# Reducing Just-in-Time Delivery Related Cost Volatility in the Global Supply Chain: Consumers and Blockchain Technology

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***Abstract*— The novelty that this paper identifies relates to the reduction of cost volatility in the global supply chain. This novelty is further seen in the proposition that blockchain can achieve this objective. Blockchain's distributed ledger framework achieves improved inventory control, improved demand forecasting, and more efficient just-in-time productivity as factors to reduce cost-loading in the global supply chain. Another novel contribution of this paper involves the assertion that blockchain's very methodology of requiring the confirmation of every single process by every single node in the network works to smooth out variation in the supply chain. Also, blockchain's ability to anticipate fluctuations in the supply chain that traditional SCM platforms cannot also works to reduce volatility because production can be increased or decreased in advance of anticipated variations. Blockchain also works to ensure that administrative fluctuations and variances do not adversely affect the supply chain. Blockchain more seamlessly supports contract formulation and exchange, smart contracts, remotely managed containers and cost reductions which all improve the JIT operating environment. Additionally, unlike traditional supply chain technology platforms like ERP and similar, blockchain allows every party involved in SCM to access the virtual supply chain in real-time. The contributions regarding blockchain and the global supply chain then are such that blockchain allows supply chain operators and retailers to more accurately assess costs per unit for forecasting purposes. This allows costs to be reduced over time and in an incremental fashion.**

***Keywords:*** *Marketing forecasting, Blockchain, Just-in-Time, Supply Chain, Cost Volatility, Forecasting.*

## 1. Introduction and Background

This report discusses the reduction of shipping cost volatility in the global supply chain. The context of this analysis relates to how cost-savings can be achieved for end-consumers and how this might be facilitated by blockchain technology. Traditional volatility in the supply chain, regional-global-or otherwise, has been largely limited to concepts such as the bullwhip effect. These types of concepts are more related to volatility and variance attributable more to SCM practice than to the types of environmental factors that now tend to affect the global supply chain. The bullwhip effect refers to a concept in which supply chain managers or inventory specialists overreact to some sort of supply disruption by over-ordering the commodity being shipped which then results in an amplification of that commodity's units within the supply chain[1]. As this excess inventory travels down the supply chain its impact on the supply chain becomes amplified over time.

In effect, it could be said that phenomena such as the bullwhip effect might be better attributed to poor inventory control or management. Regardless, its effect is contained to the supply chain and must be managed accordingly. However, shipping cost volatility is something else entirely. The bullwhip effect and similar phenomena that contribute to traditional supply chain volatility are almost entirely manageable through more effective processes. Shipping cost volatility is a phenomenon that is driven by market-based circumstances that supply chain operators have far less control over. Supply chain operators and their client firms can mitigate risk associated with supply chain volatility through improved forecasting, more effective selection of logistics service providers and some degree of strategic contract management. The actual underlying factors that cause most volatility tend to be structural in character. Regardless, no supply chain operator controls the cost of fuel, inclement weather or factors such as seasonality which all contribute to volatility in the cost of shipping. Therefore, this report attempts to identify the ways, if any, that emergent blockchain technology and supporting technologies might work to flatten out volatility in the cost of shipping. The expectation then is that if achieved, such cost savings would be passed onto the end-consumer of the product or commodity being shipped.

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## 2. Supply Chain Developments

While most laymen and, indeed, many supply chain professionals, might believe that factors such as fuel costs, labor expenses and so forth, affect volatility the most, other factors are more critical. In prior eras, these factors would certainly have been the most influential ones with respect to cost, volatility and variance in the global supply chain. In the contemporary environment, it is data and data visibility that tends to most affect the efficiency as well as the cost to manage the global supply chain. At the heart of the global supply chain in virtually any industry is Electronic Data Interchange or EDI. EDI is the global standard for the exchange, reading and tracking of products and materials within a commodity chain where intelligence such as delivery schedules, inventory levels, invoicing and delivery and transportation related data are all catalogued and made visible in real-time[2]. EDI forms the nucleus of the global supply chain in the era of technologically advanced logistics systems, platforms and processes.

