

1 **Beyond Consumer Trust: Blockchain-Based Traceability as Complementary**
2 **Information Governance in Italian Wine Value Chains**

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Abstract

This study analyzes blockchain-based traceability in Italian wineries and its effects on information governance, coordination, commercialization, and competitive dynamics in regulated wine value chains. Rather than treating blockchain as a disruptive substitute for trust mechanisms, the study shows that its effects are complementary and conditional. Based on a multiple-case study of six wineries and a blockchain platform provider, three adoption patterns emerged: operational integration, externally mediated communicational use, and implementation discontinued due to informational and organizational limitations. Blockchain complemented rather than replaced certifications and formal controls, operating effectively when reliable records and internal coordination were in place. Commercial effects were heterogeneous, including buyer-specific demand and respondent-reported economic outcomes, while sustained business relevance depended on market demand, product value, scale, and implementation costs. The study reframes blockchain as an organizationally conditioned governance mechanism and proposes a framework based on readiness, data governance, application design, operational integration, and strategic use.

Keywords: Blockchain; Wine value chains; Information governance; Institutional regulation.

1. INTRODUCTION

Wine sector value chains operate in contexts of high institutional density, in which certifications, geographical indications, public regulations, and territorial governance mechanisms sustain the legitimacy of product origin, quality, and reputation [1–3]. In these markets, trust does not depend solely on interpersonal relationships among producers, distributors, and consumers, but is structured by formal systems of control, auditing, and certification that reduce uncertainty and function as signals of quality [4,5].

Despite this institutional structure, information asymmetries persist, particularly regarding attributes that are not fully observable at the time of purchase, such as authenticity, origin, production practices, storage conditions, and the logistical trajectory of wine [4,6]. Traceability is situated at the operational level of the supply chain, as it involves production records, documentation, batch control, physical circulation, and information validation. Its effects, however, may extend to the strategic level of the value chain by influencing reputation, differentiation, commercialization, and competitive positioning [3,7,8].

Blockchain has been presented as a technology capable of enhancing transparency, security, and auditability in agri-food chains by enabling distributed, chronological, and tamper-resistant

records [7–9]. However, in wine value chains already regulated by certifications and designations of origin, its contribution cannot be assumed to replace institutional mechanisms of trust. The quality of the information recorded continues to depend on prior routines for data collection, validation, standardization, and governance [10,11].

Recent literature has advanced the analysis of blockchain adoption in agri-food chains and in the wine sector, highlighting antecedents, barriers, and potential benefits related to transparency, authenticity, and trust [8,12,13]. Nevertheless, evidence remains limited on how blockchain generates organizational effects after its adoption, especially in institutionally mature contexts in which trust is already partially ensured by certifications, collective reputation, and regulatory controls [11,14].

This study addresses this gap by analyzing the adoption of blockchain-based traceability in Italian wineries, examining its effects on information governance, coordination, commercialization, and competitive dynamics. The research question guiding the study is: how does the adoption of blockchain-based traceability affect governance structures, coordination mechanisms, commercialization practices, and competitive dynamics in wine value chains?

The article contributes in three ways. First, it provides empirical evidence on blockchain in a regulated value chain, in which certifications and institutional trust mechanisms are already consolidated. Second, it clarifies the relationship between supply chain and value chain by analyzing traceability as an operational coordination mechanism and its strategic effects on reputation, differentiation, and commercialization. Third, it specifies the conditioned effects of blockchain by showing how informational maturity, data governance, application design, operational integration, and strategic use shape heterogeneous post-adoption outcomes in regulated wine value chains.

2. THEORETICAL FRAMEWORK

2.1 Governance of Wine Value Chains and Information Asymmetry

Wine value chains are institutionally dense arrangements, structured by public regulations, geographical indications, certifications, and territorial mechanisms that define origin, quality, and legitimacy [1–3]. In European markets, designations of origin support differentiation based on authenticity, tradition, collective reputation, and territorial embeddedness, while audits, consortia, and public controls organize the relationships among producers, markets, and consumers [1–3].

Despite this institutional density, information asymmetry remains relevant, since attributes such as origin, authenticity, production practices, storage, and logistical trajectory are not fully observable at the time of purchase [4,6]. Certifications, geographical indications, brands, and reputation function as quality signals, but they do not eliminate risks of counterfeiting, inadequate labeling, or selective disclosure of information [4,5]. Thus, transparency only creates value when information is reliable, verifiable, interpretable, and relevant to the actors in the chain [5,10].

