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Unattended In-Home Delivery under Varying Scenarios of Technology-Enabled Anonymity

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ABSTRACT

Whereas many companies have explored attended in-home delivery as one solution to challenges associated with last mile delivery, few have explored unattended in-home delivery. This paper examines consumer willingness to allow unattended in-home delivery under various scenarios of anonymity. Specifically, we study how blockchain-enabled anonymity of sellers, delivery companies, and consumers can influence consumer willingness to allow unattended in-home delivery of a nutritional product in this last mile service triad. Hypotheses build on agency theory and the potential for information asymmetry and opportunism. The analyses are based on data from 784 responses to an online survey of end-consumers who were randomly assigned to treatments in a scenario-based experiment. The results indicate that blockchain-enabled anonymity of the delivery company significantly decreases consumer willingness for unattended in-home delivery. We also find that the joint anonymity of the seller and the consumer significantly decreases the likelihood of a customer allowing unattended in-home delivery.

JEL Classification: C44, M1, L87, L91

Keywords: last mile delivery, in-home delivery, anonymity, scenario-based experiment

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I. INTRODUCTION

This paper examines last mile delivery within the context of a service triad composed of a seller, logistics provider, and end consumer (Li and Choi, 2009; Wynstra, Spring, and Schoenherr, 2015). We build on concepts of technology-enabled anonymity, specifically through blockchain, and empirically analyze how the anonymity of delivery companies, sellers, and consumers influence consumer willingness to allow unattended in-home delivery. (See Brau et al. (2023) for an in-depth discussion on blockchain in supply chain management and operations.)

Last mile delivery is a critical link in the supply chain of any company offering delivery to end consumers (Esper et al., 2003; Nguyen et al., 2019; Barker and Brau, 2020). Characterized by large numbers of small shipments to unique consumer residences, last mile delivery differs substantially from other B2B logistics services that focus on bulk shipment and tight delivery schedules that enable greater efficiency. Additionally, unpredictable consumer schedules can cause multiple delivery attempts to fail (Song et al., 2009). These and other difficulties make the last mile one of the most challenging stages of supply chain delivery (Boyer et al., 2005).

Given the last mile challenges, sellers frequently employ third-party delivery services to address in-person delivery on consumers' unique schedules (Wang et al., 2014). However, even these delivery services have historically lost over a billion dollars per year due to failed deliveries according to the Interactive Media in Retail Group (Song et al., 2009). Companies are actively seeking methods for dealing with such losses.

Unattended in-home delivery is an emerging service that may address some of the challenges of in-person delivery (McKinley et.al, 2023). Unattended in-home delivery allows customers to receive packages securely even when their personal schedules prevent them from attending to deliveries at home. This flexibility allows delivery services to schedule routes for improved speed and cost. In this instance, the delivery person becomes an agent of the consumer (the principal), where the consumer and delivery person both benefit from allowing in-home delivery, where both the principal and agent benefit from the arrangement. However, despite the mutual benefits of unattended in-home delivery, allowing a delivery person access to one's home introduces a new dynamic of "placed trust" (Halliday, 2004) – trust that a delivery company will not abuse that access despite the consumer having little to no prior experience with the delivery person. The delivery person, for example, could steal an item of value from the home, especially if they think that they could do so without being observed. Employing monitoring devices (e.g., security cameras), however, decreases information asymmetry of what takes place inside the home during delivery and therefore reduces the probability of theft and helps ensure that the motivations of both principal and agent remain aligned. Given the potential benefits and risks, research is needed that examines consumers' willingness to allow unattended in-home delivery.

Unattended in-home delivery may also be influenced by blockchain, a relatively new technology that can theoretically enable secure internet purchases without disclosing the identities of involved parties. Blockchain is receiving much attention for its potential to transform the way sellers, logistics providers, and consumers interact (Treiblmaier, 2018; Durach 2020). However, because of the new and largely experimental nature of blockchain technologies, research on blockchain has been primarily conceptual (Tan et al., 2018). Researching blockchain proves to be challenging because its use cases and

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implementations have been limited to date. Researchers can aid the development of meaningful blockchain implementations by examining the effects of its various unique features and influences on supply chains (Koh et al., 2020).

The specific feature of blockchain that we explore in this research is anonymity (Yli-Huumo et al., 2016; Reynolds and Irwin, 2017). Since unattended in-home delivery requires trust by consumers, we seek to understand how consumers respond to a technology that enables anonymity of the consumer, the seller, or even the delivery service. We explore the effects of blockchain-enabled anonymity using a scenario-based survey experiment, in which participant consumers indicate their willingness to allow unattended in-home delivery when presented with situations where the anonymity of the three parties is varied. The results provide needed perspective for organizations seeking to address the last mile through unattended in-home delivery and blockchain technologies. The results also offer new insights regarding consumer perceptions of anonymity concerning in-home delivery.

II. LITERATURE

A. Last Mile Delivery

Last mile delivery is defined by Esper et al. (2003) as, "the critical link between consumer-based Internet ordering and the delivery of the product to the consumer." The last mile has been identified as the most important stage of the order fulfillment process (Esper et al., 2003) and has accounted for approximately 30% of total e-logistics costs (Wang et al., 2014). Examples of last mile delivery include unattended delivery in reception and delivery boxes (Punakivi et al., 2001), collection and delivery points (Song et al., 2009), attended home delivery (Wang et al., 2014), and drone delivery (Agatz et al., 2018). Carriers often deliver sensitive goods using attended home delivery in which carriers hand-deliver goods to customers, and sometimes receive their signatures (Wang et al., 2014). For less sensitive goods, the more common approach is unattended delivery in which carriers simply leave packages at the doorstep, porch or mailbox; the delivery person may document the time and location using pictures and messages to consumers.

Despite its importance, last mile delivery is known as one of the bottlenecks of e-commerce (Wang et al., 2014) and has been referred to as the last mile challenge (Boyer et al., 2009) and even the last mile problem (Song et al., 2009). Last mile delivery often results in increased processing and travel costs due to repeated delivery attempts, failed home deliveries, and the required consumer time and effort to retrieve the goods from alternate locations after failed carrier attempts (Song et al., 2009). Operational inefficiencies and costs of last mile delivery have led to financial pressures and the collapse of some businesses (Boyer et al., 2009; Brau, et al., 2007). Additionally, unattended delivery risks the growing concern of theft by porch pirates (Stickle et al., 2020).