Yet, despite the utility of EDI, emerging technology platforms such as blockchain, improves upon EDI and related systems exponentially. Although blockchain is most often associated with cryptocurrencies and the financial services field, its fundamental structure has wide application across any industry that utilizes technology systems and compiles data in virtually any form. At its most basic, blockchain consists of a type of distributed ledger of records that is distributed to every node in a network in which every activity is assigned a block and then each node receives a copy of this block simultaneously and in real-time[3]. Thus, fundamentally, blockchain is simply a system for data management, analysis and tracking that is extremely secure in character. This means that it is a technology platform that is not confined to just one or two core industries. Rather, blockchain has wide application for any industry and certainly for the supply chain and logistics industry[4]:

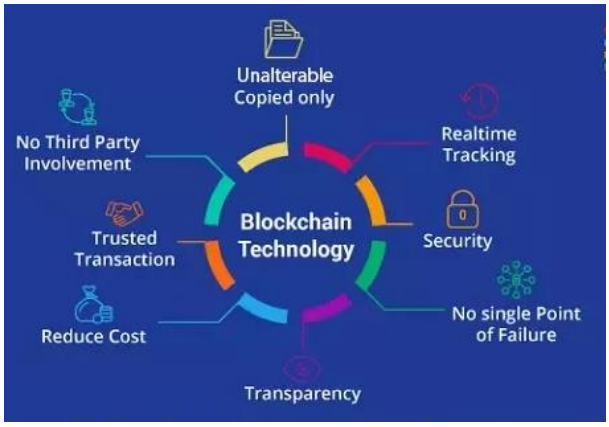


**Figure 1.** Blockchain Technology for Logistics

Blockchain applied to the supply chain industry works to improve transparency of all transactions including payment for services as well as management of the flow of commodities up and down the supply chain.

Even a rudimentary examination of the typical supply chain structure reveals how data and its exchange governs the contemporary SCM environment. In the JIT environment in which many if not most manufacturers, producers and retailers now operate, data facilitates the logistics of product ordering, fulfillment and replenishment. Within the typical global supply chain, there are essentially five fundamental processes that govern the supply chain[5,6]:

1. Management of demand: this domain includes material/product forecasting within the context of inventory control, customer/client management and service, and also sales management and support
2. Product/material distribution: this domain includes the links between the production of a product or good and its ultimate disposition in the marketplace
3. Production and manufacturing: this domain is confined to production related factors such as production volume controls, cost attributions for raw materials and so on
4. Procurement of raw materials/component parts: this domain involves the management of production related elements in terms of upstream logistics dealing with raw materials or component elements of a good or service
5. Returns or reverse supply chain: this domain relates to how products or goods are disposed of at the end of their lifecycle or how products or goods are returned when necessary

All of these processes are complex in character and depend more on data management than in prior eras. That is, these processes rely on the management of their respective data more than they do the physical allocation of resources although these too are still mission critical.

Given this primacy of data and data management within the supply chain field, it is clear that blockchain has a lot of potential. There are certain features of blockchain technology that make it ideally suited to the logistics environment. Specifically, every activity in the supply chain, once submitted to the network, cannot be altered, changed or manipulated without the established consensus of every node in the blockchain network and any data that is published across the network may never be removed[7]. These types of features make blockchain very effective for the supply chain and

logistics fields where historical tracking is so important. Additionally, blockchain is very secure being able to incorporate public-key type cryptography for data security but also employing a proof-of-work analysis system that verifies all the transactions recorded in each block[8]. While blockchain can be slower than traditional databases and datawarehouses, it is its decentralized structure that makes it so secure, reliable and accurate.

## 3. Supply Chain Volatility

Volatility in the supply chain is often measured and determined by an established tool designed to assess volatility. This tool is identified as the Supply Chain Volatility Index or the SCVI. The SCVI consists of a series of metrics identified as the following: financial based on exchange rates involved, raw material costs based on commodity or products being moved, stock market performance in affected markets, and shipping costs based on core metrics such as fuel[9]. These various performance metrics are then factored with the use of a coefficient based on estimated variation or a CoV. The result is that the SCVI is a useful tool which allows supply chain professionals to more accurately assess volatility risk. This risk is often a measure of the degree to which volatility in the supply chain will affect performance factors such as delivery times, cost and resource availability both upstream and downstream in the commodity chain.

