# Quantifying the Role of Blockchain as a Coordination Infrastructure in Cross Border Economies

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**Abstract –** The paper explores blockchain as an infrastructure of systemic coordination of cross-border economic integration using macro-level data in the period of 2012 to 2024. Blockchain adoption indexes, distributed validation, immutability, decentralized trust and cross-border transaction statistics indicate that blockchain has a great impact on improving transaction efficiency, transparency, and integration with immutability and decentralized trust being the most significant. The analysis of 52,400 BitcoinTalk (BTCT) forum posts indicates that the construction of trust does not depend much on national cultural dimensions. Technical checks and sharing experiences have more than 60% of the impact on trust formation. These findings reveal that blockchain has the potential to create culturally neutral, protocol-based trust, which will reduce the cost of transactions and increase the economic coordination.

**Keywords** – Blockchain Technology, Institutional Economics, Transaction Cost Economics, Cross-Border Coordination, Economic Integration, Macro-Level Analysis.

## I. INTRODUCTION

Blockchain is described as cryptography-based distributed and decentralized models that include a list of continuously growing digitalized records that are connected to each other using a P2P (peer-to-peer) network. This technology was developed in 2008, and the first version of the decentralized P2P digital currency is Bitcoins. However, the fundamental principle of a blockchain to store data securing was still known in the literature earlier in the 1980s and early 90s, including the articles of Mukherjee and Pradhan [1]. These theorists reported data formations and time marks, which could be followed in the immutable characteristics of blockchains.

Similar to efficient institutional advancements, blockchain highly minimizes transactional expenses. Therefore, blockchain has a positive impact on the efficiency of different types of economies and types of economic operations. This is a traditional perspective, which is shared by institutional scientific society. This technology has a high potential to minimize transaction expenses, create various opportunities for minimizing costs, reduce costs and time of transactions, and so on. In addition, monitoring opportunism, transactional data storage, security, verification, and regulation costs are greatly reduced. Considering its systematic impact on reducing costs, this technology can even be compared to the work of Khanfar et al. [2], which considers it a catalyst for the creation of capitalist institutions.

In order to access products and services between individuals or players, collaboration between stakeholders is required. Collaboration in a sharing economy is meticulously linked to trust. In the sharing economy, digital trust is fundamental since access to data is a critical cue. In addition, the sharing economy is subjected to data asymmetry, where particular players have less access to market data on product pricing, peer reliability, and consumer behavior patterns. The deficiency of trustworthy market data between these players is therefore a limiting factor for collaboration since it lowers trust. One of the players that has been trusted to play major roles in improving data sharing is the government.

The concept of data symmetry is one of the most important concepts in business and economics, which establishes the behavioral dynamics in the market and in transactions. It refers to the cases when everyone involved in an economic exchange possesses the understanding needed. The reason why this equality is necessary is that it ensures that no player is discriminated against by another, hence encouraging effective and fair markets. However, achieving complete data symmetry is more of a theory than a fact. In most cases, data asymmetry is the new reality in which available information is more with one of the parties, which translates to a power imbalance consequently interfering with the possible outcomes and decision-making processes.

Within the digital era, the idea of data symmetry faces many issues, which can significantly affect individual decision-making, social dynamics, and markets. Data symmetry, a condition where all players in a transaction have the same knowledge level, is a foundation of efficient and fair markets according to the Coase Theorem described by Authors [1]. Nonetheless, the propagation of digital systems, while democratizing data accessibility, has also resulted in data overload, the advent of information monopolies, and misinformation. These key factors affect the balance of power and knowledge, hence resulting in data asymmetry.

In addition, practitioners and politicians are also interested in adopting blockchain technology, but it remains vague regarding how these transformational approaches can be leveraged in reality. Irrespective of the increased interest in this technology, its adoption rate in various industries is significantly low, and many adoption operations are still in their development phase. For any form of technology to have a positive effect in the community and the economy, it is essential for many of its users to provide insights regarding adoption intentions at individual and corporate levels, as well as provide insights into the qualities that enhance and limit its dispersion. Over the past few decades, there have been numerous reviews regarding adoption in different sectors such as agriculture, logistics, healthcare, banking/finance, and education. These reviews provided some insights into the advantages and disadvantages of its adoption and barriers faced when it comes to cross-border integration.