A balance is needed between marketing's desires for small delivery windows that appeal to customers, and logistics' desires for larger delivery windows that permit greater delivery route flexibility and efficiency (Boyer et al., 2009). Among the existing methods of external last mile delivery, at-home reception boxes provide some added security over simply leaving a package by the door. Punakivi et al. (2001) simulate the cost savings of both reception box and delivery box home delivery of up to 60% of home delivery costs.

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However, the additional cost of renting or purchasing a box may not be worth it to some consumers. Box sizes can also limit the size of packages that delivery companies can leave.

Another approach for dealing with the last mile challenge focuses on expanding the supply of third-party delivery agents. For example, Amazon launched a new initiative in June 2018 seeking help to achieve its last mile home delivery objectives. Amazon issued a call for entrepreneurs to start up parallel delivery companies, promising "low startup costs, built in demand, and access to Amazon's technology and logistics experience" (Amazon, 2018) along with potentially high profits (Carbonara, 2018). However, skeptics warn prospective delivery startups that last mile delivery is "a desolate battlefield, due to the hefty expense of bringing packages to people's doorsteps," making it "incredibly hard to eke out a last mile profit" (Wu, 2018). Given the real risks of porch theft and high delivery costs and inefficiencies, others have looked to unattended in-home delivery as a potential solution.

B. Unattended In-Home Delivery

In many last mile approaches, the traditional role of the delivery company has been transactional, where consumers rarely concern themselves with the delivery company itself as long as the product is delivered on time and undamaged to a location outside their home. In contrast, unattended in-home delivery such as that provided by AmazonKey (e.g., www.amazon.com/keyinhome) introduces the concept of an end consumer swapping out a physical key for a digital key to access their home, and then allowing that digital key to be stored and used by the vendor. Consumers can allow the generation of a digital key for one-time use by a third-party delivery agent. With unattended in-home delivery, consumers are not required to be present, or to attend to delivery (even if home). For example, if a customer were conducting an online business meeting or college lecture, the presentation would not be interrupted while the product is delivered into the house. When the scheduled delivery agent approaches the home, they activate the digital key, open the door, and then deliver the product within the home rather than outside the door. These solutions often involve a Wi-Fi enabled digital security camera with a live and/or recorded video stream of the delivery process provided to the consumer. Once delivery is complete and the door re-locked, the consumer receives a confirmation notification.

Unattended in-home delivery has the potential to provide at least four key benefits. First, customers receive their packages secured within their personal environmentally controlled space (home) without the additional cost and size limitations of outside boxes. Second, both the customer and the delivery company benefit from the scheduling flexibility from not needing the customer to be present. Third, delivery companies reduce logistics and scheduling costs through guaranteed one-time deliveries. Fourth, the entire supply chain benefits by eliminating porch piracy of unattended items (Stickle et al., 2020).

The success of unattended in-home delivery heavily depends upon consumer willingness to allow such delivery. Compared to traditional methods of last mile delivery, unattended approaches extend the distance and scope of the last mile into the buyer's personal space. Thus, unattended in-home delivery introduces a triad of trust – a new dynamic of trust between the consumer, the selling company, and the delivery company

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that has not existed before. While studying the antecedents of customer willingness to allow unattended in-home delivery in and of itself is an interesting line of inquiry, our research introduces the added dimension of blockchain technology and specifically asks the question of how anonymity as facilitated by blockchain can influence such customer willingness. While unattended in-home delivery does not necessarily require blockchain technology, providing delivery services where one or more of the transacting members maintains anonymity does require blockchain technology as that anonymity is one of the key features that blockchain facilitates (Reynolds and Irwin, 2017).

C. Last Mile Delivery and Blockchain Anonymity

Blockchain's potential influence must be better understood if it is to help address last mile challenges such as failed first-time home deliveries, multiple delivery attempts, and multiple customer trips to secure products (Boyer et al., 2009). Research supporting the potential of blockchain in supply chain management is beginning to emerge. Padilla (2018), for example, studied blockchain-enabled transparency and automation in delivery tracking and confirmation, including improved estimated delivery times. Hasan and Salah (2018) proposed a blockchain-based proof of delivery solution to help ensure "accountability, punctuality, integrity and auditability." Capocasale (2019), among others, has researched how blockchain can reduce processing time and the risk of fake products, along with improving the ability to trace products from point of origin to consumer. However, Padilla (2018) warns that multiple, incompatible blockchains might fail to reduce delivery costs, and Capocasale (2019) emphasizes that "the savings related to the adoption of the blockchain must justify the risks of adopting an immature technology."

To understand the relevance of blockchain to unattended in-home delivery, it is important to understand some key blockchain concepts and unique features that are pertinent to consumers. Blockchain is "…a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible (a house, car, cash, land) or intangible (intellectual property, patents, copyrights, branding). Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved" (https://www.ibm.com/topics/blockchain). The essence of blockchain technology is a process of recording, validating and encrypting transactions such that each new transaction is linked to a copy of all previously validated transactions, thus creating a chain of transaction blocks. Within a blockchain, all connected ledgers view, record, and lock transactions (Iansiti and Lakhani, 2017).

We now walk through an example to explain how blockchain features might be manifest in a transaction. First, parties in the supply chain who are considering a blockchain application must determine the accessibility of the blockchain, identifying who will participate and what permissions will be given to which parties. Private or permissioned blockchains do not provide anonymity or complete transparency to all users; instead, private blockchains can be managed to allow only certain individuals or groups to participate, and can also limit transparency by controlling which information is visible to others even within a permissioned blockchain. See Ang and Brau (2002) for an example of how transparency is priced.

Next, blockchain stamps a near-permanent recording of transactions. Di Pierro

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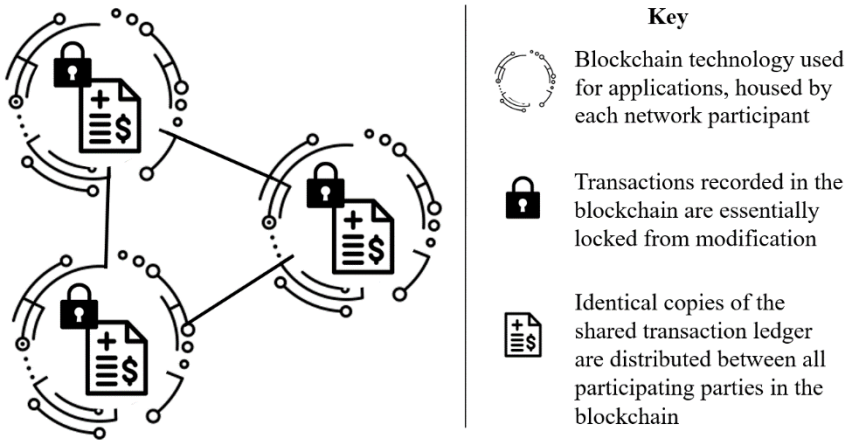
(2017) describes the nature of this recording as "a table with three columns, where each row represents a distinct transaction." The first of these columns marks the time the transaction took place; the second column stores the actual details of the transaction; and the third column stores what is called a "hash" of the transaction, with a hash being understood as a mathematically "encrypted version of the original string" (Di Pierro, 2017).

