


REVIEW

A critical review of information asymmetry in the business cycle: How digital ledger technology can transform and sustain the business cycle

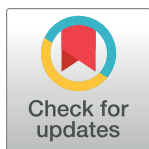
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Abstract

Distributed ledger technology (DLT) is a disruptive technology with the potential to reengineer the entire trading cycle by alleviating inefficiencies such as time lags, multiple record keeping, human errors, and transparency common with the traditional trade cycle. This study evaluates the potential benefits of DLT in mitigating information asymmetry in trading relationships and how a DLT model can be deployed to revamp the trading process. We find that information friction results from differences in stakeholder preferences by identifying and categorizing information friction into 4 groups through a review of key studies in leading management journals. This finding aligns with conclusions reached in scientific research that the benefits of DLT prevail in markets with imperfect information. In addition, we illustrate the potential benefits of DLT in mitigating inefficiencies in trading relationships resulting from information asymmetry. The article concludes with a word of caution for potential users to take gradual steps of adoption to keep pace with changing technology so as not to become laggards.



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1. Introduction

Following the principles of globalization, many countries are choosing liberal trade over isolationism [1]. As a result of the “borderless” nature of the new era (globalization), there is a need to tighten security measures to give investors the confidence that their investments are secure. Given that trade is done across international boundaries, different stakeholders involved in the trade cycle are bordered by the credibility of those with whom they trade [2]. This has given rise to information asymmetry problems, where, buyers fear that suppliers might not meet their requirements within relevant specifications, and suppliers, on the other hand, are worried about the credit and trustworthiness of the customers [3]. Traditionally, this problem is alleviated at the firm level through monitoring, by engaging a third party or by the concerned managers themselves [4]. For bilateral trade at the national level, governments use exchange rates

and tariffs to solve similar issues [5]. In recent times, the focus has however been on new technologies as a necessary tool to alleviate trust issues and promote a win-win relationship [6,7].

Mirrless [8] first identified information asymmetry in the collection of income tax by the government as citizens had information leverage on their earnings. Since then, different avenues of information asymmetry have been reported. For example, Pouryousefi and Frooman [9] observed that adverse selection can arise from the principal/agent conflict, where the principal engages with an agent who has private information. Other avenues presented in the literature include credit rationing or screening [10,11] and supply chain contracting [12]. If not properly managed, information asymmetry can lead to inefficient economic outcomes in credit creation [13], consumer protection [14], managerial expropriation [15], derailed investment and finance decisions [16], deteriorated financial reporting [17], increased cost of capital [18], and market valuation inconsistencies [19]. An extensive early overview of asymmetric research within the behavior and intention context was conducted by Devers and colleagues [20] to supplement the work of Gomez-Mejia and Wiseman [21]. They assessed the literature from 2 dimensions, the relationship between pay and performance and pay and behavior. Elsewhere, Tong and Crosno [22] reconcile the contradictory conclusions reached by scholars on whether or not information asymmetry and information sharing are good or bad or scenario specific. Despite efforts that have been made by firms and States to alleviate information asymmetry, the issue remains prevalent in trading relationships.

According to proponents of distributed ledger technology (DLT), DLT has the potential to remedy information inefficiencies in trade [23,24]. In simple terms, DLT is a distributed database of records or shared public/private ledgers of all digital events that have been executed and shared among blockchain participating agents. The use of DLT enhances reliability and transparency in trade and this can be achieved particularly using a smart contract [23]. Thus, this allows all participants to be kept informed with no one party having leverage on information flow, thereby preventing information asymmetry. Despite the promising potential of DLT in making trade more transparent, a school of thought suggests that its adoption should be approached with caution [24,25]. Given that DLT is a relatively new concept, there is a limited number of research or review articles on it, and those that exist usually focus on the architecture, benefits, and challenges. The first critical review of the concept [26] and a brief overview of the current DLT research [25] have been reported. Nevertheless, articles that look at the nexus of information asymmetry and DLT are generally scarce. Therefore, we perceive this as a gap in the academic sphere as the integration of these concepts can potentially alter the way trade is contracted.

Few studies have examined technological advancements and trade. Notheisen and colleagues [27] presented a blockchain model to facilitate pre-trade arrangements for a Danish car registry. Even though scholars had examined local and international business-to-business (B2B) trading, they did not consider advanced technologies such as DLT [28]. In an attempt to close this gap, we present an open model that can be adopted in all forms of trading relationships by illustrating how DLT works from pre-trade arrangements to post-trade settlements. We further identified and categorized areas where DLT can be deployed to alleviate information friction by reviewing key studies on information asymmetry from leading management journals which we termed “the asymmetric hotspots.”

The main goal of this study is the identification of DLT features that can potentially alleviate trade inefficiencies resulting from information frictions. This study sets out to specifically answer the questions (i) what are the key asymmetric inefficiencies in trading relationships and how can new technologies such as DLT offer real-world answers? (ii) how can players in the market leverage this technology to manage inefficiencies in trade resulting from information frictions? To answer these questions, we first reviewed various asymmetric hotspots from

4 dimensions: investment, financial inclusion, agency conflict, and taxation. This approach helps us to better understand how information frictions affect trading from multiple dimensions (trade asymmetric hotspots). Secondly, a brief overview of methods that have been used in the past to alleviate information asymmetry is scrutinized, and the potential benefit of DLT is explained. Finally, an illustration of how a DLT arrangement works, in theory, is explained to demonstrate the potential of the DLT in diminishing information frictions in trade. This study should, however, be perceived as a compressed overview of the moderator role of DLT on the effect of information friction in trade and its relevance to scholars and other contracting parties in a firm, national, and international arena as it provides insights into a new approach of combating trade inefficiencies.