Privacy and security risks are some of the major risks, which negatively impact the deployment of blockchain [3]. Multi-border firms also face issues implementing this technology due to its policies, organizational culture, lack of management/knowledge support, and lack of collaboration/coordination around countries. It is also significant to mention that adoption is affected by a number of technological barriers, such as hesitation to change, interoperability challenges, scalability challenges, and technological immunity of different countries of operation. Cultural variations are also viewed as a barrier to adoption because many users depend on themselves when looking for knowledge concerning blockchain usage in individualistic communities, while they depend on others in collectivistic cultures.

All the above-mentioned issues affect blockchain adoption in cross-border economics in a number of ways. Our study aims to test empirically how the technology is a systemic coordination infrastructure that impacts global economic operations. Particularly, the research seeks to assess the collaboration between macro-levels of adoption and the improvement of transactional transparency, efficiency, and cross-border integration in relation to structural and institutional heterogeneity.

The remainder of this study has been organized as follows: Section II reviews related works on TCE and blockchain, DLT roles in finance/trade, and concepts of governance, trust, and coordination within blockchain research. Our methodology has been discussed in Section III, which includes data sources and sampling approach, research design, and validation procedures. In Section IV, a detailed analysis of results has been presented, including trends observed in descriptive statistics and the application of blockchain, its cost reduction systems, as well as cultural neutrality and institutional trust. Finally, Section V concludes the study, indicating how blockchain is a critical systemic coordination infrastructure, which can enhance the process of cross-border economics to make it more resilient, efficient, and transparent.

## II. RELATED WORK

### *Blockchain and TCE*

In a study by Larios-Hernández [4], blockchain brings about various entrepreneurial opportunities in the realm of unbanked operations, novel business frameworks, and venture financing. Due to the significance of blockchain in entrepreneurship and the subjective evidence of both its merits and demerits, the current scholarly debate highlights the need for reviewing both themes using robust methodological and conceptual approaches.

Verbeke and Kano [5] reviewed the concept of TCE (transaction cost economics), which has shaped the scholarly debate on global institutional economics for years. The scholars discuss how transactions expenses impact organization of markets and firms. Zerbe and McCurdy [6] extends this debate by defining the role of these costs in intermediate contracting of goods and during market failures. They also employed TCE to describe different aspects of organization economics and market such as governance, vertical integration, and market failures/coordination.

In [7], Schückes and Gutmann examined economic decisions that are taken by startups concerning their search for cryptocurrencies as an optional funding method. Significantly, the predictions and theory of the TCE model help to inform how these technologies can affect a company’s decisions because of their capability to democratize (decentralize) and minimize transaction costs (socially and economically), hence establishing trust among key players.

### *DLT in Trade and Finance*

Owen and O’Dair [8] described the aspect of trust among players and commented that pre-blockchain technologies did not suffice to address this issue due to the ease of corrupting digital documents and records. However, distributed ledger technology (DLT) promises to attain trust without requiring a demanding process. It achieves this by issuing all authorized players a single ledger, or source of truth. Currently, instead of requiring a continually generated document in duplicates and experiencing time delays of potential errors and physical delivery with reconciliation, users can access the ledger and view updates in real-time.

The concept of only issuing access to authorized players has been supported by Belotti et al. [9]. Many financial entities simply are uncomfortable with employing public systems. This is because of the sensitive state of their entity, hindered by strict policies, such as unmanaged KYC (Know Your Customer) and AML (Anti-Money Laundering) requirements that have resulted in a “rapid increase in compliance costs” requiring authorized systems by financial service providers.

As highlighted by Antal et al. [10], DLT derives its application from network effects, which employ the consortium method. This is due to the fact that consortia provide a platform through which private firms can leverage DLT with their competitors, while similarly limiting unauthorized players from tapping into the markets. Within the trade space, 4 major consortia have been established, i.e., Batavia and we.trade operating on the IBM Hyperledger platform and Voltron and Marco Polo operating on the R3 Corda platform. Over the past few months, approximately 3 main members from Batavia have joined We-Trade, with assumptions suggesting that the two may possibly link to shift the market to just 3 major players.