These recordings of information are then put into "blocks," linked to previous blocks, and then stored in the "disk storage of the users, called nodes" (Yli-Huumo et al. 2016). The actual nodes participating in the blockchain confirm the accuracy of information in the chain of information (Yli-Huumo et al., 2016). Each node checks for consistency in the chain by comparing its own stored information with the stored information of other nodes, and "when all transactions are successfully confirmed, a consensus exists between all the nodes" (Yli-Huumo et al., 2016). Nodes demonstrate their approval of the new block by beginning the creation of the next block in the chain, "using the hash of the accepted block as the previous hash" (Nakamoto, 2008).

We depict these blockchain technological relationships in Figure 1.

Figure 1
Depiction of blockchain interactions within a triad



Blockchains can alter the traditional process of how transactions are recorded and maintained from a duplicative process where each party maintains its own copy of a specific transaction ledger, to a new process where all parties share ownership of a single common ledger for a particular type of transaction (Fawcett et al., 2007). Blockchains have no central owner who controls and records the information, and it is extremely difficult to change recorded blockchain transactions. Additionally, blockchain can be set up with public or private viewing.

Anonymity, or pseudonymity as it is sometimes termed, is cited as one of blockchain's most pertinent features, and is a selling point for many potential users (Reynolds and Irwin, 2017). In their review of blockchain literature, Yli-Huumo et al. (2016) conclude "the goal of Blockchain is to provide anonymity, security, privacy, and transparency to all its users." In a day with increasing discussion about privacy, transacting parties may utilize blockchain's anonymity feature to choose what aspects of

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their identities are visible to others (Sternberg et al., 2020). Sellers, buyers, and delivery companies may choose anonymity or may choose to disclose their identities to one or more parties in supply chain transactions. However, the proposition that blockchain may emerge as an anonymous system of commerce and transactions may be a potential area of concern. For example, blockchain anonymity may create worry as to whether governments will have the capability of detecting fraud on blockchain platforms (Turner and Irwin, 2018). It is also unclear when blockchain anonymity will lead to positive or negative influences in supply chains.

Some consumers care about their ability to transact inconspicuously. Recent studies affirm that consumer anonymity can significantly influence behavior. Regner and Riener (2017) study the effect of anonymity on purchases using a natural experiment in a music store in which private consumer information was made available to sellers temporarily. A 25% drop in in-store revenue resulted, with a 35% drop in online revenue. Such decreased purchasing is often worse for items associated with negative stigmas in the minds of customers (Jones et al., 2018). The importance of anonymity in exchange is also emphasized by the demand for data privacy in the current environment of publicized security breaches by companies entrusted with sensitive information (Bella et al., 2011).

Some feel that the anonymity and traceability functions of blockchain may increase, decrease, or possibly remove the need for trust (Nakamoto, 2008; Cole et al., 2019). Thus, each party must make both strategic, operational, and behavioral decisions regarding their use of anonymity. Researchers have introduced a blockchain-based delivery system called Lelantos which offers "customer anonymity, fair exchange and customer unlinkability," relying on the decentralization and pseudonymity of the blockchain (AlTawy et al., 2017). Whereas some recent research has been conducted on blockchain and consumer applications (Schlegel et al., 2018) and blockchain and last mile (Padilla, 2018; Hasan and Salah, 2018; Capocasale, 2019), there is a lack of research on how blockchain-enabled anonymity could influence unattended in-home delivery.

This research fills that gap by empirically studying in-home delivery under various blockchain-enabled contexts of anonymity. In each setting, we examine consumer willingness to allow unattended in-home delivery using blockchain technology, comparing situations in which the delivery company is known or anonymous, the seller is known or anonymous, and/or the consumer is known or anonymous. We examine three specific testable research questions. First, how does anonymity of the delivery company influence the consumer's willingness to allow unattended in-home delivery using blockchain technology? Second, is that influence consistent under seller and consumer anonymity? Third, how does seller anonymity influence willingness for unattended in-home delivery?

III. THEORY AND HYPOTHESES DEVELOPMENT

To our knowledge, no research to date examines the dynamics involved with a consumer's willingness to allow unattended in-home delivery. As per our literature review, prior research has explored both attended in-home delivery where a resident is present to receive delivery and unattended external delivery where a resident is not present but the delivery is left at the doorstep, in a box, or at some other specified location outside the home. Unattended in-home delivery, however, is new and has only recently been popularized with the technological development of Wi-Fi-enabled smart locks and

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security cameras. The technological predecessor, the mechanical lock box holding a physical key to the house (long used by contractors and real estate agents), has not been used by delivery companies to our knowledge. Moving beyond the porch and allowing a delivery agent access to the personal space of a consumer's home introduces a completely new set of risk and benefit tradeoffs for the homeowner. Technology associated with Wi-Fi-enabled smart locks and live streaming cameras can help manage these risks and make unattended in-home delivery an emerging viable option for supply chains. While no companies, to our knowledge, have yet rolled out an unattended in-home delivery solution built on blockchain technology, it is only a matter of time before these technologies intersect. Our research, therefore, is forward-looking and seeks to inform both practitioners academicians as to important theoretical and practical implications in this arena.

Agency theory (Eisenhardt, 1989) provides a useful perspective for developing hypotheses regarding consumer willingness to allow unattended in-home delivery under various scenarios of anonymity. Supply chain research has used agency theory to better understand the dynamics of service triads in business-to-business contexts (Tate et al., 2010; Van der Valk and van Iwaarden, 2011; Wynstra et al., 2015; Broekhuis and Scholten, 2018). While a delivery person is commonly seen as an agent of the selling firm since they are contracted and paid by that firm to perform delivery services, they are also an agent to the consumer, who allows access to their home for delivery service. Marketing literature has used agency theory to study and better understand consumer-seller relationships where the consumer is the principal and the seller/service provider is the agent (Singh and Sirdeshmukh, 2000; Pavlou et al., 2007). Since our interest lies in understanding consumer willingness to allow unattended in-home delivery, we employ the operationalization of agency theory where the consumer is the principal.