2. Methodology

To answer the research questions of this study, we followed a systematic literature review guideline proposed previously [29]. Information asymmetry is a broad term that is inherent in all forms of relationships, especially in trading. The papers related to information asymmetry were selected from prominent management journals. The list of journals used in the study is presented in S1 Table of the Supporting information section. The Journals considered are those in which at least 1 article on the subject of information asymmetry and or trade was published between 2000 to 2021. The papers were selected based on the following issues:

- i. The relationship between information asymmetry and trade. This helped to enhance our understanding of the various dimension of the issue of information friction that has been studied in the trading process. These papers were gathered and categorized into 4 main categories which we term the asymmetric hotspot.
- ii. Measures to alleviate information asymmetry in trade. This was important in pinpointing the demerits of these strategies and how the introduction of the new technology (DLT) can alleviate the shortcomings of these strategies.

Next, we set the exclusion criteria with the goal of ensuring the reliability of the data by selecting only papers available in full text, peer-reviewed, and written in English concerning information asymmetry and or trading between 2000 to 2021. Keywords capturing the definition of information asymmetry as established in prior literature (information friction, information gap, information advantage/disadvantage, adverse selection, and moral hazard) were chosen. These keywords were combined with the keyword trade and were applied to the titles, abstracts, and keywords of the papers. The electronic database used for this search was Web of Science and Google Scholar. Thereafter, the retrieved papers were reviewed independently and only those papers that meet the objective of this study were retained. In total, 60 papers out of the 119 that were screened were used to answer the research questions. Table 1 presents a frequency distribution of the number of papers reporting on information asymmetry. Among

Table 1. The most frequently studied context of information asymmetry in Management Science.

<i>Domain</i>	<i>Frequency</i>	<i>Proportion</i>
Investment	14	23%
Taxation	6	10%
Agency conflict	6	10%
Financial inclusion	9	15%
Strategies	16	27%
Others	9	15%

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which, 23% focused on information friction in an investment decision, and 27% were based on prior approaches to alleviating information asymmetry. Also, taxation and agency conflict represented 10% of the sample papers, while 15% was attributed to published papers reporting on the information gap of financial inclusion and others not included within the specified hotspots. It was observed that between 2016 to 2021 about 25 papers were published on the subject of information asymmetry as opposed to just 11 papers between 2000 to 2005 (S1 Table), suggesting that scholars paid more attention to this topic in recent times.

To capture each of the trade asymmetric hotspots categorized above, an attempt was made to classify the literature on information asymmetry as follows: (i) information asymmetry in trade; (ii) trade asymmetric hotspots; and (iii) prior strategies used in alleviating information asymmetry. In S2 and S3 Tables of the Supporting information section, we present summaries of different authors, their contributions, and various strategies to curtail information friction. Based on the sampled papers, the most prominent strategy used to curtail information friction in management science is signaling.

3. Information asymmetry

3.1. Information asymmetry and trade

Information asymmetry can be regarded as an instance in which one party has leverage on information over another connected party leading to a lack of trust and increase uncertainty. It is established that trade volatility is driven by information friction in both local and cross-border trade. This is particularly true in the domain of trade balance [30], pricing of agricultural produce [31], exchange rates [32], stock volatility [33], pricing of options [34], and oil prices [35]. While these scholars agree that information frictions dwindle trade volumes and volatility, Baley and colleagues [36] reported a surge in trade volumes in the presence of information friction but noted that their model was only applicable in well-established trading relationships. Nevertheless, we think that information friction is persistent in all business interactions. This is because, by human tendency, people tend to portray what others want to see and not necessarily what is real. In this regard, examining instances in which such behavior is portrayed will enhance understanding of how information friction affects trade relationships.

3.2. Information asymmetry hotspots

Considering different classes of stakeholders of a firm, it can be observed that while managers are concerned about their jobs and related benefits, shareholders are worried about the return on their investment. Similarly, the employees are worried about job security, suppliers fear recoverability of outstanding debts, customers wonder if the firm can satisfy their needs, and the government worries about recovering tax revenue. Fig 1 presents a simple stakeholder map of a firm. These stakeholders have varied objectives giving rise to a conflict of interest that has been noted as a hotspot for asymmetric problems [9]. For example, managers as agents of shareholders (principals) can engage in selfish behaviors that allow them to achieve their Key Performance Indicators (KPI), which may erode shareholder wealth. Singla and colleagues [37] reported the presence of secondary (principal-principal) agency problems while investigating the presence of secondary agency issues in family-owned and controlled firms in India. In a like manner, Barclay and Holderness [38] argued that block holders, as a result of their voting rights, enjoyed private benefits in pricing block trade for Amex Corporations.

Even though information friction exists in trade, the effects are stronger for firms going international due to differences in cultural, linguistic, political, and business environments [39]. Other areas in literature where scholars have established the presence of information