The data produced through the application of SCVI in the supply chain industry can easily be incorporated into blockchain. Firstly, blockchain is a functional ledger that records every activity across what amounts to a peer-to-peer network in which there is no centralized control over the platform and each activity that embedded with a block is automatically encrypted[10]. Also, supply chain professionals incorporating blockchain technology have instant access from any node to all of the data within the system at any given time to support the SCVI analysis. In essence, blockchain in the supply chain environment not only records time, location, date, commodity status, order status, payment status, historical orders and so on but it does so in a fully transparent way that cannot be manipulated.

This integration and application of a tool such as the SCVI within the context of blockchain technology is critical in leveling out, where possible, supply chain disruptions. The SCVI is extremely practical both from a historical perspective as well as a forecasting perspective. For instance, in the application of the SCVI in a historical context as might be recorded within the blockchain, results in graphs such as the following can be utilized by supply chain professionals to identify variances[11]:

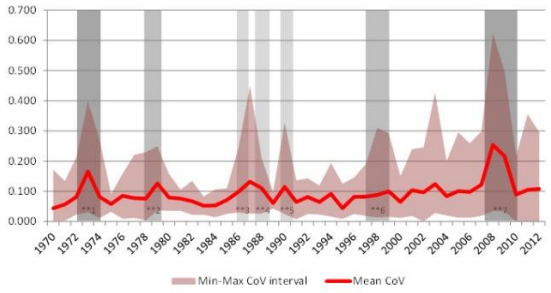


**Figure 2.** SCVI Historical Chart

As the chart above indicates, a historical review of the supply chain leads to an enormous amount of intelligence.

The association of each of these variances with their particular product attributions can inform the supply chain professional about what causes them. Such spikes, depending on what they are associated with, can indicate weather factors, fuel disruptions, labor disputes or resource shortages and so forth[12]. Each instance is unique but if such factors have a historical influence on the performance of the supply chain in question then these associations can be addressed. They may be addressed either by mitigation in future iterations of the supply chain or forecast into them as a means to smooth out the volatility following blockchain supported analytics. Blockchain incorporates far more possibilities in the SCVI paradigm than do traditional EDI supported analytics. Blockchain embeds not only shipping related product data such as cost, location and service provider but also invoices, payment status, order tracking, customs documentation, certifications, copyrights, patents, licenses and warranties[13]. All of these datapoints have a role to play in how products and goods are mediated within the supply chain and blockchain is the only technology platform that can effectively integrate all of this data in an intelligent manner.

Furthermore, there are other SCM elements that can be incorporated into blockchain that also drive supply chain efficiency. In this type of application efficiency is equated with reduced variance as well because variance in the supply chain is typically associated with some sort of increased cost factor. For instance, each supply chain is associated with one or more suppliers or vendors that produce the product or commodity in question as well as suppliers or vendors that provide logistics services of some kind. Fundamentally this fact alone contributes to the presence or absence of volatility in the supply chain. This is because each of these various suppliers or vendors also must work to accommodate variation, volatility and risk within the spectrum of their own individual responsibilities in the supply chain[14]:

**Table 1: Sourcing Configurations and Volatility**

| | Single Product/Good Source | Multiple Product/Good Source |
|---|---|---|
| **Positives** | Achieve Improved Economies of Scale<br><br>Improved Quality Control & Oversight<br><br>Improved & More Accurate Vendor-Logistics Communication | Greater Access to Product & Logistical Experience<br><br>Downstream Client Can Place Downward Pressure on Prices<br><br>Downstream Clients Are Able to Switch Suppliers |
| **Negatives** | More Vulnerable to Supply Disruptions<br><br>A Single Supplier is Affected (positively or negatively) By Order Volumes<br><br>Upstream Supplier is Able to Leverage Supply as a Factor in Pricing | Supplier Commitment is Reduced<br><br>Quality Control is More Difficult<br><br>Economies of Scale are Reduced |

As the information in this table points out, the very composition or underlying philosophical approach to supply chain design affects volatility. That is, the design of the supply chain and its theoretical integration of single versus multiple sourcing partners affects the character of volatility within the global supply chain.

## 4. Turbulence is the New Normal

Another extremely beneficial feature of blockchain technology as a means to reduce costs in the supply chain relates to its real-time visibility. The contemporary supply chain environment is turbulent by nature because most producers of virtually any product or commodity now function within a lean manufacturing and distribution environment governed by just-in-time processes. Just-In-Time or JIT is a concept originating from a manufacturing environment. JIT is originally a Japanese managerial philosophy that has been developed for the production and manufacturing environments. JIT requires the manufacturer or producer to have current number of items/units of the most appropriate quality as well as quantity at any given time and, most important within the context of this paper, in any given place[15]. The consensus is such that JIT has been heralded as being responsible for enormous advances in the production and manufacturing activities that reside at the top of any global supply chain.

