feasibility of businesses investing and creating blockchain-enabled supply chain systems, O'Leary (2017) questions if blockchain shared by multiple businesses is an effective solution to the supply chain efficiency and transparency goals. He notes that large institutional-level businesses often rely on legacy software services which would require substantial overhead to complete blockchain adoption throughout an industry. He proposes it may make more sense for businesses to retain the use of their legacy systems and then use the smart supply chain ledger to interface between businesses in a supply chain (O'Leary, 2017, p. 144). Additionally, the current security and reliability of blockchain infrastructure are underwhelming.

*A Note on Technical Deficiencies*

All current blockchain programming languages and tools are flawed and produce bugs. An essential component of blockchain programming is smart contracts. Smart contracts are programs on the blockchain which execute when specific events occur. For example, when a food shipment arrives at the grocery store within compliant temperatures then the grocer pays the

supplier automatically. Zou et. al (2022) found in a discussion with 20 developers of blockchain programming that it is difficult to write smart contract code because there are no established best practices, conventions, or standards (p. 2096). This problem is amplified because "There are no reliable code auditing tools to help you do a comprehensive analysis of smart contract code. I hope we can have such tools to help us analyze the code, and tell us whether there are some potential bugs, security problems, or convention violations" (Zou, 2022, p. 2091). Businesses that adopt smart contracts inherit these risks which may result in serious operational and reputational damages.

*Business Case – Walmart*

Walmart had a large outbreak of hazardous milk and infant formula in China affecting 300,000 people; this outbreak was time-consuming to resolve because the contaminating commonality had to be identified by compiling and cross-referencing paper records. This was an unacceptably frequent occurrence for Walmart's food supply chains. Walmart's solution was to develop a privately managed smart supply chain which it forced suppliers to adopt. They have expanded this solution to Latin American suppliers of produce as well as pork suppliers for the Chinese domestic market. To exemplify the success of this system for Walmart operations, sliced mangos outbreaks could be traced back to a specific regional supplier in 2.2 seconds instead of 6 days. Walmart is now requiring all suppliers of leafy greens in the US to integrate with their private and centralized blockchain ledger (Park & Li, 2021, p.10).

*Business Case – IBM*

IBM led an initiative *Tradelens* to operate a public decentralized blockchain for supply chain management of large international shipping cargo vessels. Cecere comments, "When it comes to

Tradelens, enterprise blockchain as a technology worked, but the limited deployment vision was a death nail" (2022, p.2). The issue for IBM was that they could not convince enough shipping companies and countries to join the smart supply chain network as partners making it a commercially unviable product. This is despite the fact that Tradelens could "reduce shipping administrative costs by 15% of the value of shipped goods" (Vujičić, 2020, p.5). Shipping companies feared they would experience reputational damage for the number of shipments that would be verifiably out of compliance.

## Discussion

First a summary of the results focusing on the incentives for each stakeholder group in contributing to and utilizing a smart supply chain. While some of these interests are aligned between stakeholder groups others are at odds, thus creating a conflict as to what extent transparency exists in smart supply chains. Then an analysis of the insights from IBM and Walmart case studies as to what variants of smart supply chains are likely to succeed.

### *On Stakeholder Conflict – shaping of smart supply chains*

Table 1 summarizes the research by providing characteristics of what smart supply chains enable for each stakeholder group in the "intra-enablement" row. Smart supply chains may make businesses more efficient; they can identify disruptions and trace issues in their own supply chains. Regulators would have improved auditing capabilities because of the abundance of data on the blockchain which allows regulators to enforce to a much greater extent. Consumers can make more informed decisions about purchasing products that align with their values. The second row, "inter-conflict", captures how the extent of transparency can create conflict between stakeholders. For businesses, a public ledger would disclose private information, increasing

competition. Additionally, businesses could be held accountable by regulators and consumers for unsafe and unethical actions identified by utilizing blockchain data. Regulators only enforce more effectively with more data, but businesses are incentivized to provide less data. Lastly, for consumers to be fully informed they require abundant data that businesses and regulators may not be willing to disclose.