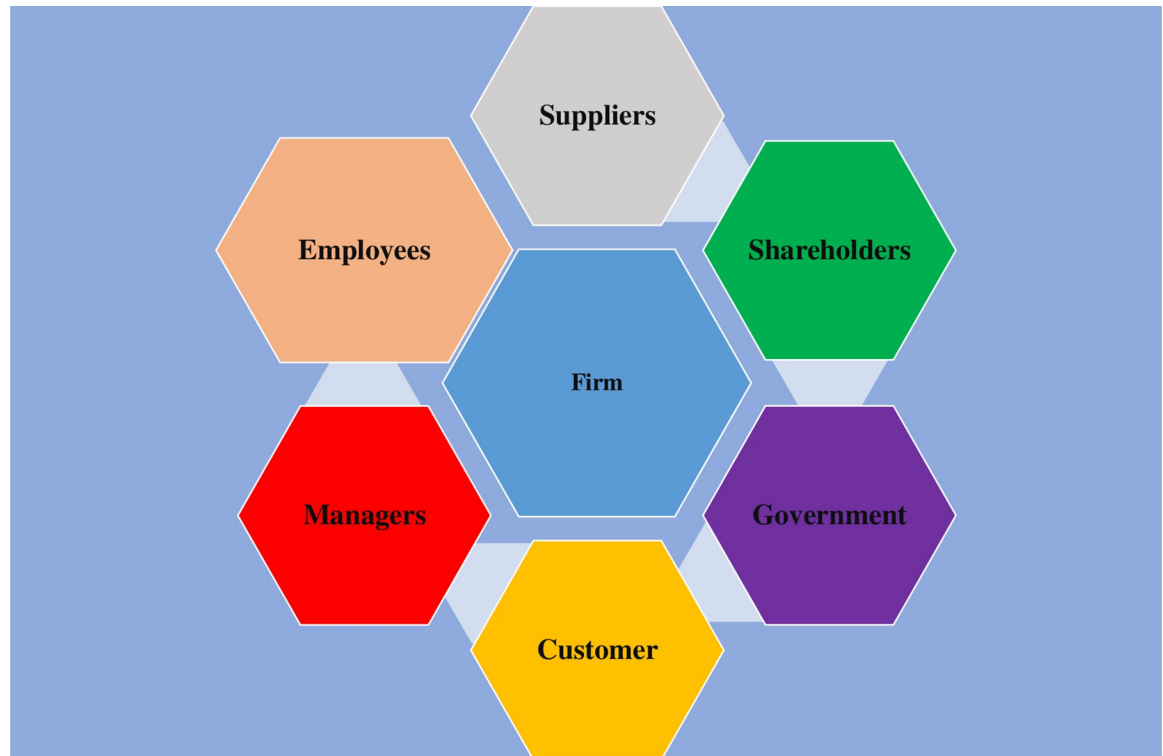


Fig 1. A simple framework of different stakeholders of a firm involved in a business cycle.

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asymmetry include (i) market efficiency, where evidence shows that information asymmetry erodes market efficiency while allowing a surge in equity misvaluation [3]; (ii) investment, where firms with higher information asymmetry turn to lower their investment and financing [16]; (iii) financing, where firms with inadequate information incur a higher cost of capital [40]; and (iv) taxes, where Government revenue from taxes reduced in information asymmetric credit markets particularly for developing economies due to tax evasion [41]. In a like manner, Harju and colleagues [42] observed “missing miles,” a term describing a decline in mileage while comparing reported mileage declared by car importers at the port of entry with subsequent information from vehicle assessments. Below we focus on 4 key hotspots, namely investment, financial inclusion, agency conflict, and taxation.

3.2.1. Foreign direct investment (FDI). A unique contribution brought about by FDI and trade is the growth and development opportunities it offers to a State. FDI fosters the optimization of financial capital and technological know-how, accelerates average productivity and domestic investments, and provides better employment benefits compared to the domestic average [43]. An indirect consequence of FDI is the increased demand for intermediate inputs, labor mobility, and knowledge sharing with local partners [44]. Following the enormous benefits derived by a host country from FDIs, it is, therefore, a worthy course for firms and governments to seek solutions necessary to minimize the effect of information asymmetry on trade. The literature on investment posits that firms do not suddenly learn about economic opportunities; their environment helps model their economic decisions [45,46]. Evidence demonstrates that disclosed information plays an influential role in investment decisions [47,48]. The relevance of information in trade can therefore not be overemphasized.

A strong link exists between trade and investment and this is particularly true in cross-border trade as exporters may require investors in the export market to create a distribution

network [49]. Such a partnership will save the exporter some operational cost of setting up and running an overseas plant, hence, an increase in trade flows [50]. In a situation where investment is not seen as secure due to inadequate information or uncertainty about legal protections, firms may not invest, leading to a reduction in trade. Also, Hummels and Schaur [51] explained the time-intensive nature of trade and display how it shapes the cross-border pattern of trade. Furthermore, information frictions affect import transactions as such transactions are frequently executed using a cash-in-advance-like arrangement [52]. Besides, information asymmetry affects investors' perception of a given market that can potentially hamper trading. It is a common opinion among some scholars that local investors have an advantage over foreign investors. This is because local investors are perceived to have superior information about firms due to their physical nearness, their knowledge of the sociopolitical environment, and their shared linguistic and cultural origin [53]. Nonetheless, another school of thought posits that foreign investors possess more information about firms due to their superior investment experience and expertise, which translates into profitable trade ventures [54].

3.2.2. Credit creation and financial inclusion. The lifeblood of every business venture is finance. It is estimated that about 80% to 90% of world trade relies on some form of trade finance [55]. A common form of raising finance is through debt. Debt financing is greatly favored by firms because of its tax advantages. Also, for fear of dilution of power, the sitting shareholders of some firms will favor debt financing over equity, and it is also not an easy process to obtain an initial public offering (IPO) in some markets [56]. Financial intermediaries have long played a pivotal role to assist businesses raise the much-needed funds for their operations. They achieve this goal through the allocation and reallocation of resources from net savers to net borrowers. Nonetheless, due to the malicious behavior of some borrowers, all loans are given out on a loan recourse basis to protect the lender from any default in the settlement. The loan recourse arrangement requires collateral that often constrains trade financing especially for those businesses that lack the appropriate collaterals thereby slowing down trade. Also, it is suggested that credit constraint is a principal factor that inhibits a firms' ability to participate in international trade [57] and for small and medium-sized enterprises to take advantage of growth opportunities [58].

It is known that firms engaged in the exportation of products rely more on external finance than those who produce for local consumption on 4 premises: (i) the initial fixed cost incurred in establishing trade networks overseas; (ii) time lags between payment, clearing, and settlement that strains working capital management; (iii) information frictions resulting in a lack of trust between overseas trading partners; and (iv) an additional cost to hedge against all risk inherent in cross-border trade [59]. This paper focuses on the third point. To this end, Park and colleagues [60] observed that large firms involved in cross-border trade have more access to external financing compared to smaller firms in markets where information asymmetry is low moderate. Also, adverse selection has a significant influence on the trading of tokens in the initial coin offering (ICO) market [61]. To build trust between trading partners, financial intermediaries as liaison officers provide guarantees and commitments in the form of letters of credit to allow grimy firms to establish trust with foreign trading parties [62]. This notwithstanding, the issue of such a letter of credit is left in the hands of large banks [63]. Hence, those who lack access to mainstream banks remain financially excluded.