This discussion requires distinguishing between the supply chain and the value chain. The supply chain corresponds to the operational level of physical flows, production records, quality controls, documentation, bottling, distribution, and traceability [7,8]. The value chain corresponds to the strategic level of reputation, commercialization, differentiation, competitive positioning, and relationships with consumers and institutional actors [3,5]. In this study, traceability is analyzed as an operational mechanism, while its effects on reputation, commercialization, and competitiveness are examined at the level of the wine value chain [7,8]. Information governance connects these levels, as data on origin, quality, compliance, and product trajectory must be produced, validated, stored, and shared before they can be mobilized as reputational and commercial assets [10,15]. In wine chains, this requires process standardization, data integration, interfunctional coordination, and the definition of those responsible for recording and validating information [8,15]. Therefore, digital traceability does not automatically generate governance or market benefits, since its effects depend on informational maturity, organizational capabilities to integrate systems, coordinate processes, and transform data into managerial information, as well as articulation with existing certifications and controls [11,14,16].

2.2 Blockchain as a Complementary Infrastructure for Information Governance

Blockchain is a distributed ledger in which transactions are stored chronologically through cryptographic mechanisms that make subsequent alterations to data difficult [7,9]. In supply chains, these properties can support traceability, auditability, transparency, and the reduction of information asymmetries when multiple actors share data on product origin, movement, and conditions [7,8]. In the wine sector, blockchain can strengthen the authentication of provenance and broaden the visibility of information, but its adoption depends on costs, technical capabilities, standardized protocols, regulation, collaboration among stakeholders, and the perception of organizational benefits [8,12,17].

In the Italian wine sector, the intention to adopt blockchain is mainly associated with performance expectancy and trust, reinforcing that its adoption depends on the perceived benefits related to organization, transparency, and authenticity, and not only on the technical availability of the technology [13].

Recent literature has moved away from interpreting blockchain as a universal solution for trust and has advanced toward understanding it as a sociotechnical infrastructure for information governance [7,11]. Its contribution lies in its capacity to organize, record, and audit informational flows, but immutability does not guarantee the truthfulness of the information entered. Data reliability depends on the quality of prior records, verification procedures, audits, responsibilities assigned to actors, and routines for feeding the platform [9,10,15,18].

This limitation is relevant in wine value chains, in which trust is already partially institutionalized through certifications, designations of origin, and formal controls [2,3]. Blockchain platforms can increase trust in data, but they do not eliminate the interpersonal and institutional trust embedded in established relationships [8,10]. Thus, in regulated chains, blockchain operates as an additional layer of information governance articulated with existing certifications and controls, rather than as a substitute for these mechanisms [8,10].

The architecture of blockchain influences its effects on information governance. The literature distinguishes between public, private, permissioned, and consortium blockchains, each with distinct rules for access, validation, control, and distribution of authority [7,9]. This distinction is relevant because traceability systems frequently involve producers, certification bodies, technology platforms, and distributors, requiring clarity regarding who records, validates, and accesses information [8,9]. Therefore, claims about blockchain governance cannot be generalized without considering architecture, validation mechanisms, and the data governance model [7,9].

These architectures differ in terms of the degree of network openness, access permissions, and the distribution of validation authority. Public blockchains, which are generally permissionless, favor greater transparency and decentralization, as they allow more open participation and validation. Private blockchains concentrate control within a single organization, with restricted access and validation. Consortium blockchains, in turn, operate with authorized participants and distribute governance among a group of organizations, which may make them suitable for chains involving multiple actors. The term permissioned refers to the rules that define who can record, validate, or access information. Thus, the effects of blockchain on transparency, control, auditability, and information governance depend on the rules of access, validation, and data use established in each application [19,20].

Accordingly, this study understands blockchain-based traceability as a complementary infrastructure for information governance in institutionally regulated wine value chains. At the supply chain level, blockchain can support the organization of records, traceability, auditability, and coordination between production and logistics processes [8,15]. At the value chain level, it can reinforce provenance communication, reputational protection, fraud prevention, and differentiation in premium and export-oriented segments [10,14]. These effects remain conditioned by the informational maturity of wineries, the integration of internal systems, the technological architecture, and the capacity to articulate blockchain, certifications, designations of origin, and consolidated regulatory mechanisms [11,13].