Blockchain technology is ideally suited to the JIT environment that now governs most commodity classes from origin through to destination. Basically, commodities are produced in JIT environments, shipped in JIT configurations and inventoried, displayed and sold in JIT frameworks. The specific attributes of blockchain that resolve some of the supply chain issues related to JIT governed products involve paperless tracking, smart contracts and invoicing, shipping containers that can control environmental factors such as temperature and humidity, scalable last-mile delivery management, intermodal exchanges, and many more features[16]. Ultimately, JIT if integrated appropriately blockchain improves product quality, elevates manufacturer productivity and most critically reduces cost, waste and shrinkage within the supply chain[17]. The potential for supply chain operators to gain these particular benefits has ensured that many SCM organizations are increasingly seeking out blockchain supported solutions. These supply chain operators are tasked with developing supply chains that respond to the JIT processes in use by their client firms. JIT ultimately is a managerial approach that integrates established management practices but incorporates emergent practices such as improved data management and visibility up and down the supply chain.

Currently, many supply chain operators are integrating JIT related considerations into their supply chain operations due to the heavy globalization of commodity chains. Supply chain operators and third-party logistics providers (3PL) are aware of the extreme pressure that is placed upon them by the demands of JIT manufacturing. This, in

turn, limits the availability of redundancy in orders, materials and capacity within the supply chain itself. Overall, the integration of or reliance on 3PL service providers can have a significant impact on the character of the supply chain and especially so if mediated through the use of blockchain solutions[18]:

**Table 2: 3PL Provider Attributes in the Supply Chain**

| Positives | Negatives | Problems |
|---|---|---|
| Converting fixed expenses to variable expenses within the supply chain | Lack of full control over all aspects of the shipping process | Establishment of shared performance objectives |
| The capacity to achieve economies of scale across the supply chain | 3rd party providers could potentially shut down mid-shipment | Developing effective performance matrices for each 3rd party provider |
| Developing a more lean and more adaptive logistics service | No real-time access to operating data that is collected by the firm | Contract management may not be part of the provider's services |
| Facilitating quicker market access as well as access to expanding markets | 3rd party providers do not necessarily share the objectives of the shipper | Willingness on the part of the 3rd party provider to engage in a process of continuous improvement over time |
| Reconfiguring distribution routes and characteristics in the form of shipping modalities | Data compatibility and visibility issues | Contract renegotiation at select intervals based on performance |

Not every single leg in the supply chain can be outsourced to a 3PL firm nor should supply chain professionals seek this outcome. The use of 3PL providers should be approached strategically within the supply chain as a means to both control costs and reduced volatility. The integration of blockchain platforms can significantly improve the management of such 3PL service providers in the supply chain environment.

## 5. Managing Volatility for Cost

The global supply chain and SCM may involve a host of physical and material resources such as ships, trucks and fuel and so forth. However, it is the abstract management of these factors through demand identification and management of each product being distributed that truly affects the level of volatility in the typical supply chain. Consequently, demand management or DM is a rational approach to SCM in which supply chain professionals engage in a never-ending process of pairing the level of product demand to the level of identified capacity within the supply chain[19]. Any failure or inaccuracy in this process contributes to greater volatility either through excess inventories, bottlenecks, cost-spikes or a mix of all of these factors. Yet, with the introduction of blockchain into the supply chain, all of these factors can be effectively controlled, mitigated and eliminated in some cases. Blockchain has the capacity to integrate not only traditional product factors into the forecasting process but also a host of casual datapoints as well that are captured from the diversity of sensors, UPC readers, scanners and other devices that are now linked together on the internet of things platform[20]. All of this newly available data is not just simply stored in the database but can now be analytically evaluated by a range of parties across the distributed network of the blockchain.