3.2.3. Principal/agency conflict. Conflicts between stakeholder groups emanate from differences in objectives and the desire to gain at the expense of others. It has been argued in prior studies that most of the instruments used to align the interest of managers to that of shareholders (tier 1 agency problems) will give birth to a second type of tier 2 (principal-to-principal) (P2P) conflict [64]. For example, the use of a stock option to align the interest of managers as agents to that of shareholders (principal) will create new shareholders who can

use their dual position as a tool to extract unwarranted benefits from the firm leading to tier 2 conflict [65]. At the corporate level, the asymmetric problem could occur when the bone of contention is (i) whether the principal can observe information at the design stage in a contract; and (ii) whether the principal can judge the information provided by the agent as legitimate [9]. Managers (agents) are very ambitious and are more focused on the short-term survival of the business, demonstrated through growth in profitability, while shareholders are more concerned about the long-term growth of their business. It is against these differences in goals that managers can engage in risky trade deals with short-term profitability while compromising long-term growth. This is particularly the case when monitoring is low [15]. Likewise, in an attempt to evade a decline in firm value, controlling shareholders may become risk-averse. This behavior can create agency conflicts as controlling shareholders may try to protect their private benefits of control rather than maximize minority shareholders' wealth [66]. Accordingly, Wang, [67] argues that agency conflict is high for FDI firms stemming from information frictions that may lead to the exploitation of stakeholders. Often, people collaborate with people they can trust. This makes trust a key ingredient for a successful business relationship.

3.2.4. Tax collection. A principal source of government revenue is tax such as income and consumption taxes, import tariffs, and taxes on property transactions and ownership. The government generally tends to rely more on firms than individuals for the collection of tax since their income are easily traceable. However, both individuals and firms may misrepresent their income to defraud the government. This act is referred to as tax evasion and is punishable by law. Scholars investigating the size and determinants of tax evasion estimated the threshold gap between the expected taxable liabilities and actual tax collected for Europe and America (United States) between 18% to 20% [68,69].

It is difficult to detect tax evasion as the motive of the concerned parties is to mask their lack of compliance. A growing school of thought has associated a lack of compliance with peer influence [70,71]. Nonetheless, attempts have been made to overcome tax fraud by national and international authorities such as third-party reporting [72], auditing [73], and information exchange on request (IoR) for cross-border trade [74]. Nonetheless, evaders keep devising new means to lower their tax liabilities. Also, globalization, growth in cross-border trade, the surge in E-commerce, technological advancement, money laundering, and corruption by taxpayers and their agents are some of the special issues that necessitate the deployment of strategies that promote transparency and early detection of possible tax evasion.

From the foregoing discussion, building from a stakeholder perspective for contracting parties, it was observed that information asymmetry stems from differences in preference among the stakeholders in a trading cycle [39]. Further analysis revealed that the main asymmetric concerns include: quality of available information [51], access to relevant information [53,54,75], transparency [74], and the cost involved in building a credible relationship [76–78] and trust [59]. More specifically, “trust” cuts across all 4 asymmetric hotspots, thus, we discuss how “trust” is implicit in information asymmetry (see Text A in [S1 File](#)).

4. Methods to curtail information asymmetry

Information asymmetry is a normal economic phenomenon and efforts to eliminate it may change the paradigm of economic activities. Therefore, efforts have been made to at least manage this phenomenon to a bearable minimum. As early as the 1970s, the Signaling theory was introduced. This theory proved effective in reducing information asymmetry [79] and remains relevant in recent times as Connelly and colleagues [80] and Jolink and Niesten [81] presented supportive evidence. Also, Chung and Jo [19] argued that the watchdog role of security

analysts helped lessen the agency costs associated with the principal/agent asymmetry conflict. Other mechanisms that have been empirically established as effective in alleviating information asymmetry problems are: verification services offered by the auctioneer [82]; the use of external auditors to align the interests of the majority and minority shareholders [4], the appointment of non-executive directors (NEDs) [83]; and network intermediaries [84]. For a data-driven market in the European Union (EU), Van de Waerdts [14] reported that the General Data Protection Regulation was not able to mitigate the information asymmetry problem significantly. The author's conclusion remained robust after considering alternative regulations. Similarly, it was reported that patents partially alleviated information asymmetry in the area of bank loans to R&D-intensive firms [13].

The main concerns with the strategies explained above are: First, they only apply to conflict situations that are easy to spot. However, as noted earlier, asymmetric hotspots like tax evasion cannot be easily spotted. Similarly, several reasons account for why trading parties hoard information leading to a lack of precision. Secondly, such strategies necessitate continuous monitoring to endure that there are no lags in the trading relationship rather than letting the relationship grow organically with little direction or oversight. The third concern with the above measures is that of interpretation. Taking signaling as an example, it has been reported that the signaler and the receiver have conflicting interests when it comes to signal interpretation [85]. This conclusion is similar to that arrived at by Van de Waerdts [14] while studying the General Data Protection Regulation for the EU in moderating information asymmetry. Therefore, variation in interpretation by contracting parties hampers such strategies as measures to alleviate information friction in trade. Finally, the cost involved in the implementation of the above strategies is generally expensive. For example, the reliability and relevance of a signal are driven by the cost. That is, the higher the cost, the better the signal being sent [86].