3. METHODOLOGY

The empirical context of this study is the Italian wine sector, characterized by consolidated regulatory mechanisms for production, certification, traceability, and legitimation of wine origin [14]. This context makes it possible to examine blockchain adoption in a chain in which institutional trust is already sustained by certifications, designations of origin, and formal controls. The research adopted a qualitative approach based on a multiple-case study, which is appropriate for analyzing organizational phenomena in their real-life context [21]. The unit of analysis was the implementation and use of blockchain-based traceability in Italian wineries, considering its effects on information governance, coordination, commercialization, and competitive dynamics.

The cases were selected according to intentional and theoretical criteria, prioritizing wineries that had adopted or initiated the implementation of blockchain-based traceability in real production contexts. Participants were selected because of their direct involvement in strategic, operational, or technological decisions related to the implementation. The sample included owners, managers, employees involved in production, marketing, commercialization, and traceability, as well as a representative of the company providing the technology used by some of the wineries analyzed. Initial access occurred through contact with the first Italian winery identified in the literature as having adopted blockchain-based traceability, followed by a snowball procedure to identify additional participants [21,22].

Data were collected between September 2022 and February 2023. Ten semi-structured interviews were conducted with thirteen participants, since some interviews involved more than one respondent. The interviews were conducted online and in person, lasting between 34 and 135 minutes. The interview protocol was derived from the theoretical framework and addressed motivations for adoption, resources mobilized, capabilities developed, information

management practices, implementation challenges, and perceived impacts on governance, coordination, and commercialization. The empirical material was collected within a study on blockchain-based traceability in Italian wine value chains and addressed data recording, validation, certifications, information flows, QR-code communication, and the organizational use of traceability information. In addition to the interviews, institutional materials from the wineries, websites, scientific publications related to the cases, information accessed through QR codes, and evidence from direct observation during in-person visits were analyzed.

Triangulation was operationalized by comparing the different sources of evidence available for each case. Interviewees' accounts regarding the purpose of adoption, the type of information recorded, QR code use, integration with internal processes, and the role of certifications were compared with direct observation conducted during in-person visits, information available on the wineries' websites, institutional materials, and data accessed through the digital labels linked to the QR codes on the bottles, when available.

Thus, when interviewees indicated that blockchain was used to communicate traceability to consumers, the information accessible on the digital label was verified in order to identify what type of data was effectively made available. Likewise, when participants reported greater integration or a predominantly communicational use of the technology, this information was compared with evidence observed in the field, institutional materials, and data accessed through the wineries' digital channels.

In Cases 1, 2, and 6, triangulation was also reinforced by a demonstration of the platform's operationalization presented by the technology provider. This procedure made it possible to preserve a chain of evidence, as proposed by Yin [21], and to distinguish cases in which blockchain operated as an operational infrastructure for information governance from those in which its use remained predominantly communicational.

The interviews were transcribed and organized by case and by source of evidence, preserving the traceability of the analytical process and the chain of evidence [21,22]. Data were analyzed through content analysis, following the stages of pre-analysis, coding, categorization, and interpretation proposed by Bardin [23], with the support of NVivo®. The initial categories were derived from the theoretical framework, with emphasis on organizational resources, capabilities, information governance, traceability, coordination, benefits, challenges, and limits of blockchain. During the analysis, these categories were refined in light of the empirical evidence. Cross-case comparison followed Yin's logic of analytical generalization [21], allowing the identification of patterns of operational integration, communicational use, and discontinued implementation.

Table 1 summarizes the methodological alignment among objectives, sources, and analytical procedures, supporting the cross-case comparison and analytical generalization in accordance with Yin [21].

Table 1. Alignment between research objectives and methodological procedures

Research objectives	Data sources and instruments	Analytical procedures
Analyze the implementation of blockchain in wine traceability	Interviews with managers, employees, and the technology provider; direct observation; websites, institutional materials, and digital information accessed through QR code or digital label	Content analysis, triangulation of sources, and preservation of the chain of evidence
Identify the resources and capabilities mobilized	Interviews, direct observation, and platform demonstration in Cases 1, 2, and 6	Categorical coding of technological, informational, human, and organizational resources
Examine effects on information governance	Interviews, digital labels, QR codes, websites, institutional materials, and platform demonstration when available	Triangulation among accounts, digital evidence, and direct observation; identification of the data governance model
Analyze effects on coordination and commercialization	Managers and employees involved in operations, traceability, marketing, and commercialization	Cross-case comparison, distinguishing operational integration, communicational use, and discontinued implementation
Identify the impacts and limits of blockchain	The set of empirical evidence from the six cases	Integration among analytical categories, triangulated evidence, and identified limitations