Commodity/product transportation shipping firms provide the actual physical link between supply chain operators and the end consumers. Supply chain operators are what amount to the contracted owners of a given commodity/product while the product is in the supply chain. For instance, product manufacturers, product distributors, and of course retailers all share a vested interest in ensuring that a product reaches its final destination in good order. Shipping firms are basically transportation companies, such as trucking firms, rail companies, airlines, and ocean-going container vessels that all, either individually or together, move product from origin to the final market destination. Blockchain is the technology platform that can now integrate all of these disparate parties into a seamless analytical environment that is fully transparent. Prior technology platforms such as ERPs and similar enterprise applications could be accessed through networks but due to data security concerns, all access by all parties is governed by a use case,

security considerations and authority levels[21]. The use and integration of blockchain eliminates these types of siloes that can and do develop in traditional technology platforms.

Within this blockchain enabled supply chain environment supply chain service providers such as trucking firms are able to fully access the system. Loads can be paired instantaneously with available trucks and so on. This is critical since trucking for example represents between 80-90% of the commodity/product transportation costs in the typical supply chain[22]. This volume of product moved by truckload (TL) accounts for the majority of the commodities that rely in part or in whole on trucking services. In TL related supply chain operations, each individual truck is generally committed to a single product shipment moving between the market of origin and the market of destination. However, in the case of the less-than-a-truckload or LTL as well as parcel shipping firms, which work to consolidate many smaller shipments on an individual trucking platform, many different shippers are integrated into the same supply chain chode as it were. Blockchain technology platforms reduce redundancy in available resources, improve utilization rates and eliminate waste in terms of fuel, labor costs and equipment maintenance.

Therefore, the reduction in TL related expenses can have a very large impact on the overall supply chain cost. In turn, such shared cost platforms can also express a positive influence on the profitability of the supply chain which reflects upon the shipper's balance sheet. It is this type of cost-outcome that justifies the growing support and attention given to the procurement process of transportation services within the supply chain. Many supply chain operators and shippers themselves focus on procurement of transportation services within the supply chain. This focus primarily works to analyze the advantages of the aforementioned contract management processes. These include aggregate bidding as well as aggregate procurement and practices such as conditional bidding which is the possibility that a shipping firm quotes shipping prices on different product groups or on different shipping lanes[23]. Additionally, focus is also committed to the bid preparation process in negotiating shipping terms. This type of dynamic contract management is ideally suited to blockchain technology. Blockchain technology was specifically developed to manage smart contracts which support the digital governance of contract negotiation, signing, amendment and terms development. Blockchain smart contracts incorporate the product payment terms, detail any liens on the transaction, support confidentiality, minimum/maximum order quantities as well as listing any trusted intermediaries that have authority to amend the order or take possession of the products[24]. These types of elements can be achieved through more generic contracts or through customized bids that account for unique product classes or intermodal alternatives and so on but they cannot be managed in real-time and in a manner that is visible to all parties.

Still, significant volatility in the supply chain operator's procurement of transportation shipping services persists. The fact is that most supply chain operators use or rely on annualized auctions to procure transportation shipping services. This in turn leads to annual contracts and contract prices that are typically in effect for longer periods of time. These approaches usually start by estimating the commodity/product that needs to be shipped over the next year or two based on forecasted demand which, conversely, is often itself predicated on product movements from the prior contract period[25]. The supply chain operator will transmit information to the shipping firms in the form of a list of shipping lanes on which they intend to bid. Shipping transportation firms then quote the prices at which they are able to profitably move the products in question. The supply chain operator evaluates each of these bids on a lane by lane basis. This evaluation is primarily focused on price but in practice it should also integrate other factors as well in order to improve the mitigating effect of the contract negotiation targeting shipping terms.

In effect, it could be said that the contract between the supply chain operator and the shipping firms is often linked solely by an annual volume of commodity/product being shipped. This estimation is often based on annual movements and in the blockchain all of these past activities are attached to the current product data and available to all stakeholders in the supply chain process. But it can be based on virtually any predetermined timeframe, season or other factor that defines a functional period of time based on volume. All of these factors are integrated into the blockchain and move downstream with the product to the final product destination.

Supply chain volatility can have two primary consequences for supply chain operators and their client firms. When the supply chain operator asks the transport firm to move additional product, for example, certain issues may arise that could be anticipated in the blockchain. These are issues such as if the transport firm may not have the necessary capacity to accomplish this added request or may not otherwise be able to offer a price reduction in return for the added volume due to load configurations, fuel costs or space requirements and so forth[26]. This type of outcome may seem as if the transportation shipping firm is being obstinate but

there are so many factors that contribute to a cost profile that this is often not the case. Mitigation strategies include seeking out alternative shipping firms, improving forecast demand metrics or reconfiguring the supply chain to a more responsive format such as assembling component parts in the destination market rather than in the market of origin and so on. Blockchain facilitates all of these cost-reducing and cost-efficient activities for supply chain operators.