**Table 1**

*Stakeholder Benefits and Conflict*

| Summary Points | Businesses (B) | Regulators (R) | Consumers (C) |
|---|---|---|---|
| Intra-enablement | Efficiency, Traceability | Omnipresent, Enhanced Auditing | Full Information |
| Inter-conflict | B: Private Information R&C: Accountability | B: Extent of Compliance Data | B&R: Availability of Data |

Note: X: Y indicates a given stakeholder (column) is in conflict with the group X over Y

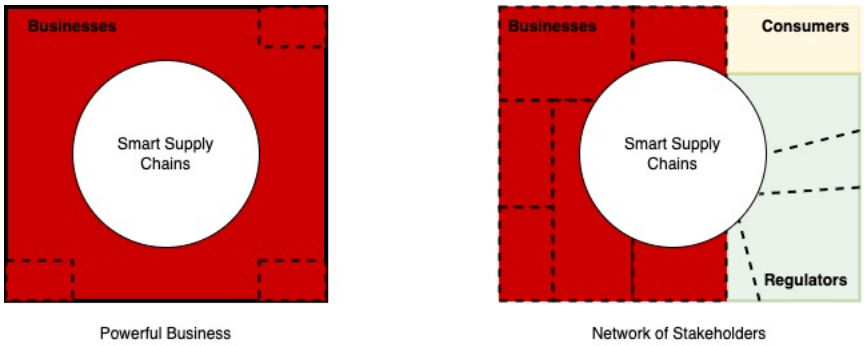
Actor-Network Theory (ANT), is a framework where equally important sociological and technological actors inter-relate in networks that produce some social outcome. In the network of food supply chains, smart supply chains can be designed to achieve more favorable outcomes for specific stakeholders. In this way, smart supply chains can 'act in roles' which favor specific stakeholders. There is a conflict between the stakeholder groups as to what extent aspects of each role the technology will support. In the Walmart case, since they designed and own the technology. It only enables efficiency, planning, and traceability without conceding any private information or enabling transparency. In essence, Walmart's smart supply chains only behave in business-aligned roles because of the designed data privacy. Contrastingly, IBM was trying to

design a smart supply chain and acted in multiple compromise roles for different stakeholder groups. It still increased efficiency for the businesses in the supply chain. The technology accommodated regulators by streamlining the customs enforcement processes. And because the blockchain was public consumers had more information about their products than they would've otherwise.

The fundamental difference between the two cases was each business's relative power. Relative power in this context is a combination of market share and political and social capital. Walmart has more relative power than IBM. They control large extents of their supply chains and hold substantial leverage over suppliers and consumers – many have no choice but to do business with Walmart. As opposed to IBM which attempted to design a smart supply chain that accommodated a network of many businesses and regulators. The agent in this network with the most relative power was shipping companies because they largely facilitated the interactions between all other agents of the food supply chain network. Shipping companies did not believe that contributing to IBM's designed network advantaged them, so they did not participate. As a consequence, the network with smart supply chains dissolved, and Tradelens as a business failed.

**Figure 3**

*Influence over Smart Supply Chain Roles*




The power dynamics are illustrated in figure 2. The area for each stakeholder demonstrates their relative power, the amount of contact each stakeholder has with the perimeter of the circle indicates the stakeholder's ability to shape the technology of smart supply chains to their interests. The powerful business, Walmart case, does not allow small suppliers to have influence over the shaping of the technology. Consumers gain no information and regulators have no audibility since the blockchain is private. Whereas the Network of Stakeholders, IBM case, has some mutual shaping between businesses and regulators. The dotted lines indicate the many regulatory bodies and businesses that must interface within their stakeholder group and sometimes between stakeholder groups. For example, some businesses that use this smart supply chain would interface with other companies but never regulators because their intermediate products are not being sold internationally. And regulators of a specific country have to interface with other regulatory bodies from other countries for customs enforcement. Consumers do not design the technology but exhibit limited power by leveraging increased publicly available information to hold businesses and regulators accountable.

## Conclusion

Smart supply chains are a promising new transparency-enhancing technology that can benefit society. However, there are structural tensions in the socio-technical system that prevent smart supply chains from being maximally beneficial to society. It is likely that more powerful businesses, like Walmart, will continue to develop smart blockchains which purely advantage themselves. Which still overall improves our society because the food we consume is safer by consequence. However, a smart supply chain designed to accommodate many stakeholders advantages each stakeholder to further increase the benefits to society. But these aforementioned structural tensions prevent this maximally beneficial form of the smart supply chain from existing.

While the findings are focused on food supply chains, they are applicable to many industries. Each industry will need to design its own smart supply chains since the social-technical system varies between industries. Future work on smart supply chains should carefully consider opportunities in different industries to reduce structural tensions by making technological design compromises.

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