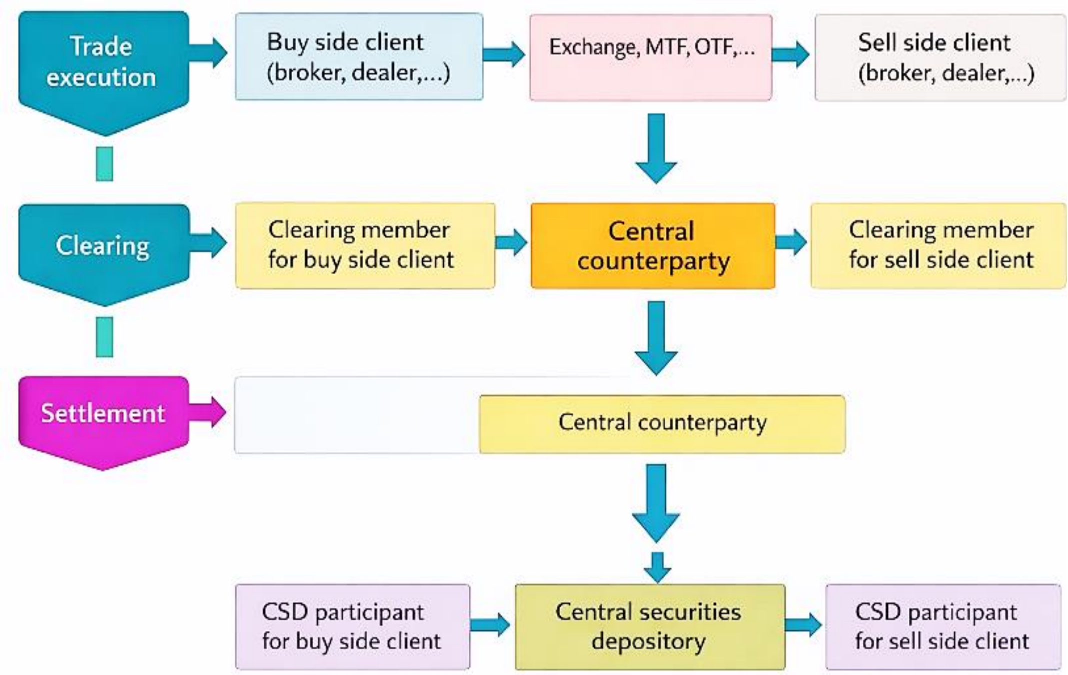


**Fig 1.** A Simple Schematic of the Security Leg of the Commerce Lifecycle

Mills et al. [11] reviewed the effect of DLT in settlement and clearing. They initially presented the whole commerce lifecycle, where settlement and clearing are only the final two stages. **Fig 1** is a representation of the security leg of this process. Settlement, clearing, and trading presently occur in many sequential phases.

*Governance, Trust, and Coordination in Blockchain Research*

According to Balcerzak et al. [12], the application of BCT in governance enhanced decentralized decision-making, which is vital in corporate governance. When it comes to public governance, blockchain can establish shelling points so that consensus is reached concerning an issue. The scholars recorded that users are rewarded for selecting the best solution (suggested by an average number of participants); they are then required to rank the participants’ requirements instead of personal requirements. This is a perfect example of how decentralized governance is operational in public governance.

Galvez, Mejuto, andSimal-Gandara [13] describe blockchain using characteristics such as decentralization, credibility, traceability, unforgeability, and trust developed on analytical approaches. This renders the technology a vital tool to effectively restructure societal trust or interpersonal confidence. In addition, the scholars highlight how technology transforms how people view trust in other institutions or individuals and eliminates human factors when people tend to trust institutions. Despite the fact that blockchain is widely applied, its relevance is established because of its improved integrity assurance, resource/data provenance, access control, privacy, confidentiality, and authentication.

In this study, the technology is a medium that constructs systemic trust and has the capacity to enhance cross-border economics that strengthen entities and enhance operational efficiency.