Agency theory discusses two related dilemmas faced by the contracting parties: information asymmetry and opportunism (Singh and Sirdeshmukh, 2000). With unattended in-home delivery, both the principal and the agent operate with some level of incomplete information, but in the present case the principal (consumer) is at a disadvantage given a higher level of incomplete information relevant to the exchange. The consumer, for example, would generally not know the delivery agent's personal identity, background, or place of residence. The consumer would also lack other information on the delivery agent such as a criminal background or disciplinary history. With unattended in-home delivery, the delivery person may observe family pictures, notice unlocked doors or windows, view calendars and vacation times, or discover valuable belongings or information in the dwelling. From the other perspective, the delivery agent operates under the assumption that unlocking and delivering a package inside the principal's home will not expose the agent to any risk, such as an aggressive dog or unnecessary suspicion of breaking and entering. However, many specifics of the in-home delivery environment are unavailable to delivery personnel. Whereas both sides have some level of incomplete information, the asymmetry is greater for consumers as principals, who have more to lose and whose risk of loss is immediately tangible with delivery agents accessing their homes.

The information asymmetry present in this scenario could result in an increased chance of opportunistic behavior absent any control mechanisms. Opportunism in the presence of information asymmetry can result in individuals acting out of self-interest (Singh and Sirdeshmukh, 2000). A delivery person that has access to enter a home with

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no one present could, for example, steal valuable items from the home or take note of and use private information. Agency theory research has identified information technology as a mitigating tool to deal with opportunism and information asymmetry by increasing visibility and transparency (Eisenhardt, 1989). In its rollout of unattended in-home delivery, Amazon integrated a required security camera to its service to enable live streaming and recording of the delivery to the consumer (http://amazon.com/keyforhome). The existence of this information technology tool decreases the information asymmetry of the actions of the delivery agent and helps reduce the probability of opportunistic behavior.

Another tool cited in agency theory research for managing information asymmetry is signaling theory (Singh and Sirdeshmukh, 2000; Connelly et al., 2011; Taj, 2016). Signaling has three key components: the sender, the signal, and the receiver (Taj, 2016). A sender decides whether and how to signal information that may be incomplete for the receiver; the receiver decides whether to receive that signal and how to interpret it. The signal itself is the mechanism used to convey information that may facilitate decision-making regarding the exchange. Signaling is especially relevant in understanding the role that blockchain-enabled anonymity could play in the buyer/seller/delivery agent triad with unattended in-home delivery. Some agents reduce information asymmetry through signals of marked/branded vehicles and/or uniforms, closing the information gap for the consumer and reducing perceived risks from asymmetry of information. Other agents could transact through blockchain and withhold their direct identity, keeping affiliations anonymous by using unmarked/unbranded vehicles and by not wearing identifying uniforms. Given the high cost of managing the last mile, firms such as Amazon have turned to independent drivers to make last mile deliveries to help manage costs (Amazon, 2020). These drivers sometimes use their own vehicles and unbranded clothing when making deliveries. Whereas using independent drivers with personal vehicles may help manage costs for companies like Amazon, this approach removes key signals from the process and increases information asymmetry for consumers. A 2017 reddit.com blog post on the topic captures the reticence of a consumer with unmarked/unbranded delivery agents:

> *"I've gotten several Amazon deliveries in unmarked personal vehicles lately. I do not like this. We've had shady door to door people around here, and a couple of burglaries. When a vehicle pulls into my driveway, I need to be able to see if it's a delivery person, or someone that I need to be on guard with. Amazon needs to provide magnetic signs to their drivers or some other way customers can visually identify that it's an Amazon delivery."*
> *-Posted by user 'u/signal15' (https://www.reddit.com/r/amazon/comments/51zop2/concern_about_deliveries_in_unmarked_personal/)*

This comment aligns with how signaling theory predicts the increase of information asymmetry in the absence of effective signals. In this specific case, the consumer prefers the signal of a marked vehicle (even just a magnetic sign) to help provide desired information to assess the risks associated with the arrival of an unknown person at their residence.

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We recognize that the anecdotal example cited above was given in context of attended home delivery. However, such an experience can anchor the consumer in assessments regarding the trustworthiness of the delivery agent given that ordering from a specific retailer is rarely a one-time event. For example, as of December 2019 over 112 million people in the United States held Amazon Prime loyalty memberships (Ali, 2020), indicating intent for ongoing purchases.

If the delivery agent is wearing some type of identifying uniform and/or driving a marked vehicle, then the intended signal may be recorded in video footage. The consumer is then able to accept that signal as an indicator of quality, reducing information asymmetry and leading to increased trust and willingness for future unattended in-home deliveries. If the delivery agent drives an unmarked vehicle and has no identifying uniform, then the lack of signal perpetuates and possibly exacerbates the information asymmetry. We use this discussion of the impact of marked vehicles and uniforms to underscore the importance of signaling. Similar to signaling through the branding of vehicles and clothing, the use of blockchain to enable anonymous delivery is a signaling mechanism that influences information asymmetry. Signaling theory and agency theory therefore combine to predict the following hypotheses:

H1: When the delivery company is known to the consumer there will be a greater likelihood that the consumer will allow unattended in-home delivery as opposed to when the delivery company is anonymous to the consumer through blockchain.

H2: Irrespective of consumer and/or seller anonymity, blockchain-enabled anonymity of the delivery company will decrease the likelihood that consumers allow unattended in-home delivery.

Blockchain enables secure transactions where sellers can choose whether to share their identities with customers. A seller's identity and brand itself can be a signal of good or bad reputation. The anonymity of a seller removes potentially positive or negative signals. A product or service purchased where the supplier is not known is defined as an 'opaque product' (Fay, 2008). Extant research on opaque offerings typically focuses on services in the travel and hospitality industry such airline tickets and hotel stays offered by online merchants such as Hotwire and Priceline (Fay, 2008; Jerath et al., 2010). A supplier is more likely to provide opaque offerings when there is a high level of brand loyalty in an industry (Hong and Cho, 2011) and the supplier wants to grow revenue with a price sensitive segment of the customer base (Fay, 2008). Suppliers also use opaque approaches when desiring to unload excess inventory to price sensitive customers without eroding existing brand equity (Jerath et al., 2010; Henry, et al., 2023). Regardless of the motivation behind a company withholding its identity, seller anonymity provides one less signal to help consumers deal with information asymmetry. Given that fulfillment is one of the most critical elements in developing trust in an online environment (Urban et al., 2000), and given that access to enter a customer's home requires a high level of trust, we anticipate that:

H3: When the selling company is known to the consumer there will be a greater likelihood that the consumer will allow unattended in-home delivery as opposed to when the selling company is anonymous to the consumer through blockchain.