5. Application of digital ledger technology (DLT) in trade

5.1 The structural design of a trade model based on DLT

DLTs such as smart contract and blockchain have received considerable attention from the mainstream media as well as industry practitioners as software that could transform trade and post-trade clearing and settlement [87]. DLT is designed to capture and store a distributed record of digital events. With this software, participants are connected by nodes that are devices running the DLT software that collectively maintain the database records [23]. Each participant with a node maintains a common ledger and new transactions are only added to the chain following the approval of an absolute majority of participants [88]. Fig 2 shows a simple example of how participants in a DLT arrangement are connected. DLT arrangements take 2 forms: open systems that anyone can access (e.g., Bitcoin platform) and closed systems where access is restricted [89]. The role participants play within a DLT arrangement can be viewed from 2 spectrums, "permissionless" in which the participants are allowed to perform all activities (Fig 2A) and "permissioned" where participants' activities are restricted and often used within a firm or consortium (Fig 2B) [87].

5.2. Elements of a DLT trading process

A traditional trading process has a series of stakeholders and processes that facilitate the movement of goods and services between the supplier and customer. Each of these stakeholders keeps individual ledgers at their various entities. It is this independent record-keeping procedure that creates trust issues among trading partners. Previously, issues of trust were dealt with using a trusted third party such as brokers and external auditors [4].

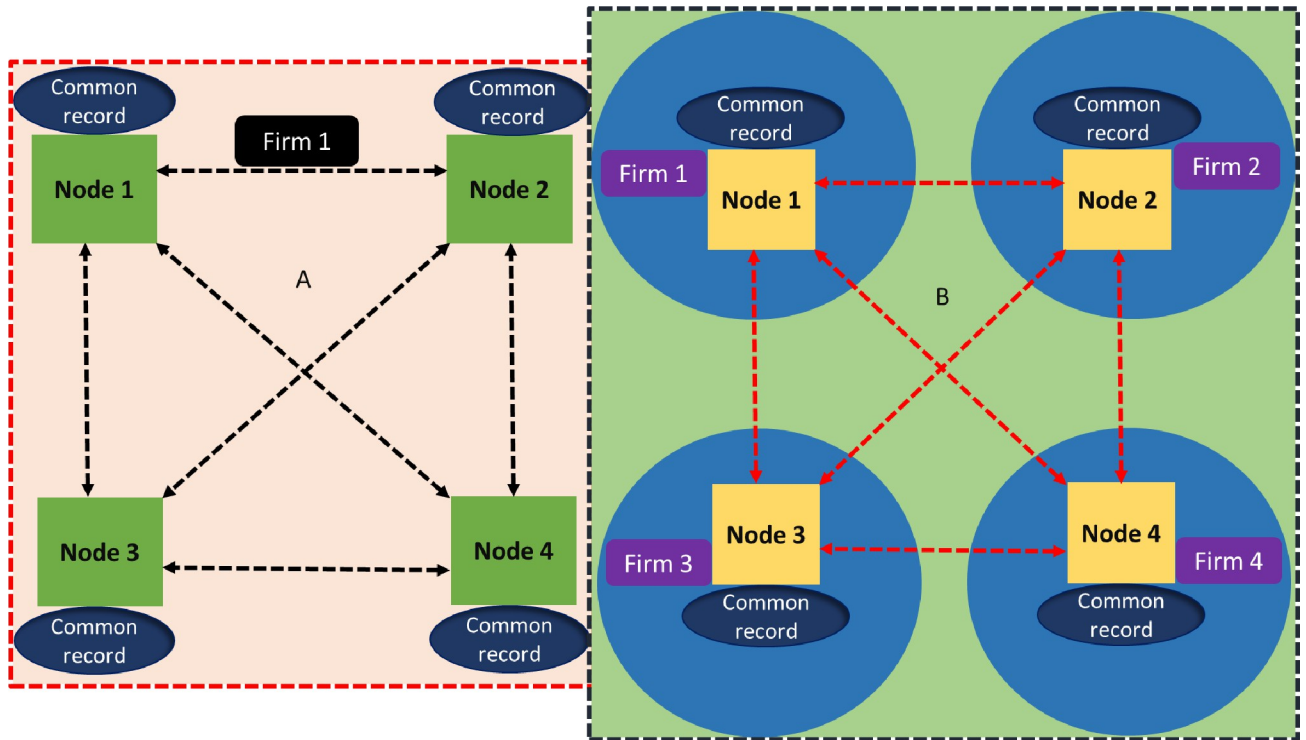


Fig 2. Permissionless DLT arrangement with a single firm hosting all nodes (A) and permissioned DLT arrangement with multiple firms each hosting a node (B) (adopted from [24]).

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In Fig 3A, a simple traditional trade cycle with a single third party and 4 participants is captured. The trusted third party serves as the information hub as it has a host of transaction files of trade participants that go through it. All other participants maintain their independent