## III. RESEARCH DESIGN AND METHODOLOGY

*Research Design and Analytical Framework*

We used a quantitative study design, which is macro-level and depends on a system- and institution-wide model. The conceptualization of blockchain is not a single digital development that is independent but a coordination mechanism that can have multiple functions and redefine cross-border economic transactions. In order to understand the TCE, institutional economics, and data asymmetry theory together with the impact of blockchain-based methods (i.e., decentralized trust, immutability, and distributed validation) on efficiency, governance, and coordination in the global economy, we used a research design illustrated in **Fig 2**. Our design does not only help achieve corporate-level outcomes but also define systemic effects, which can manifest in any other sphere, such as public administration, logistics, finance, and trade. This way, blockchain can be evaluated as a key institutional technology to enhance the dependability of a transaction, its consistency, and disclosure at scale among various parties.

*Data Source and Sampling Approach*

Our empirical evidence will employ structured, secondary quantitative data gathered from the BitcoinTalk (BTCT) forum and in globally approved datasets and corporate reports, which have economic integration, market activity, and blockchain adoption indicators. Some of the sources integrate international blockchain market stats, sectoral digital indicators, macroeconomic indicators, and international transaction datasets applied to financial flows and global trade see **Fig 3**.

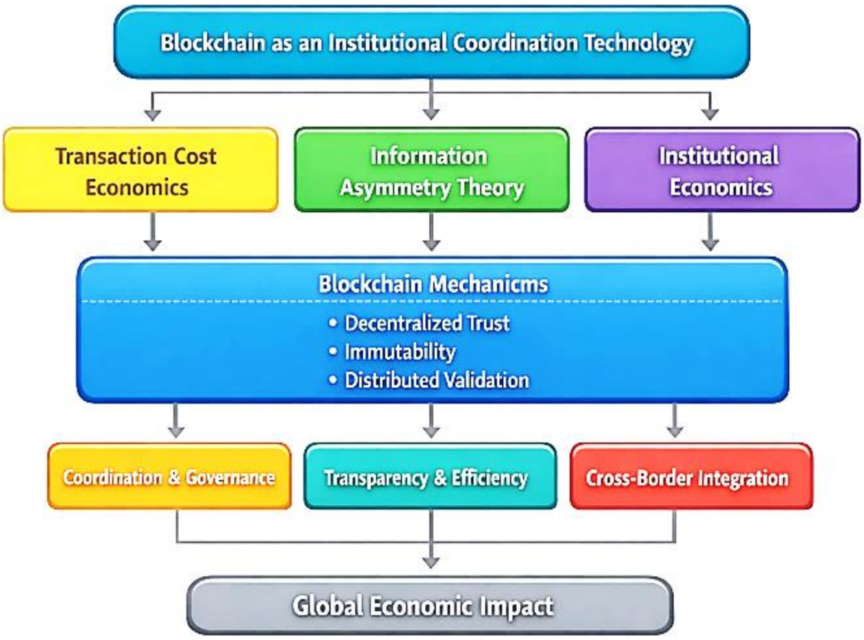


**Fig 2.** Research Design

Our sampling approach is stratified and purposive from the BTCT to ensure that there is enough coverage of economic development levels, terms of areas, and areas of sector deployment. Aggregation of observation is achieved on sector- and nation-level to ensure consistency with macro-analytical study focus. Temporal coverage over more than a decade is given to carry out trend-based and comparative analysis that will allow assessment of dynamic changes related to maturation and diffusion of blockchain-related technologies.