4. RESULTS

The comparative analysis of the six cases shows that the adoption of blockchain-based traceability did not produce homogeneous results. The observed impacts depended on the wineries' informational maturity, the origin of the recorded data, the degree of integration of the technology into internal routines, and the data governance model. The cross-case comparison allowed the identification of three main patterns: operationally integrated implementation, external use mediated by certification and communication, and implementation initiated but discontinued due to organizational and informational limitations. In Cases 1 and 2, blockchain showed greater proximity to operational traceability routines. In Case 1, adoption was motivated by protection against counterfeiting, brand differentiation, and

the digitalization of internal records. The interviewee reported that the winery had been “victim of a counterfeiting episode” and that the technology was adopted for “anticounterfeiting, transparency and marketing reason and operational reasons”. The respondent also reported increased sales volume and lower operating costs; because longitudinal financial records were not collected, these outcomes are treated as respondent-reported economic effects rather than causal impacts.

In Case 1, blockchain was integrated into traceability through a digital application for production-data entry and consumer access. The solution mapped the stages of the chain and created batch-specific information accessible through a QR code. The interviewee characterized the underlying blockchain as public and permissionless, describing it as “public, transparent, open”; the platform demonstration corroborated the public registration of the solution. Thus, the case combined permissioned data entry at the application level with public blockchain registration, linking operational traceability, information authentication, anti-counterfeiting protection, and brand differentiation.

Case 2 used blockchain as an extension of existing traceability processes for a specific product, supported by internal records, control routines, and production data. The technology provider described the proposal as tracking the process “step by step” and recording the associated data on blockchain, emphasizing two objectives: “monitoring the internal processing” and “expose the data to the markets”. Because the underlying technical architecture was not independently confirmed, this case was classified according to its data governance model and degree of operational integration.

In Cases 3, 4, and 5, blockchain was used in externally mediated certification and communication initiatives. The consumer-facing information derived mainly from existing certification records and winery narratives, and triangulation with digital labels, websites, institutional materials, and direct observation indicated limited integration with internal routines. Case 3 nevertheless revealed a specific commercial effect: the respondent reported that buyers in two European export markets requested wine carrying blockchain-based traceability. Despite this buyer-specific demand, the initiative was not sustained because its perceived additional value was insufficient for the winery’s business model. This differs from Case 6, where the obstacle concerned implementation feasibility arising from informational and organizational limitations.

These cases reinforce the complementary role of blockchain in regulated wine value chains. The technology authenticated and communicated information already supported by established certification systems rather than replacing institutional controls. Case 5 also revealed an

economic boundary condition: implementation costs were considered difficult to justify for large-volume portfolios and more coherent for products with substantially higher unit value. Thus, externally mediated applications generated reputational and market-facing effects without substantially reconfiguring internal information governance.

Case 6 represents an implementation that was initiated and subsequently discontinued because of difficulties in collecting, standardizing, and updating production data. The technology provider emphasized that implementation first requires defining “what you want to do and what you can do with the data that you already have”, adding that even a comprehensive platform cannot support blockchain tracking when the necessary data are unavailable or cannot be used. This case shows that blockchain does not correct pre-existing weaknesses in information governance; fragmented records and unclear recording responsibilities can prevent implementation.

The analysis distinguished data governance at the platform level from the technical architecture of the blockchain. Although data entry was restricted to authorized actors, this did not allow the solutions to be automatically classified as private blockchains. For this reason, the cases were differentiated according to the origin of the data, validation arrangements, access through QR code or digital label, and technical architecture only when direct evidence was available.

Table 2. Comparison of the cases studied

Case	Type of adoption	Data governance model	Resources and capabilities mobilized	Main impacts
Case 1	Consolidated operational implementation	Traceability data entered with winery participation; access through QR code; public and permissionless architecture reported by the interviewee, with public registration corroborated by the platform demonstration	Structured informational base; digitalization of records; management involvement; internal coordination	Information governance; anti-counterfeiting protection; reputational differentiation; respondent-reported sales increase and operating-cost reduction
Case 2	Partial operational implementation	Same technological solution as Case 1, with data associated with a specific product; architecture not independently confirmed	Internal records; traceability routines; articulation among production, control, and communication	Improvement of information management; reinforcement of transparency; potential expansion of traceability