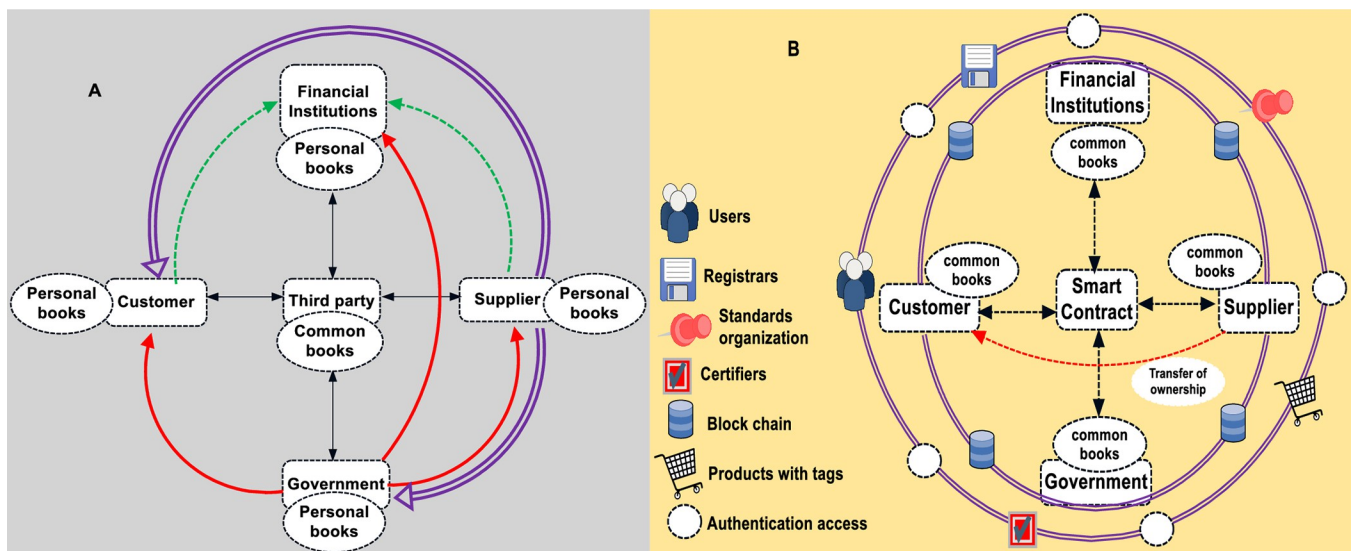


Fig 3. (A) Simple traditional business cycle with a single third party and 4 participants. Black doubled headed arrow = information exchange between third party and participants; green dashed arrow = sourcing of finance by customer and receipt of payment by the supplier; red arrow = the government as a regulator; purple hollow arrows = transfer of goods to new owners. (B) A reengineered business process based on a DLT arrangement (adapted from [23,91]).

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transaction files that include those contracted through the third party and others. As shown, the government acts in a dual capacity as a regulator and a purchaser of goods and services. Also, the customer as an end-user relies on financial institutions for the resources necessary to settle its transactions, while the supplier as custodian of goods and services also relies on financial institutions for trade settlement. Nevertheless, the procedure and transaction mode of a DLT trade model is somewhat different from the traditional one. Thus, it is necessary to identify the elementary trade processes to evaluate how DLT trade design functions. The proposed DLT design is presented in Fig 3B. Basic elements of the trading process include participating stakeholders, transaction commodities, basic operation modes, and post-trade activities (see Text B in S1 File).

5.3. An illustration using the DLT trade process

In this section, we establish a basic illustration of how buyers and sellers initiate and complete a transaction in a DLT arrangement. As discussed in 4.2 and Text B in S1 File and Fig 3, each physical product is assigned a virtual identity that makes it tradable on the network. Besides, this hypothetical illustration assumes that all participants on the network have been duly signed in by the registrar unto the network. Furthermore, the standard organization appoints certifiers to assert if the rules for standard procedures are being adhered to products that are added to the block. If they are satisfied, then both the certifiers and standard organizations will digitally sign a certificate that is displayed on the participant’s profile. Now, we have a buyer (Com A) who produces chocolate and a seller (Com B) that grows cocoa, and there are other actors within the network that trade in other commodities as well as financial institutions and regulators. The entire trading flow is explained below.

5.3.1. Deal initiation. The buyer can scout for the desired product on the network using their unique digital key from a DLT product catalogue (Fig 4A). Once Com A selects the desired product by clicking on the product tag, an order will automatically be generated and broadcasted in the network with details such as name, tag identifier, description, issuer, location, information type, issue date, and expiration date (Fig 4B). At this point, the cocoa producer (Com B) can initiate a trade with Com A, where the transfer of cocoa beans to Com A is completed by signing a digital contract that is saved on the network [90]. This allows for ownership traceability within the network.

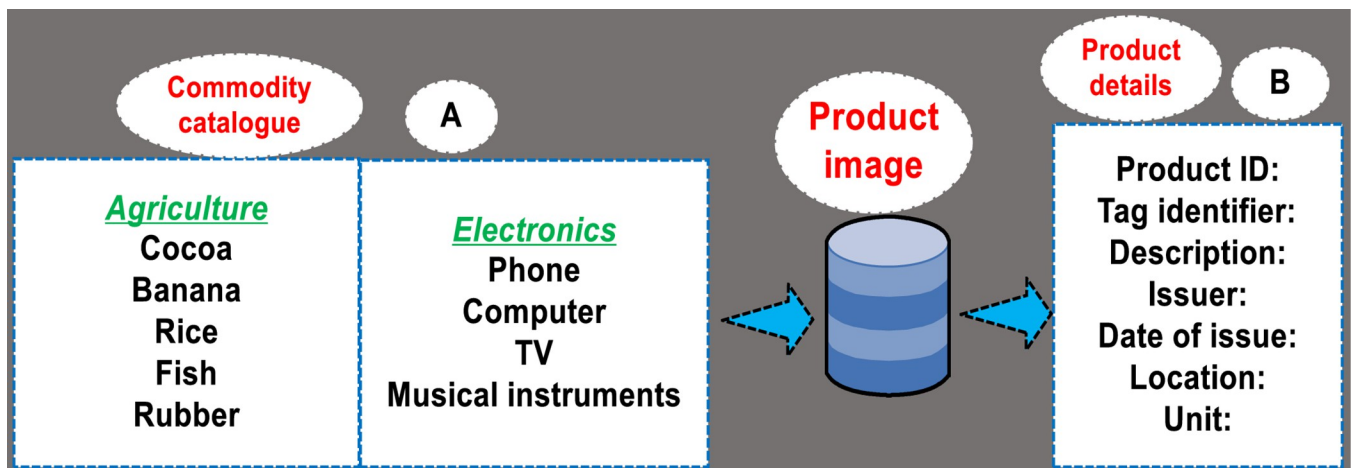


Fig 4. A simple DLT commodity information catalogue.