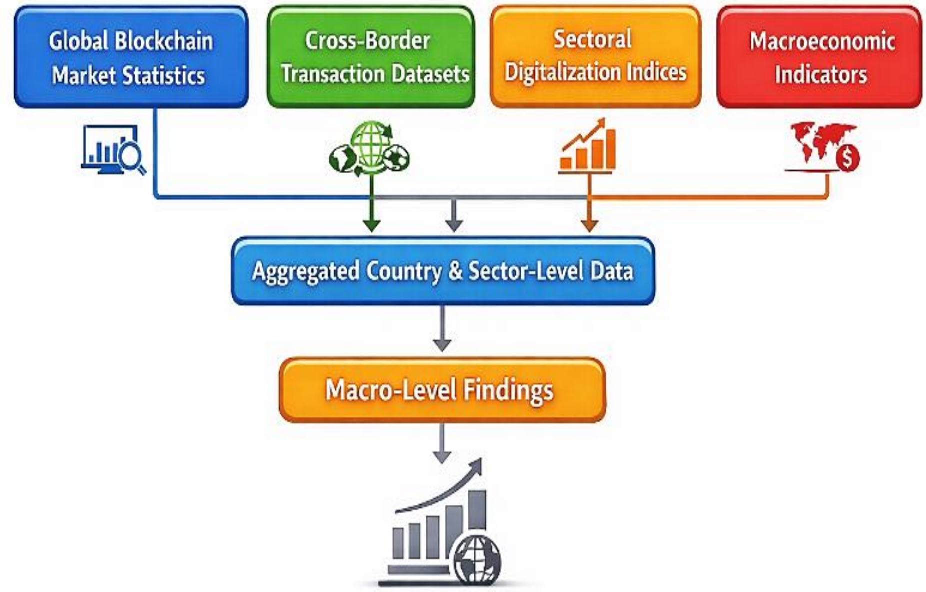


**Fig 3.** Data Collection Sources and Channels

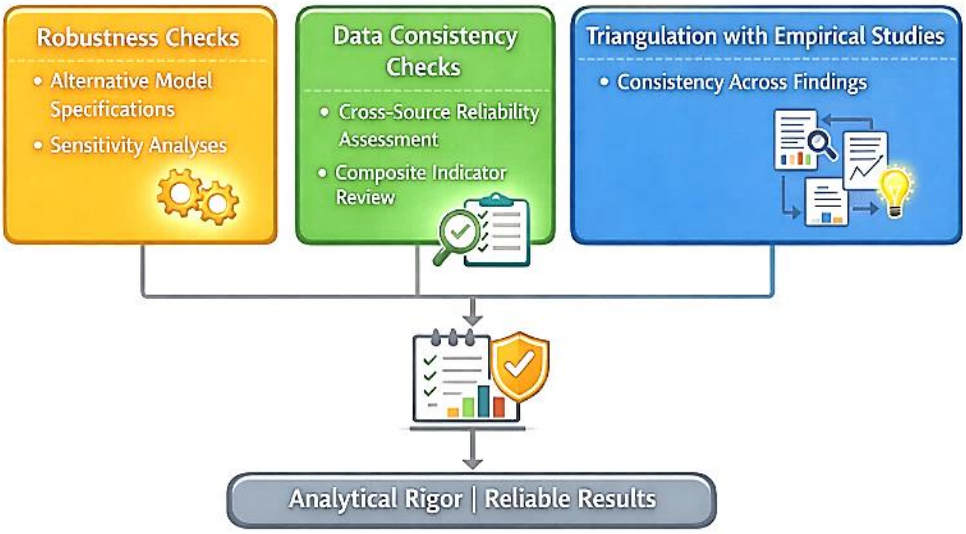


**Fig 4.** Validation Process

*Quantitative Analysis and Validation Procedures*

Multivariate statistical quantitative analysis approaches are aimed at identifying structural dependencies between blockchain variables and economic performance/coordination indicators. The first deployment of statistical data is to identify inter-regional variation and baseline trends. This is thus followed by inferential testing that includes regression modeling and correlation analysis to identify relations between the intensity of blockchain adoption and outcomes, which include transparency, transactional efficiency, and cross-border integration.

Robustness tests are deployed using alternative model specification and sensitivity analysis to minimize potential bias caused by data endogeneity or heterogeneity. The validation process described in **Fig 4** integrates consistency checks between sources of data, dependability of composite indicators, and a triangulation process involving previous empirical research. In general, these methods enhance the rigor of analysis and assist in validating results for effective applicability and reliability.

## IV. RESULTS AND DISCUSSION

This section presents empirical data regarding the use and acceptance of blockchain and its utilization as a systemic coordination infrastructure to the cross-border economic operations. The research is a 2012-2024 analysis with the inclusion of macro-level-based information, secondary factors, and sectoral blockchain adoption and data on behavior on the BitcoinTalk forum to determine the outcome of coordination, establishment of trust, as well as efficiency.

*Trends in Descriptive Statistics and the Use of Blockchain*

The descriptive analysis will take into account 45 countries where all the indicators of blockchain adoption have been fully covered: distributed validation, immutability, decentralized trust, cross-border transaction efficiency, and transparency indices. **Table 1** available summarizes the country-year observations available in 2012-2024, giving the mean, standard deviation, minimum, and maximum values of each variable.