Case	Type of adoption	Data governance model	Resources and capabilities mobilized	Main impacts
Case 3	External initiative based on certification	Data derived from certified records and storytelling; external mediation	Limited provision of information; low integration with internal systems	Institutional visibility; buyer-specific commercial demand; limited perceived business value for sustained use
Case 4	External initiative with communicational use	Traceability and product information made available through QR code or digital label	Certified data; institutional materials; mediation by the certification body	Authentication of already certified information; limited impact on internal routines
Case 5	Communication and transparency project	Data associated with existing certifications and the winery's narrative	Consolidated certifications; product information; communication resources	Reputational reinforcement; respondent-reported cost constraints; economic viability conditioned by product value, scale, and implementation cost
Case 6	Implementation initiated and discontinued	Same technological solution as Cases 1 and 2, but with fragmented internal records	Complex production structure; low informational centralization; difficulty in data standardization	Project discontinuation; evidence that blockchain requires prior consolidation of information governance

The comparison shows that integration determines impact depth. When incorporated into productive and informational routines, blockchain strengthened records, traceability, coordination, and market-facing use of authenticated information. Externally mediated applications generated narrower effects, including institutional visibility and buyer-specific demand in one case, while fragmented records prevented implementation. Thus, blockchain operates as a complementary information-governance infrastructure whose value-chain effects depend on informational maturity, integration, and economic context.

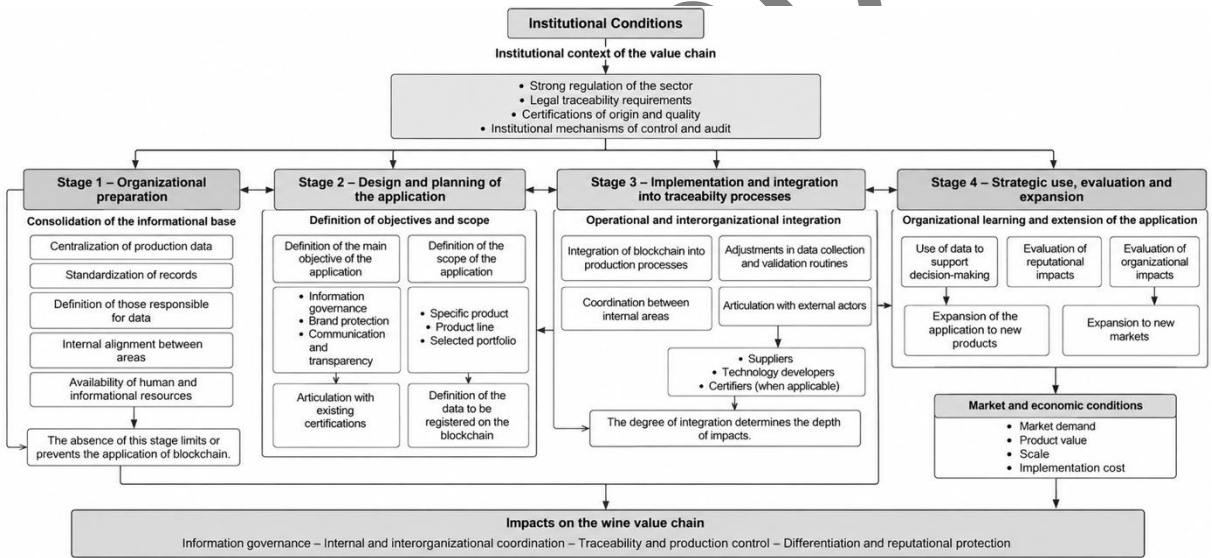
5. DISCUSSION

The results indicate that blockchain adoption in regulated wine value chains does not represent an institutional rupture, but rather an incremental reorganization of information governance. The technology does not replace certifications, designations of origin, or formal control

mechanisms, as these continue to sustain the legitimacy of the origin, quality, and reputation of wines [2,3]. Its contribution occurs when productive, certification-related, and narrative data are organized, validated, and communicated in a more auditable manner, reinforcing blockchain as a complementary infrastructure for information governance [10,11].

Figure 1 summarizes the main analytical contribution of the study by showing that the effects of blockchain are conditioned by institutional conditions, organizational readiness, data governance, application design, degree of integration, and strategic use of information. Market and economic conditions, market demand, product value, scale, and implementation cost, operate as boundary conditions shaping whether these effects become commercially relevant. The framework starts from the recognition that wine value chains already operate under strong regulation, certifications of origin and quality, legal traceability requirements, and institutional control mechanisms [1–3].