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5.3.2. Deal validation. Com B will have to be certified by a legitimate standard organization such as ISO. This organization now appoints certifiers or auditors who will visit Com B to verify their compliance with the requirement of ISO 34101–4 (<https://www.iso.org/standard/64765.html>). Upon completion of the verification process, Com B's profile and products can be digitally signed by the certifiers and standards organization to prove their certification. To further confirm if the cocoa bean belongs to Com B, other participants in this trade deal, with permission to act as validators, can audit the transaction record by decrypting it with a mathematical algorithm and Com B's public key [24]. Here, certifiers also validate the identity of all other participants and disclose this information to the network through the registrar. The above verification is referred to as the verification of ownership. There are also conditionality checks intended to authenticate the availability of funds and access to credit by the counterparty (Com A) to allow for smooth settlement of the deal [89]. In sum, this step improves the transparency, integrity, and security of the entire network.

5.3.3. Deal execution. Sales are considered complete in a DLT arrangement once the new owner of a product acknowledges receipt of the product. In this scenario, Com A will acknowledge receipt of the cocoa bean by scanning them through their node scanner [91]. Therefore, Com A now has the sole authority to update the product profile. To this end, the common ledger will be updated with the new ownership position of the relevant stakeholder [23]. A change in ownership is then broadcasted in the nodes that maintain a copy of the ledger; which is by consensus regarded as the new version. The consensus is an algorithm that captures and records transactions on a common ledger in a DLT arrangement [24], thereby, eliminating the need for duplication in record keeping and multiple reconciliations.

5.3.4. Deal settlement. Deal settlement warrants Com A to pay Com B for the goods supplied. An Interledger Protocol (ILP) that creates a point of convergence among digital ledgers can be employed. Here, Com A and Com B agree on a payment trail by creating a ledger escrow account where the fund is blocked [24]. This ledger can then be integrated into the DLT software by enabling escrow transfers [92]. The protocol will execute escrow transactions upon reception of a cryptographically signed receipt from the recipient (Com B) that payment has been received. Furthermore, the protocol is easily adaptable. Thus, an integration of ILP protocol into DLT protocol will go a long way to accelerate the problem of scalability that is a common limitation of DLT protocol raised in prior literature [26].

6. The potential benefits and drawbacks of DLTs

6.1. Potential benefits of DLTs

Earlier works on trust have discussed the possibility of using “trust” as a mechanism to balance the bright and dark side effects it has on trading relationships [93,94]. In this regard, we posit that the optimization of DLTs can foster trust among trading partners as it facilitates better control and audit thereby reducing information frictions. The distributed and peer-to-peer (P2P) nature of the technology improves information integrity, transparency, trust, and reduces cost [95,96]. Particularly, its efficacy is felt more when there is a conflict of interest and imperfect information [27]. Its design advocates “distributed consensus” where participants collectively verify the validity of a transaction before it is captured in the network and allows for improved transparency [88].

With DLT, newly added transactions are time stamped, and several copies are created and stored at different participating nodes to fortify data integrity and accessibility. The record can then be viewed by any participant with the cryptographic “public key” but cannot be modified, even by the user who initiated this transaction [87]. In addition, all transactions on the DLT

network are executed based on agreed terms between participants using a Smart Contract, which enables business and legal agreements to be stored and executed online [23].

Due to its numerous potential, industry practitioners are considering deploying DLT in their operations since it can reduce frictions in the clearing and settlement of stocks, thus, saving them from incurring a third-party cost [24]. According to Abeyratne and Monfared [91], new application software with DLT features will make these improvement goals more organizationally, technologically, and economically feasible.

A summary of the potential benefits of DLTs in alleviating information friction is presented in Table 2. The growing potential of DLT in reducing information gaps is of great interest to players in the financial service industry, particularly in the context of trading and settlement. In this regard, DLT can potentially help address problems involving cross-border transfers as well as hitches encountered in allowing end-users access to a large array of financial services. Financial institutions can leverage the technology to manage risk relating to regulatory compliance, transaction reporting, credit allocation, and other audit processes [97]. For example, R3 has developed a digital platform “Corda” that allows the recording and management of financial transactions. (R3 is an enterprise software firm that is pioneering digital industry transformation. The company began an in-depth exploration of DLT in 2014, and in September 2015, formed a consortium of 9 institutions, which quickly expanded to more than 80 firms and regulators across 22 countries. The R3’s Corda is a scalable, permissioned P2P DLT platform that enables the building of applications that foster and deliver digital trust between parties in regulated markets (<https://www.r3.com/about/>.) The emergence of new institutions such as Skuchain (<http://www.skuchain.com>) with a vision to foster various DLT-based initiatives at all stages in the trading cycle indicates the possibility of this technology delivering on its embedded potential. (Skuchain is a Currency Agnostic Blockchain that links procurement and contract management, financing arrangements, direct enterprise control of corporate payments, and inventory tracking in a buildable manner. The result of such a construction is a Liquid Supply Chain, where data flows downstream in real-time and early payments flow upstream in a risk-mitigated manner from new pools of capital.)

Agent and Principal trust issues can be resolved using DLT. Specifically, DLT could be used as a firm’s new informational backbone. Blockchain (BC) from the DLT family is fondly referred to as “the trust machine,” which implies it takes care of trust issues between individuals [103]. In other words, systems and processes built on this technology, run without human

Table 2. Asymmetric hotspots and the potential benefits of DLTs.

Hotspot	Asymmetric concerns	Authors	Benefit of DLTs	Literature	Explanation
FDI	Information integrity	[51]	Improve data quality	[89,98]	Information stored in a system represents real-time data since peers must agree before transactions are entered into the system. This results in higher data quality.
	Access to information	[53,54,75]	Improve access to information	[23,96]	The DLT design is decentralized; hence, information is stored at multiple nodes that can enhance the speed of access to relevant information.
Financial inclusion	Lack of trust	[59]	Trust machine	[95,99]	Facilitates control and audit as business records are stored and executed online based on pre-agreed rules. This can thus enhance trust.
Principal-agent conflict	Cost of monitoring	[76,77,100]	More economical and cost-effective	[24,96,98]	The costs of conducting and validating a transaction can be reduced as each actor maintains a common ledger that allows network participants to share the costs of maintaining recordkeeping infrastructures.
Taxation	Transparency	[74]	Improved transparency and auditability	[101,102]	The transaction history can be viewed by any participant with the cryptographic “public key” but cannot be modified, even by the user who initiated this transaction.