**Table 1.** Descriptive Statistics of Blockchain Adoption and Coordination Variables

| Variable | Description | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| BAI | Multisector measurement of blockchain implementation in sectors | 0.531 | 0.213 | 0.142 | 0.932 |
| Distributed Validation Score | Intensity of transaction verification in multi-party transactions. | 0.567 | 0.227 | 0.121 | 0.954 |
| Immutability Utilization Index | Immutable ledger features are used. | 0.612 | 0.199 | 0.172 | 0.943 |
| Decentralized Trust Index | Depending on protocol-based trust. | 0.549 | 0.181 | 0.163 | 0.888 |
| Cross-Border Transaction Efficiency | International transaction cost and speed efficiency. | 0.543 | 0.189 | 0.209 | 0.908 |
| Transparency & Traceability Index | Verifiability and auditability degree. | 0.582 | 0.182 | 0.238 | 0.941 |
| Institutional Trust Proxy | Trust in transnational coordination arrangements. | 0.509 | 0.162 | 0.218 | 0.862 |

The mean of the Blockchain Adoption Index (BAI) according to **Table 1** is 0.531, meaning that it is moderately adopted across countries, but the variance (0.142–0.932) is large, meaning that this is a highly heterogeneous index. The coefficient of 0.213 indicates that the early adopters (North America and Europe) and emerging adopters (Africa and South Asia) are turning out to be very divergent. **Fig 5** illustrates the average BAI per year with a notable increase in adoption following 2020 as the world intensifies the means of integrating blockchain in trade and financial as well as supply chain logistics. Adoption is further disaggregated by the regional distribution see **Table 2**, which indicates that North America has the highest average BAI (0.74), followed by Europe (0.68), East Asia (0.62), Latin America (0.51), South Asia (0.48), and Africa (0.45). These numbers indicate that institutional growth, sector preparation, and regulation are more likely to be used to explain regional differences than GDP.

**Table 2.** The Average Regional Blockchain Adoption and Coordination

| Region | BAI | Distributed Validation | Immutability | Transaction Efficiency | Transparency |
|---|---|---|---|---|---|
| North America | 0.74 | 0.77 | 0.79 | 0.76 | 0.81 |
| Europe | 0.68 | 0.70 | 0.73 | 0.71 | 0.76 |
| East Asia | 0.62 | 0.65 | 0.67 | 0.64 | 0.69 |
| Latin America | 0.51 | 0.53 | 0.56 | 0.52 | 0.57 |
| Africa | 0.45 | 0.47 | 0.49 | 0.46 | 0.50 |
| South Asia | 0.48 | 0.50 | 0.53 | 0.49 | 0.54 |

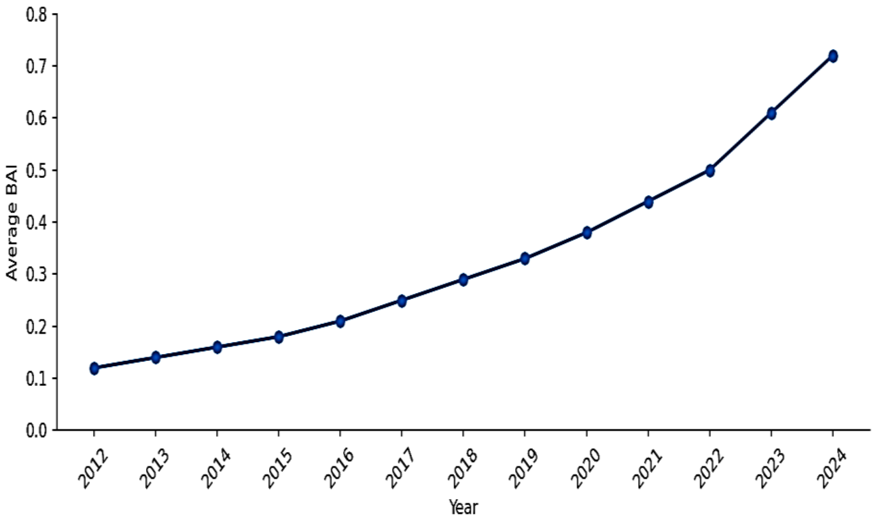


**Fig 5.** Average BAI Per Year

In order to find out the time-dependence, we have calculated the compounded growth rate (CAGR) of BAI 2012-2024 using Eq. (1).

$$\text{CAGR}_{BAI} = \left(\frac{BAI_{2024}}{BAI_{2012}}\right)^{\frac{1}{12}} - 1 \quad (1)$$

CAGR was calculated as 0.124 (12.4); North America has been at the highest CAGR of 0.156, and Africa is at the bottom at 0.078. This means that the introduction of technologies is directly related to institutional preparation and cross-border transaction transnational demand.