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Lastly, we consider the situation where the consumer remains anonymous to the seller. Given that a physical address is needed to complete unattended in-home delivery, it is not possible to fully mask the identity of the consumer from the delivery company. However, if all parties are using a shared distributed ledger (blockchain), it is feasible for the seller to price delivery using just a zip code or region code and the only party that would have visibility to the specific delivery address could be the delivery company. In this case, information signals provided to the consumer neither increase nor decrease, while the consumer could remain anonymous to the seller. While some consumers may benefit from their own anonymity if they desire to avoid further contact or marketing by the seller, many products and services include some level of warranty or guarantees for buyers. Therefore, we do not anticipate or hypothesize a noticeable difference in consumer willingness to allow unattended in-home delivery due to their own anonymity. However, we include the consideration of consumer anonymity in our research for completeness.

IV. METHODS

A. Design

We employ recommended research design methods in establishing a scenario-based experiment administered through an online Qualtrics survey in April 2018. We match the experimental design a priori to the level of analysis and survey development to ensure reliable analysis and results (Flynn et al., 2018). We randomly assign respondents into treatment scenarios based on varied anonymity.

We develop the general scenario using multiple iterations of refinement and feedback from a presentation to university faculty and a focus group of students. Based on that feedback, we use the term "new technology" rather than "blockchain" for treatment-related questions, ensuring that all participants answer questions based on the same set of features or technological characteristics, rather than potential differences in understanding and sentiment to the term "blockchain." We describe the core features of the "new technology" consistently to all participants (see Appendix A) prior to their answering the survey questions about their given scenarios. We ask survey participants to imagine they are interested in buying products and services (specifically, an FDA-approved, nutritional drink) through an online app that uses a new technology to record transactions between the seller, the delivery company, and them as the consumer. Participants are asked to suppose they will be using the new technology to purchase the nutritional drink every two weeks during the next year using an in-home delivery option. The new technology generates a one-time-use "digital key" to a smart lock, enabling the delivery company to unlock the front door and place the package inside. Additional details on the treatment scenario are documented in Appendix B. As part of a broader survey, participants read one of the randomly assigned treatment scenarios summarized in Table 1.

Within each treatment scenario, all participants answer questions regarding their willingness to allow digital entry under situations where the delivery company is first known, then anonymous (Table 2). Using this order was consistent with how participants are most likely to experience in-home delivery: participants first consider a context that

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is currently familiar to them (delivery company is known), and then they consider a future scenario that is not familiar to most (delivery company is anonymous).

Table 1
Between-subject Treatment Scenarios based on Blockchain-enabled Anonymity between the Seller and Consumer

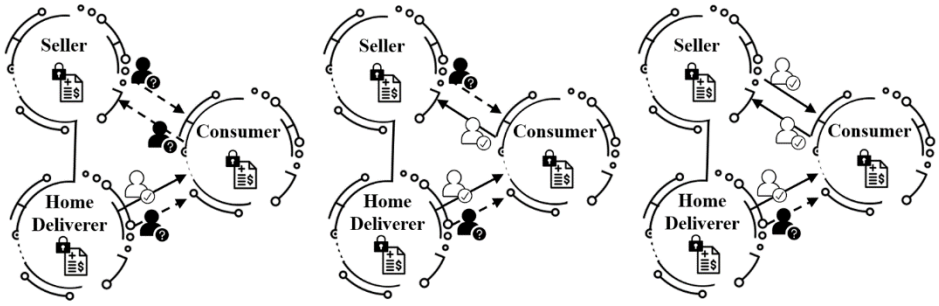
Treatment 1 (n=260) Consumer Anonymous / Seller Anonymous	**Treatment 2 (n=264)** Consumer Known / Seller Anonymous	**Treatment 3 (n=260)** Consumer Known / Seller Known
"You have chosen to make your identity **ANONYMOUS** to the seller, and the seller has chosen to make its identity **ANONYMOUS** to you (thus, the sources of ingredients are also NOT visible to you)."	"You have chosen to make your identity **KNOWN** to the seller, but the seller has chosen to make its identity **ANONYMOUS** to you (thus, the sources of ingredients are also NOT visible to you)."	"You have chosen to make your identity **KNOWN** to the seller, and the seller has chosen to make its identity **KNOWN** to you, and the sources of ingredients are also VISIBLE to you."

Table 2
Within-subject, Repeated Measure Treatments based on Blockchain-enabled Anonymity of the Delivery Company

Delivery Company is Known	Delivery Company is Anonymous
"The DELIVERY COMPANY has chosen to make its identity **KNOWN** to you, and **WILL** use a vehicle with a company name or logo on it."	"In this new situation, the DELIVERY COMPANY has chosen to make its identity **ANONYMOUS** to you, and will **NOT** use a vehicle with a company name or logo on it."

Figure 2 depicts each of the treatment scenarios described above and the number of participants responding to each treatment.

Figure 2
Treatment Scenarios of Blockchain-enabled Anonymity for in-home Delivery



Treatment 1
Consumer: Anonymous
Seller: Anonymous
(n=260)

Treatment 2
Consumer: Known
Seller: Anonymous
(n=265)

Treatment 3
Consumer: Known
Seller: Known
(n=260)

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B. Participants and Level of Analysis

Our results are based on 784 participating respondents. Following recommended standards for research design (Flynn et al., 2018) we carefully match subjects and the level of analysis with the chosen phenomena of the study, a priori. Our level of analysis is the individual decision-maker, or individual consumer. The phenomena we seek to analyze within blockchain-enabled contexts is consumer willingness to allow unattended in-home delivery. We select undergraduate university students as the participant pool as they represent the next generation of consumers that may have significant influence on the adoption and use of blockchain in consumer decisions. Undergraduate students are a reliable source for many types of research in supply chain (Katok, 2011), as well as consumer behavior in marketing research (McKnight et al., 2002). Additionally, this demographic may be less concerned about risks of possessions being stolen and risks to family than other demographics, leading to findings that are more conservative. Our research design is also consistent with "behavioral operation studies that focus on individual decision-makers" with "research questions targeting the perceptions of an individual" (Flynn et al., 2018).

C. Dependent Variable Measures

Measures are based on various questions regarding consumer willingness to allow in-home entry of the delivery company (see Table 3 for specific survey measures). Flynn et al. (2018) recommend that each construct remain monadic or based on a single perspective; accordingly, our questions are designed to capture only the consumer's perspective. We use a typical 7-point Likert scale: 1=Strongly Disagree to 7=Strongly Agree.