DLT, distributed ledger technology; FDI, foreign direct investment.

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interference, thus, making a transaction “trust-free” [104]. Given that DLT is a decentralized network of peers, no one can unilaterally take actions on behalf of their peers without their profound authentication [105]. In such a democratized context, agents cannot unilaterally breach corporate protocols. Collomb and Sok [106] proposed that DLT could be relevant in corporate governance by ensuring a free and fair election during shareholders meeting through secure electronic voting, and it can also assist managers to identify all shareholders thereby allowing for transparent dividend payouts to shareholders or coupon payments to bondholders.

DLT also has the potential for use in alleviating asymmetric issues linked to tax fraud. For example, a Digital Invoice Customs Exchange (DICE) has been identified as a technology-intensive tax compliance program for value-added tax/general goods and service tax (VAT/GST) [107]. DICE makes use of invoice encryption to ensure the exchange of data between trading partners at the local and international levels, and at the same time, alert concerned authorities about the specificities of all transactions. DICE has so far proven effective in preventing tax evasion. For example, after a successful implementation of DICE in Rwanda, the country recorded a surge in revenue by 16% within 6 months [107]. Although DICE is technology intensive, it operates using a centralized system and therefore still falls short of being used in a trustless environment. Thus, we follow Ainsworth and Todorov [108] to propose that an upgrade of DICE to a permission blockchain-DICE will allow all connected nodes within the chain to exchange tax data and allow transaction history visible to all connected nodes. This will go a long way to facilitate early detection of tax fraud, prompt effective domestic data gathering, frequent record updating, frequent accuracy checks of local taxpayers, and create an enabling environment for cost-effective tax auditing. In general, the software has the advantage of enhancing trust, improving transparency, and curtailing intermediary costs.

6.2. Limitations of DLT technology and possible solutions

In cognizance of the fact that the development of new technologies generally gives birth to a new series of challenges be it social, economic, or technical, DLT is no exception. The limitations of DLT come under 3 categories. Firstly, technical issues such as scalability limit the number of transactions that can be run at a time [25]. This issue is being handled by developing distributed ledgers that allow the integration of Application Programming Interfaces (APIs) [24]. Secondly, the initial cost is generally high and can be reduced by the collaboration between developers and consortium members. This helps to foster usability and lowers the cost of managing the infrastructure [97]. Thirdly, the regulation remains a big concern both at the firm and national level. Nonetheless, regulators and practitioners are seeking means to develop common standards within consortiums to guide the interaction between participants. These limitations may deter the full adoption of the technology, but the good news is that developers are working together with users to deliver packages to meet their specific needs (<http://www.skuchain.com>). That is to say, the software is flexible and easily adaptable.

7. Conclusions

Access to and quality of information are essential ingredients for business relationships to thrive as information can alter people’s behavior. The main aim of the study is to highlight how DLTs could function as a transparency device to mitigate inefficiencies in trading relationships with imperfect information. In addition, the study demonstrates how the DLT arrangement can transform the traditional trading model. The study makes the following contributions to academic research; first, we identify key asymmetric hotspots and evaluate various mechanisms that have been used in scientific literature to mitigate information friction and their

drawbacks. This is done to portray the limitations of prior measures and demonstrate how the DLT approach can potentially alleviate these concerns. Next, we propose a new trade model using a hypothetical example that provides trading parties with reliable, transparent, and complete records of each transaction's history.

Furthermore, the proposed trade model remains relevant to several stakeholders. For example, to attract FDIs, a secured business environment is a necessity. DLT has key features of security, auditability, and transparency. Therefore, its adaptation will attract FDIs as well as enhance investors' trust. Also, governments on their part can leverage this technology to manage tax evasion issues. In like manner, firms can adopt this technology to meet up with corporate governance requirements more efficiently. More so, financial institutions also benefit from such technology in managing problems of adverse selection and moral hazards as the technology supports the historic traceability of transactions. In a nutshell, the features of DLT help reduce information asymmetry to the lowest minimum. We hope our model will spur the adoption of DLT at the firm and national levels.

Despite the limitations of this technology, as discussed above, efforts are being made in the industry and academic sphere to address these concerns which strengthen our resolve that the technology is worthy of adoption. This is particularly the case for businesses that want to remain competitive in an ever-changing market triggered by technological advancements. Thus, we hope that the theoretical illustration herein serves as a starting point for the adoption of DLT in trading relationships, be it at the national or international level.

In summary, this study has made attempts to introduce a potential solution to issues of divergence in interest and trust known as DLT solution that is generally regarded as a "trust Machine" from a theoretical perspective. However, its efficacy will be stronger when the research community works in collaboration with industry practitioners along with developers. To this end, industrial actors will have to make their data available to researchers that will help them minimize the issue of biases when they base their conclusions on simulations. By extension, these firms will gain insights into concepts and practices that were initially unknown to them. Therefore, future research can extend the work of Allen [31] who empirically studied the relationship between information asymmetry and trade by introducing DLT as a moderating variable to test the quantitative benefits of the technology.

Supporting information

S1 File. Text A. The importance of trust in trading relationships. Text B. Elements of a DLT trading process: Participating stakeholders. Transaction commodities. Basic operation modes. Post-trade activities.
(DOC)

S1 Table. Bibliographic sources of information friction in business relationships.
(DOCX)

S2 Table. Categorization of information asymmetry by topic sentence.
(DOCX)

S3 Table. Prior measures to curtail information asymmetry.
(DOCX)

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