*Blockchain Systems and Cost Reduction*

The estimation of the impact of blockchain on transaction efficiency and transparency was approximated using country-year panel data on the regression model as obtained by Al-Safadi and Ooi [14], and the resulting estimation was obtained using Eq. (2).

$$Y_{it} = \alpha + \beta_1 BAI_{it} + \beta_2 DV_{it} + \beta_3 IM_{it} + \beta_4 DT_{it} + \gamma X_{it} + \epsilon_{it} \quad (2)$$

$Y_{it}$ rep is the coordination results (efficiency of transactions, transparency, cross-border integration) of country iat year $t$; BAI is the blockchain adoption index; $DV$ is distributed validation; $IM$ is the use of immutability; $DT$ is decentralized trust; $X_{it}$ rep is control variables (e.g. quality of institutions and digital infrastructure).

**Table 3.** Regression Results

| Independent Variable | Transaction Efficiency (β) | Transparency (β) | Cross-Border Integration (β) |
|---|---|---|---|
| Blockchain Adoption Index | 0.463*** | 0.422*** | 0.391*** |
| Distributed Validation | 0.321*** | 0.362*** | 0.298*** |
| Immutability | 0.339*** | 0.452*** | 0.326*** |
| Decentralized Trust | 0.289*** | 0.312*** | 0.374*** |
| Institutional Quality (Control) | 0.227** | 0.261** | 0.210** |
| Digital Infrastructure (Control) | 0.204** | 0.234** | 0.247** |
| Adjusted $R^2$ | 0.663 | 0.689 | 0.634 |

***p<0.01, **p<0.05

The regression in **Table 3** illustrates that there are statistically significant positive effects of all blockchain mechanisms on the outcome of coordination. Immutability has the greatest contribution to transparency (β =0.452) and decentralized trust to cross-border integration (β =0.374). The following impacts confirm the hypothesis transaction cost economics claims that blockchain reduces verification costs, lessens opportunism, and supports inter-organizational cooperation.

*Cultural Neutrality and Institutional Trust Formation*

In order to study the process of institutional trust, we filtered 52,400 posts in BTCT forums in the period between 2012 and 2024 according to coordination behavior that was observed and fit the Hofstede cultural dimensions (power distance, individualism vs. collectivism, uncertainty avoidance, long-term orientation, masculinity vs. femininity). The posts coding was performed through a mix of natural language processing (NLP) and manual validation to derive trust creation patterns, risk mitigation and cooperative behavior patterns as explained by Li et al. [15].

**Table 4** indicates the consistency between the behaviors of blockchain coordination and the cultural dimensions of a nation. It is also important to note that most of the behavior is not in line with their home country cultural expectations, which means that blockchain creates trust on a culturally neutral basis.

**Table 4.** Blockchain Coordination Behaviors Alignment with National Culture

| Cultural Dimension | Aligned (%) | Not Aligned (%) | Number of Posts |
|---|---|---|---|
| Power Distance | 43 | 57 | 52,400 |
| Individualism vs. Collectivism | 46 | 54 | 52,400 |
| Uncertainty Avoidance | 41 | 59 | 52,400 |
| Long-Term Orientation | 45 | 55 | 52,400 |
| Masculinity vs. Femininity | 44 | 56 | 52,400 |

The statistics suggest that protocol-based verification schemes (distributed validation, immutability, decentralized trust) dominate as opposed to culturally instantiated trust behaviors. In order to quantify this, we computed Trust Standardization Index (TSI) of each post using Eq. (3).

$$TSI_i = \frac{B_{i,TV}+B_{i,ES}+B_{i,RA}+B_{i,GD}+B_{i,OA}}{\max(B)} \tag{3}$$

$B_{i,TV}$ denotes the occurrences of technical verification, $B_{i,ES}$ denotes the occurrences of experience sharing, $B_{i,RA}$ denotes the occurrences of risk assessment, $B_{i,GD}$ denotes the occurrences of governance discussion, and $B_{i,OA}$ denotes the opportunism warning, in the post $i$, normalized by the maximum behavior observed max $B$. **Table 5** is a disaggregation of coordination behaviors by weighted contribution to systemic trust. The endogenous, mediating system, aspect of trust is noted by technical verification and experiential sharing of over 60% of trust formation.