We held a focus group in April 2018 with student reviewers (consistent with the chosen study population) to refine survey measures and scenarios. Focus group participants completed the survey questions and recorded feedback on both the constructs and individual measures. We also discussed various potential items for the purchase scenario; the focus group agreed upon a nutritional drink as the best item for this study. Based on focus group responses and feedback, we refined the measures and thus increased face validity.

Table 3
Construct Measures, Reliability, and Validity for Consumer Willingness to Allow in-home Delivery

	Known Delivery Company						Anonymous Delivery Company					
			Reliability		Validity				Reliability		Validity	
Allow Entry Measures	Mean (n=785)	Std. Dev.	CITC	SMC	Path Loading (standardized)	Sig.	Mean (n=785)	Std. Dev.	CITC	SMC	Path Loading (standardized)	Sig.
I would feel secure in allowing the delivery company a one-time digital key entry into my home for delivery of my purchases	3.468	1.889	0.929	0.880	0.956	$p < 0.001$	2.315	1.606	0.920	0.848	0.942	$p < 0.001$
I would be willing to give the delivery company a one-time digital key access to my home to receive my purchases indoors	3.483	1.886	0.941	0.894	0.976	$p < 0.001$	2.302	1.588	0.934	0.873	0.962	$p < 0.001$
If I needed to make a return, I be willing to give the delivery company a one-time digital key entry access to pick it up from inside my home	3.336	1.851	0.893	0.799	0.910	$p < 0.001$	2.256	1.561	0.924	0.856	0.948	$p < 0.001$

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D. Construct Reliability and Validity

Face validity of the dependent variable (willingness to allow entry) is first established through the focus group as explained. Next, as summarized in Table 3, construct reliability and validity meet recommended cutoffs and reflect strong internal consistency of the measures within the construct, whether related to known or anonymous delivery settings. Corrected Item-Total Correlation (CITC) (>0.890 for all measures) demonstrates reliability or internal consistency that items measure the same concept; CITC reports the correlation of a given item to the score of the construct when excluding that item. Inter-item correlations are > 0.86 for all measures. Squared Multiple Correlation (SCM) (>0.799 for all measures) likewise reflects internal reliability or communality of measures. Cronbach's alpha also reflects strong construct reliability for Allow Entry in contexts with both known (alpha=0.963) and anonymous (alpha=0.966) delivery company settings. Additionally, path loadings and significance are found through confirmatory factor analysis (CFA), reflecting strong convergent validity. Having established sound construct reliability and validity, we use the average of the measures within a construct (the average for known delivery, and average for anonymous delivery) for our analyses.

V. ANALYIS AND RESULTS

Our experimental design (Figure 2) and data collection include both between-subject treatments and within-subject treatments with repeated measures. Accordingly, we utilize a mixed-methods model with a Tukey-Kramer adjustment for testing both between-subject and within-subject differences to answer our research questions. The mixed-methods approach accounts for fixed effects and random effects. We use SAS to conduct the hypotheses testing.

We first examine results for H1 by analyzing within-subjects differences regarding delivery-company anonymity. In each treatment comparison (see Table 4, Table 5, and Table 6), Panel A reports Delivery Company Identity, the variable that represents whether the delivery company is 1. known, or 2. anonymous (Table 2). In strong support of H1, the F-test for each comparison demonstrates high statistical significance (Delivery Company Identity $p<0.0001$). These results also support H2 – that regardless of whether consumers and sellers know one another, delivery company anonymity significantly decreases consumer willingness to allow unattended in-home delivery. For example, in contexts where both seller and consumer are anonymous (Table 4, Panel B, Treatment 1), the mean response estimate is 3.34 (7-point scale) when the delivery company is known (Entry 1), but only 2.19 when the delivery company is anonymous (Entry 2). Similar results for known vs. anonymous delivery company occur in contexts with known consumers but anonymous sellers with means of 3.35 and 2.28 respectively (Table 5, Panel B, Treatment 2), and when both seller and consumer are known with means of 3.61 and 2.42 respectively (Table 5, Panel B, Treatment 3). These differences represent a 15-17% change in consumer willingness to allow entry. Thus, we find that consumers are significantly more willing to allow unattended in-home delivery when the delivery company is known rather than anonymous through blockchain. Furthermore, the impact of knowing or not knowing the delivery company is not contingent on knowing or not knowing the identity of the seller or consumer.

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Table 4
Mixed Method Analysis: Anonymous Consumers and Sellers (Treatment 1) vs. Known Consumers and Sellers (Treatment 3)

Panel A

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Delivery Company Identity	1	518	221.39	<0.0001
Treatment Group	1	518	4.03	0.0453
Interaction	1	518	0.02	0.8765

Panel B

Least Squares Means

Effect	Treatment	Entry	Estimate	Standard Error	DF	t Value	Pr > |t|
Interaction	1	1	3.34	0.1035	518	32.27	<0.0001
Interaction	1	2	2.19	0.1035	518	21.12	<0.0001
Interaction	3	1	3.60	0.1035	518	34.78	<0.0001
Interaction	3	2	2.42	0.1035	518	23.40	<0.0001

Entry 1 = Delivery Company Known; Entry 2 = Delivery Company Anonymous

As additional support for H2, we find that the fixed effects tests for the variable Interaction (which equals Delivery Company Identity * Treatment Group) are insignificant when comparing Treatment 1 and Treatment 3 (Table 4, Panel A, p=0.8765), when comparing Treatment 1 and Treatment 2 (Table 5, Panel A, p=0.4929), and when comparing Treatment 1 and Treatment 2 (Table 6, Panel A, p=0.6183).

We can test the results for H3 regarding seller anonymity by comparing Treatment 3 (seller known) with either Treatment 1 or Treatment 2 (seller anonymous). We first compare Treatment 1 (completely anonymous – consumer and seller are both anonymous to one another) and Treatment 3 (completely known – consumer and seller are both known). We find that consumers are significantly less willing to allow in-home delivery in settings where both the consumer and seller are anonymous to one another (Table 4, Panel A, Treatment Group p=0.0453); this finding supports H3.