## 6. Downstream Costs and Consumers

The ability to source the most reliable overseas suppliers as well as the most reliable and efficient 3rd party logistics providers is a central cost-factor. Blockchain, in addition to all of the aforementioned features, also excels as a data aggregator allowing for a catalogue of product, industry and operator intelligence that can be accessed with immediacy by any stakeholder in the product movement. In the JIT environment, any supplier and 3rd party logistics provider that suffers from poor quality ratings and low reliability ratings is almost certain to cause an upward price trend in the destination market. Increasing costs cannot be sustained for very long in the highly competitive global marketplace. The supplier analysis model example in Appendix 1 demonstrates how supply chain professionals develop performance metrics to measure supplier and service provider effectiveness[27]. As the supplier analysis model demonstrates, not only do per-unit costs directly affect profitability as well as loss depending on the circumstances.

It also demonstrates that simply leading the market in quality and reliability is not enough if the per unit cost cannot be reduced or controlled. This model employs a carry-rate estimation along with the cost of capital for the supply chain operator and the client firm. Without these two factors it would be impossible to develop an accurate cost model as means to separate high performers from low performers. Thus, 3rd party logistics providers have to support the cost parameters of the supplier while also delivering on improved quality and reliability in the shipping and distribution operations within the supply chain. All of this can be integrated into blockchain such that raw materials to produce a commodity can be sourced more cheaply, manufacturers produce more appropriate amounts of product based on more accurate forecast models, distributors and retailers inventory less product but order more and every financial transaction is recorded for each activity[28]. In this regard, it becomes readily apparent that blockchain is ideally suited to the supply chain environment.

## 7. Conclusions and Recommendations

Ultimately, reduced volatility is a concept that is in many respects, associated with sustainability as well. Passing cost-savings onto the customer or client within SCM is largely an expression of a firm's triple bottom line or TBL. TBL is a concept that consists of three performance factors that each have their own metrics: people or the stakeholders involved, planet or the environmental effects of a supply chain, and finally profits or the financial costs associated with the supply chain[29]. It is usually the case that an effective SCM paradigm leads to improvements in a supply chain's overall TBL. In turn, this TBL may be utilized by the client firm as part of its own corporate social responsibility or CSR platform in order to demonstrate how value is returned to its own customers or consumers.

Blockchain is the technology platform that sutures all of these various product related activities together. At one time the supply chain might have been primarily limited to physical distribution processes, but this is no longer the case. Rather, while physical processes manage how products and goods are distributed geographically across time and space, digital data is now produced at each step of the transportation process and is more important than the actual products. Some of the most prominent effects of blockchain implementation in the supply chain involves payment processing and standardization which reduces transaction fees and optimization of cargo space in all modes of shipping including containerized vessels, trucking and railway modalities[30]. These outcomes all contribute to the reduction of costs associated with a particular product class and category. Once achieved, these cost-savings are invariably passed onto the client firm due to lower bid requirements on the part of the client firm. In turn, the client firm, whether retail or commercial in terms of business orientation, passes these cost-savings onto their consumers in the form of lower product pricing.

In order to be in a position to pass cost-savings from reduced shipping cost volatility onto the end-consumer, supply chain operators must achieve use rationale. That is, they should have a manageable control over the supply chain which is increasingly facilitated through blockchain driven solutions. This is achieved through a mix of both technology and structural elements such as smart contracts within the blockchain. Shipping cost volatility within the global supply chain up and down the commodity chains that they support, originates from environmental. These are environmental factors such as fuel costs, labor costs and so forth. Hence, if operating contracts managed by the blockchain are put in place that mitigate some of this risk then 3rd party operators absorb most of this volatility cost. It is clear that volatility largely originates from factors

such as weather-based seasonality, market-based seasonality (major shopping seasons), and demand for shipping services/space[31]. These are environmental factors that are beyond the control of the typical supply chain operator.