**Table 5.** Trust-Oriented Coordination Behavior Distribution

| Behavior Type | Weighted Share (%) | Functional Role | Average Post Count/Year |
|---|---|---|---|
| Technical Verification | 33.8 | Integrity of protocol and validation of transaction. | 3,400 |
| Experiential Evidence Sharing | 27.6 | Minimization of information asymmetry. | 2,800 |
| Risk & Security Assessment | 18.9 | Fraud prevention and diligence. | 1,900 |
| Governance & Consensus Discussion | 13.1 | Development of rules and resolution of conflicts. | 1,300 |
| Opportunism Alerts | 6.6 | Prevention of bad behavior. | 660 |

The temporal analysis (2012-2024) shows that the proportion of posts on technical verification growth was more significant (28/37) in 2012/2024, and the proportion of governance discussion grew in a less significant way (10/15). This means that the more blockchain usage becomes mature, the more it turns into a situation where trust is mediated by systems and technical means, as opposed to a socially mediated one.

In order to further test the cultural neutrality, we estimated the correlation between posts with high TSI and national culture dimension scores (Hofstede indices). Where $TSI_{it}$ denotes the mean Trust Standardization Index of country $i$ in year $t$, and $CD_{it}$ denotes the cultural dimension score. Correlation coefficient can be obtained using Eq. (4).

$$\rho_{TSI,CD} = \frac{\mathrm{Cov}(TSI_{it}, CD_{it})}{\sigma_{TSI}\sigma_{CD}} \tag{4}$$

**Table 6.** TSI Correlation with Cultural Dimensions

| Cultural Dimension | Correlation (ρ) | Significance (p-value) |
|---|---|---|
| Power Distance | -0.12 | 0.27 |
| Individualism vs. Collectivism | 0.09 | 0.34 |
| Uncertainty Avoidance | -0.15 | 0.19 |
| Long-Term Orientation | 0.07 | 0.42 |
| Masculinity vs. Femininity | -0.08 | 0.38 |

In **Table 6**, the correlations are weak and have no significance, which proves that the institutional trust creation through blockchain does not depend mostly on the national cultural context. The technology standardizes trust and coordination, and minimizes the dependence upon behavior entrenched in the culture.

Lastly, a regression of a cross-border transaction efficiency ($TCE_{it}$) on TSI establishes that the system-mediated trust has a high level of positive impact on the result of coordination computed using Eq. (5).

$$TCE_{it} = \alpha + \beta TSI_{it} + \gamma X_{it} + \epsilon_{it} \tag{5}$$

where $X_{it}$ (institutional quality, digital infrastructure) are the control variables. The calculated -0.361($p < 0.01$) shows that a 10% rise in standardized trust posts results in an efficiency of cross-border transactions rising by 3.6 percent, which is empirical data that the establishment of trust is a major process that blockchain helps to improve macro-level coordination.

## V. CONCLUSION

The results indicate that blockchain can be regarded as a strong systemic coordination infrastructure that can facilitate the process of cross-border economic transactions in order to be more transparent, efficient, and resilient. The empirical evidence of 2012-2024 shows that blockchain, distributed validation, immutability, and decentralized trust are positively related to the transactional efficiency and integration, which verifies the assumptions of the transaction cost and institutional economics. The creation of the trust in the systems that are mediated by blockchain is culturally neutral, and the technical verification and experience sharing are the main driving forces, rather than the national cultural norms. Higher level of system mediated trust has been revealed to increase cross border coordination tremendously as a result of regression analysis.

### CRediT Author Statement

The authors reviewed the results and approved the final version of the manuscript.

### Data Availability

No data was used to support this study.

### Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.

### Funding

No funding agency is associated with this research.

### Competing Interests

There are no competing interests.

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