Support for H3, however, is not as strong when comparing Treatment 2 (seller anonymous) with Treatment 3 (seller known) (Table 5). The consumer is known in both treatments, enabling analysis of just seller anonymity. This scenario aligns with the opaque products literature in which known consumers seek products from sellers whose identities are hidden. These results provide interesting nuances for understanding seller anonymity, differing from results when comparing completely anonymous with completely known scenarios. Here, when varying only seller anonymity, we do not find a significant change in consumer willingness to allow entry (Table 5 Panel A, Treatment Group p=0.1173). This p-value does not meet the threshold of statistical significance, but subsequent tests with the most engaged participants find this result to be significant (see Robustness Tests section). Combining the results from Table 4 and Table 5, there is support for H3 in the context of complete anonymity (anonymous seller and anonymous consumer).

Table 5
Mixed Method Analysis: Known Consumers but Anonymous Sellers (Treatment 2) vs. Known Consumers and Known Sellers (Treatment 3)

Panel A

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Delivery Company Identity	1	523	221.93	<0.0001
Treatment Group	1	525	2.46	0.1173
Interaction	1	523	0.47	0.4929

Panel B

Least Squares Means							
Effect	Treatment	Entry	Estimate	Standard Error	DF	t Value	Pr > |t|
Interaction	2	1	3.35	0.1042	523	32.18	<0.0001
Interaction	2	2	2.28	0.1041	523	21.88	<0.0001
Interaction	3	1	3.61	0.1051	523	34.32	<0.0001
Interaction	3	2	2.42	0.1052	523	23.04	<0.0001

Entry 1 = Delivery Company Known; Entry 2 = Delivery Company Anonymous

Lastly, the results in Table 6 all occur under settings in which the seller is anonymous to the consumer but differ by consumer anonymity. Whereas we did not hypothesize a significant effect given the lack of theoretical support, we test these comparisons for completeness. In Treatment 1, both the seller and consumer are anonymous to one another using blockchain. In Treatment 2, the consumer does not know the seller, but the seller knows the consumer. As expected, we did not find a significant difference based on whether the consumer is known in the supply chain in the context of purchasing products such as a nutritional drink.

TABLE 6
Mixed Method Analysis: Anonymous Consumers and Sellers (Treatment 1) vs. Known Consumers but Anonymous Sellers (Treatment 2)

Panel A

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Delivery Company Identity	1	523	206.59	<0.0001
Treatment Group	1	524	0.18	0.6700
Interaction	1	523	0.25	0.6183

Panel B

Least Squares Means							
Effect	Treatment	Entry	Estimate	Standard Error	DF	t Value	Pr > |t|
Interaction	1	1	3.34	0.1032	523	32.35	<0.0001
Interaction	1	2	2.19	0.1032	523	21.17	<0.0001
Interaction	2	1	3.35	0.1022	523	32.80	<0.0001
Interaction	2	2	2.28	0.1021	523	22.31	<0.0001

Entry 1 = Delivery Company Known; Entry 2 = Delivery Company Anonymous

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A. Robustness Tests

We treat for manipulation awareness and attention through a two-step process (Lonati et al., 2018). First, we provide a diagram on each page of the survey using bold, large font to highlight the treatment (i.e., which parties are anonymous, shown in Table 1). Second, to address and test for participant attention, we ask the question, "Please indicate how thoughtful you were in answering the questions in this survey." The question is a 7-point Likert Scale, with 7 being the most thoughtful. Table 7 indicates response frequencies by treatment. Based on ANOVA results (general linear model), we find no significant between-subjects effects ($p=0.788$) in attention response between Treatments 1, 2, and 3 (means: 4.88, 4.88, and 4.95, respectively).

We repeat the analyses reported in Tables 4-6, first using only attention responses > 5, and then only responses = 7. For attention responses > 5, we have approximately 200 observations per treatment. Results for Delivery Company Identity are as follows: Table 4 Effect ($F=199.56$; $p<0.0001$); Table 5 Effect ($F=229.49$; $p<0.0001$); and Table 6 Effect ($F=206.46$; $p<0.0001$). When we repeat using only those with attention responses = 7 (approximately 50 per treatment) the results are as follows: Table 4 Effect ($F=57.20$; $p<0.0001$); Table 5 Effect ($F=43.87$; $p<0.0001$); and Table 6 Effect ($F=48.92$; $p<0.0001$). These results confirm original findings for delivery company anonymity as reported in Tables 4-6 and provide robustness for the H1 and H2 findings.

Regarding H3 and seller anonymity, the findings from robustness tests are significant when comparing full anonymity to completely known identity scenarios (Table 4), for attention responses > 5 ($F=3.29$; $p=0.0707$), and for responses = 7 ($F=5.47$; $p=0.0213$). When comparing scenarios under known consumer identity, but anonymous or known seller identity (Table 5), robustness tests using attention responses > 5 ($F=2.63$; $p=0.1054$) are consistent with the original insignificant findings. However, robustness tests with only the highest levels of attention (response = 7), show significant support for H3 ($F=5.88$; $p<0.0171$), that seller anonymity alone may decrease consumer willingness to allow unattended in-home delivery even when the consumer is known. For completeness, results from Table 6 regarding anonymous consumers remain insignificant for attention responses > 5 and for those = 7 ($p=0.8879$ and $p=0.8369$, respectively).

Table 7
Indication of Respondent Attention (Thoughtfulness)

	Frequency of Response			
Response	Treatment 1	Treatment 2	Treatment 3	Total
1	2	4	4	10
2	12	13	8	33
3	48	37	39	124
5	144	161	156	461
7	54	49	53	156
Total	260	264	260	784

Note: One individual did not answer, yielding n=784.

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VI. IMPLICATIONS AND CONCLUSIONS

Prior research has examined service triads for outsourced activities (Karatzas et al., 2016). However, no research to our knowledge studies the last mile service triad of unattended in-home delivery. Understanding what influences consumer willingness to allow such a service is a critical first step for organizations seeking to utilize in-home delivery. Our study extends research on last mile delivery by providing empirical analyses of blockchain-enabled anonymity for unattended in-home delivery to end consumers. We find three main implications pertaining to the anonymity feature that blockchain technology offers, as applied to delivery companies, sellers, and end consumers.

First, consumer comfort levels with unattended in-home delivery are generally quite low for our respondents. On a 7-point scale, the overall average willingness is only 2.86 (n=784), and only 2.23 when the delivery company is anonymous, and 3.42 when known. Given the ongoing challenges with last mile delivery, it is important to examine decisions that either increase or decrease willingness to allow unattended in-home delivery. We note that our respondents – university students – were selected as those who are some of the most technologically savvy and anticipate that they may be some of the most accepting consumers for in-home delivery. However, future research can extend this study to include different demographic and geographic groups to provide unique insights to strategy in the supply chain/marketing interface. We anticipate that willingness for in-home delivery would decrease among many other types of consumers, particularly those with children at home and older generations.