Therefore, supply chain and logistics operators can utilize a variety of different blockchain solutions to both mitigate volatility and reduce transportation and transaction costs. Blockchain specifically manages shipping contracts in order to effectively mitigate volatility by smoothing out price fluctuations related to shipping modalities such as the previously highlighted ability to optimize shipping space within transportation modalities. This recommendation identifies the use of smart contract management supported by blockchain for shipping services within the global supply chain that lock in pricing[32, 33]:

1. Tender(auction)-based contract: this shipping contract is organized in an auction format whereby various logistics operators bid on shipping predetermined shipping terms for various product classes
2. Short-term contract: this shipping contract locks in a shipping rate for a commodity for a short period of time based on the commodity class
3. Long-term contract: long-term contracts are useful because they allow supply chain operators to more accurately forecast cost. However, they also ensure that if environmental factors like fuel costs go down, they will not be able to benefit from the cost reductions
4. Spot shipping contract: these are short-term contracts but based on a single product/commodity shipment and thus any later shipments must be renegotiated
5. Commodity-driven contract: commodity shipping contracts are based purely on the type of commodity that is being shipped which the shipping/transportation companies have predetermined for each commodity class
6. Freight-all-kinds or FAK contract: this shipping contract allows shipping agents to mix and match different commodities within a single shipment (at the pallet level on up to the container level) as a means to achieve an average shipping cost across all commodities

Many supply chain operators fail to adopt a customized approach to their shipping contracts within the supply chain.

However, as the information above reveals, committing the resources to negotiating the most effective shipping contract with 3rd party providers directly reduces expenses. These operators include those such as container vessel operators or rail/truck operators which have the capacity, when optimized, to smooth out shipping cost volatility. While blockchain technology requires substantial capital investment upfront, its residual returns over time rapidly compensate the supply chain operator for the investment. Having the capacity to pass cost-savings onto client firms and from them onto consumers provides a level of competitive sustainability as well. This is because the client firms that do pass on such cost-savings to their consumers are more able to weather macroeconomic events such as inflation that could otherwise place downward pressure on sales revenue.

Finally, in a move that might be viewed as counter-intuitive considering the decades-long push to employ overseas manufacturing, changing the source of production is an option. Of course, this type of solution is readily available to any supply chain and logistics operator even without blockchain technology. Yet, blockchain technology greatly facilitates alternative sourcing strategies because its extensive accumulation of data supports competitive bidding, vendor performance analysis and similar analytics that allow an operator to assess manufacturing alternatives. Essentially, locating manufacturing/production facilities closer to areas of demand also contributes to reduced shipping cost volatility. This concept is referred to as nearshoring, as opposed to offshoring, in which client firms and supply chain operators beginning sourcing units/commodities closer to where demand (the consumer market) is located[34]. This strategy effectively reduces the overall cost of shipping since the distance to market is lowered. All other things being equal, the cost of shipping in this type of scenario will always be lower than traditional low-cost outsourcing in distant markets that require extensive international transportation modalities. Furthermore, when used in tandem with the aforementioned smart contract management strategy facilitated by blockchain, significant shipping cost savings can be achieved. Then, these cost savings can be subsequently passed onto the client firm and then from there to the end-consumer.

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## Appendices

**Appendix 1:** Supplier Analysis Model

| | |
|---|---|
| Order Lot/Batch Size | 1000 |
| Forecasted Demand | 100,000 |
| Item Per Unit Weight | 20lbs |
| Administrative Processing Expense | 75 per batch order |
| Carry Rate for Inventory | 22% annually |
| Cost of Capital | 10% annually |
| Targeted Profit Margin | 20% |
| Completed Unit Cost | $14 |
| Back-Order Expense | $15 per unit |

| **Price Per Unit** | **Vendor One** | **Vendor Two** |
|---|---|---|
| 1 1000 units per order batch | $50 | $55 |
| 01 to 3000 units per order batch | $45 | $49 |
| 3,001 & Up units per order batch | $40 | $44 |
| Production Costs per Batch | $15,000 | $16,000 |
| Shipping Terms | 3/10, net 40 | 3/10, net 40 |
| nsportation Distance | 000 miles | 700 miles |
| Quality Rating for Vendor | 3% | 3% |
| eliability Rating for Vendor | 1.5% | 2% |

Truckload = TL ≥ 20,000 lbs: $0.95 per ton-mile

Less-than-a-truckload = LTL: $1.05 per ton-mile

Per ton-mile = 1500 lbs per each mile/365

working days