Figure 1. Analytical framework of the conditioned effects of blockchain in the wine value chain



The framework comprises four analytical stages, while the cross-case analysis identified three empirical patterns of blockchain use. In Cases 1 and 2, structured records, defined responsibilities, and internal alignment enabled operational integration, affecting information governance, coordination, and consumer communication. In Cases 3, 4, and 5, use remained predominantly communicational, based on certified data and storytelling, although Case 3 also revealed buyer-specific commercial demand. In Case 6, weak informational consolidation and coordination prevented continuity. Interviews, observation, digital labels, websites,

institutional materials, and platform demonstrations in Cases 1, 2, and 6 triangulated these patterns.

5.1 Economic Implications for the Wine Value Chain

The cases reveal specific rather than uniform economic effects. In Case 1, blockchain-based traceability supported anti-counterfeiting protection and reputational differentiation, while the respondent also reported increased sales volume and lower operating costs. Because longitudinal financial indicators were not collected, these outcomes are interpreted as respondent-reported economic effects rather than causal estimates. In Case 3, buyers in two European export markets explicitly requested wine carrying blockchain-based traceability, showing that the technology can become a commercially relevant attribute in particular B2B relationships.

These effects were nevertheless conditional. In Case 3, buyer-specific demand did not translate into sufficient perceived business value to sustain the initiative, whereas the Case 5 respondent indicated that implementation costs are more difficult to justify for large-volume portfolios and may be more economically coherent for very high-value products. Thus, the commercial relevance of blockchain after adoption depends on the fit between organizational readiness, authenticated traceability, market demand, product value, scale, and implementation cost [11,17]. These findings extend prior work on blockchain adoption enablers and consequences in the wine industry [13,14,17] by distinguishing motivations for adoption from the conditions under which commercially relevant effects are sustained.

5.2 Organizational and Governance Implications

The organizational implications are concentrated on readiness, application design, and integration with traceability processes. Blockchain functions as an infrastructure for information governance only when articulated with internal routines, clear responsibilities, and structured data, which reinforces its sociotechnical nature and its conditioning by organizational resources, process integration, and coordination capacity within supply chain systems [7,11,24]. These findings confirm Brookbanks and Parry [10] in showing that blockchain can improve data visibility without replacing established trust relationships. They extend Galati et al. [14], who emphasize knowledge acquisition, assimilation, and outsourced implementation as adoption enablers, by showing that these organizational conditions also shape the depth of integration after adoption. They also qualify Sabbagh et al. [17], who identify value creation and counterfeit prevention as important consequences of adoption, by showing that such

commercial and strategic effects are heterogeneous and depend on organizational integration and market and economic conditions.

The distinction among platform, data governance, and blockchain architecture is also relevant. Digital platforms controlled by providers or certifiers do not automatically allow the solutions to be classified as private blockchains. The empirically verifiable elements were permissioned data entry, validation arrangements, and restricted public access to the information made available through QR code or digital label. This distinction avoids generalizations about the effects of blockchain without considering technical architecture and validation mechanisms [9]. Thus, blockchain should be understood as a conditioned information-governance mechanism. The cross-case evidence shows that the transition from operational traceability to value-chain outcomes is neither automatic nor linear: it occurs when authenticated information is organizationally integrated and strategically useful to market actors. This helps explain why similar technological solutions generated heterogeneous outcomes across cases.

6. SUMMARY

This study examined how blockchain-based traceability affects information governance, coordination, commercialization, and competitive dynamics in regulated wine value chains. Blockchain did not replace certifications, designations of origin, or formal controls. When supported by structured records, clear responsibilities, and reliable data, it strengthened information governance and coordination; when externally mediated, effects were mainly communicational; and when the informational base was fragmented, implementation did not progress.

The commercial and competitive effects were heterogeneous rather than universal. One integrated case reported increased sales volume and lower operating costs, while another case showed buyer-specific demand for blockchain-based traceability in export relationships. Other evidence showed that buyer-specific demand and reputational visibility may still be insufficient to generate sustained business value and that economic viability depends on product value, scale, and implementation cost. These findings identify specific commercial pathways through which blockchain may affect competitive dynamics, without implying a general causal effect on firm performance.

The study reframes blockchain as an organizationally conditioned information-governance mechanism whose economic effects also depend on market demand, product value, scale, and implementation cost. The framework links readiness, data governance, application design, operational integration, and strategic use to value-chain effects. Because longitudinal financial

indicators were not collected, reported economic outcomes are not causal estimates. Future research should test these pathways and boundary conditions across markets, countries, and blockchain architectures with longitudinal commercial and financial data.

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