Second, we find that the highest consumer comfort levels with unattended in-home delivery (3.6 / 7.0) occurred when all three members of the triad are known to one another (Treatment 3; Table 4, Panel B, Entry 1), calling into question the efficacy of blockchain creating trustless transactional systems as some have proposed. Our empirical findings are supported by theoretical insights from information asymmetry and opportunism in agency theory (Singh and Sirdeshmukh, 2000). The goal in a principal/agent relationship is to maintain alignment of motivations and desires. Having knowledge of who the acting partners are in the triad helps ensure that if anyone acts in conflict with the desires of the principal, accountability can exist. Further, if the transactions including data related to entry such as time of entry, name of the delivery person, etc. are recorded in a blockchain-shared ledger, then it will be even easier to hold parties accountable for acting in a harmful manner (such as theft of items from the home). Using monitoring devices and ensuring that identifying information is recorded on blockchain can help make sure that the delivery person does not act in their own self-interest that negatively harms the principal. In this manner, blockchain can help create an environment of trust where motivations remain aligned and as a result, parties increase trust and engage in an ongoing business relationship that creates value over time.

Third, blockchain-enabled anonymity can significantly decrease consumer willingness to allow unattended in-home delivery. This decrease occurs most significantly under the anonymity of the delivery company, regardless of whether the seller and/or consumer are known to one another. This third finding is consistent across all three treatments, with varying degrees of consumer and seller anonymity in the blockchain; from a statistical standpoint, this is the strongest result of the study. Additionally, consumer willingness for unattended in-home delivery is significantly lower when blockchain is used by the seller to remain anonymous to the consumer, and

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especially when the consumer is also anonymous. These findings may indicate an overall level of reticence to place trust in a system where parties maintain opaqueness to each other. We do not find evidence that consumer anonymity alone influences willingness of the consumer to allow unattended in-home delivery. These mixed findings may indicate a multi-dimensionality of trust where trust in the system rather than trust in a specific supply chain member may be a relevant unit of analysis. Future research could explore this question.

The combined results provide evidence that blockchain-enabled anonymity of delivery companies and sellers, even in the context of other blockchain features such as traceability, will likely hamper efforts by companies seeking to address last mile challenges through unattended in-home delivery. Organizations may increase the likelihood that consumers will embrace such a service by first ensuring that delivery companies are known to consumers. Increased transparency of seller identity can also improve the likelihood of unattended in-home delivery.

This study also demonstrates how researchers can examine potential influences of specific blockchain features to address current needs and challenges in the world's supply chains without waiting for a large-scale rollout of blockchain solutions. We focus on the feature of anonymity across different parties. We also address the need for more research on consumer decisions and preferences, an area of research that has received limited attention. We find that, despite some claims of blockchain creating "trustless" transactions, consumers are significantly less comfortable with anonymous delivery companies and sellers. Future research could examine other blockchain features that influence consumer experiences with last mile delivery. Additional studies may also examine potential moderating effects from blockchain features. For example, the feature of "programmability" offers the option for smart contracts. One could study consumer willingness for in-home delivery when consumers use blockchain smart contracts to specify delivery company qualifications, delivery timing, etc.

Blockchain technologies enable varying degrees of anonymity across supply chain participants and introduce a new triad of trust between consumers, sellers, and delivery companies in the case of unattended in-home delivery. Consumer experiences within this triad of trust can have significant implications for supply chain success with blockchain and last mile efforts. Our research provides unique insights into how blockchain-enabled anonymity of delivery companies and sellers significantly reduces consumer's willingness to accept both risks and benefits associated with unattended in-home delivery.

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APPENDIX A

Core Blockchain Features Given to Survey Participants

Participants were asked to focus on the following 5 important features of blockchain that they "need to know about the new technology to answer questions in this survey":

1. Valid. The new technology confirms that transactions are valid only once they are agreed upon by all parties. This is done by comparing transaction histories across the network of all participating computers. New transactions are added to the verified records only when the records across the computers match.

2. Shared. The new technology stores transaction details in digital records that are shared by the seller, the delivery company, and you. Details can include the seller's name and address, the consumer's name and address, the product quantity and price, and delivery company's name and delivery times, etc.

3. Unchangeable. Once recorded in the new technology, transaction records are nearly unchangeable as all parties share identical copies of the transaction history and can see if others attempt to change them.

4. Traceable. The technology can be used to trace and make visible the source and ownership of the product through all stages of its creation (from raw materials through production and on to delivery). It links each transaction to the history of prior transactions with dates and times, etc.

5. Anonymous. The new technology lets participants (the seller, the delivery company, and you) choose to remain anonymous or to make their identities visible to others. The new technology allows transaction information to be made either visible (decrypted) or invisible (encrypted) in a given transaction. For example, a transaction could take place where both buyer and seller choose not to reveal their identities but are still able to transact with each other given the visible information of product, quantity, and price. The buyer may make its address known only to the delivery company (not the seller), thus enabling a completely anonymous transaction between buyer/seller.

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APPENDIX B

Survey Treatment Scenario Details

"Suppose you are interested in buying products and services through an online app that uses a new technology to record transactions between the seller, the delivery company, and you as the consumer. In traditional online apps, the selling company is responsible to protect consumers' personal information that it collects and stores. However, with this new technology all transactions are encrypted and stored on a ledger (or transaction record) that is publicly owned and shared (not owned by any one party).

"There are 5 important features you need to know about the new technology to answer questions in this survey: 1. Valid, where transactions are only valid once agreed upon by all parties, 2. Shared, where digital records are shared by all transacting parties, 3. Unchangeable, where one can see if others attempt to change records, 4. Traceable, where ownership and sources can be traced, linked, and made visible, and 5. Anonymous, where the seller, buyer, and delivery company can choose to be known or anonymous to others.

"Suppose that you are using the new technology described above to buy an FDA-approved, nutritional drink. The seller of the drink sources its ingredients from around the world and can match ingredients to your nutritional needs."

"Now suppose that during the next year, you plan to use the new technology to purchase the nutritional drink every two weeks using an IN-HOME DELIVERY option. In-home delivery requires both a smart lock on your front door and a security camera (pointed at the door) which are already installed in your apartment. The new technology can generate a one-time-use "digital key" that will allow a delivery company to unlock and open your front door, place the package right inside your door, and then close the door which automatically locks. The security camera records the delivery and can stream the delivery to you in real time to your phone. The new technology records the times that the door is unlocked and then locked after delivery."

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