

EVALUATION OF BLOCKCHAIN IMPLEMENTATION EFFECTIVENESS

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Abstract. This study focuses on the effectiveness of blockchain technology implementation. Blockchain technology is widely regarded as transformative due to its potential to enhance transparency, security, and operational efficiency. This has led to the widespread adoption of blockchain technology across various companies and industries. However, an increasing number of companies are facing challenges in developing qualitative and effective approaches to evaluating the efficiency of implementing this technology. Therefore, it is necessary to develop specialized approaches to assess the effectiveness of blockchain technology implementation. The research subject encompasses the approaches to evaluating the effectiveness of blockchain technology implementation, such as Return on Investment (ROI), Net Present Value (NPV), and Total Cost of Ownership (TCO). By examining case studies and real-world implementations, the study evaluates the application of traditional economic metrics, such as ROI and TCO, and expands the evaluation framework to include intangible benefits like transparency and customer trust. The study also addresses challenges such as scalability, privacy, and legislative impacts, offering solutions based on MCDA and a multi-dimensional assessment approach. The integration of these methods allows for a holistic evaluation of blockchain's effectiveness. The primary aim of this study is to identify robust evaluation tools that organizations can utilize to determine the feasibility and benefits of blockchain adoption. By bridging gaps in existing assessment models, the research provides a comprehensive framework to streamline decision-making processes. The key findings demonstrate that while ROI remains a critical metric, it must be complemented by broader economic and non-economic indicators to achieve a thorough evaluation. The strategic alignment of blockchain technology with organizational goals is essential for maximizing its benefits. The research concludes that adopting a flexible and standardized evaluation methodology is vital for accurately assessing blockchain technology's impact. This includes integrating financial, organizational, and technological indicators into a unified framework. Future research is recommended to explore industry-specific metrics and the inclusion of qualitative impacts such as transparency, trust, and customer satisfaction. The study highlights that blockchain's effectiveness depends on addressing technical, operational, and external challenges while leveraging its transformative potential to drive innovation and efficiency. In conclusion, this research demonstrates that a holistic evaluation framework with integrating quantitative financial metrics with qualitative factors such as transparency, trust, and regulatory considerations is essential for accurately assessing blockchain implementation effectiveness and guiding strategic decision-making

Keywords: blockchain implementation, return on investment (ROI), net present value (NPV), total cost of ownership (TCO), efficiency evaluation.

JEL Classification: O33, M15, C80, G32, D85

1. Introduction

The relevance of blockchain technology continues to grow, driven by its potential to offer transparency, security, and operational efficiency across numerous sectors. Despite the increasing interest, the evaluation of blockchain's effectiveness remains complex due to varying industry applications and technological adaptability. This article addresses the challenge of quantifying blockchain's value by exploring economic

evaluation methods. Our study focuses on the development of a standardized approach for assessing blockchain effectiveness, specifically aiming to identify methods that integrate both short-term and long-term financial impacts, as well as intangible benefits.

This study aims to contribute to the development of a more comprehensive approach to evaluating blockchain implementation effectiveness. It emphasizes the importance of combining economic metrics

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with qualitative indicators to reflect the full range of blockchain's potential benefits. The research also addresses practical challenges, such as scalability, privacy, and compliance with regulatory requirements, which often complicate the evaluation process.

To achieve its objectives, this study focuses on the following tasks:

1. Investigate the economic, technological, and organizational dimensions that influence blockchain evaluation, emphasizing their interconnected nature.
2. Analyze how traditional financial indicators can be refined to better assess the efficiency of blockchain implementation.
3. Explore ways to account for intangible benefits such as trust, transparency, and customer satisfaction in the evaluation framework.
4. Identify and analyze key barriers to effective implementation, including scalability, privacy concerns, and regulatory constraints, while suggesting practical strategies to overcome them.
5. Propose a multi-dimensional approach that integrates financial, organizational, and technological metrics for a more holistic evaluation.

By addressing these tasks, the research provides a novel perspective on blockchain evaluation by integrating diverse factors into a unified framework, offering practical solutions for overcoming barriers, and enhancing understanding of its effectiveness across various contexts.

2. Key Aspects of the Evaluation

For businesses, adopting blockchain technology represents a significant investment of time, capital, and resources. Evaluating the efficiency of such implementations is critical to ensure alignment with organizational goals, maximize returns, and minimize risks (Philip Boucher, Susana Nascimento, Mihalis Kritikos, 2017). A robust evaluation framework helps companies identify potential pitfalls, allocate resources effectively, and measure the success of blockchain initiatives. Evaluating the efficiency of blockchain implementation typically involves three interconnected dimensions: economic, organizational, and technological. Each dimension provides unique insights into how blockchain projects can succeed or fail within an enterprise.

Economic efficiency in blockchain implementation refers to the balance between the financial outlays (development, maintenance, compliance) and the tangible or measurable returns (cost savings, revenue growth, asset appreciation). Frequently assessed by metrics like ROI, NPV, and TCO, economic efficiency offers a foundational perspective on whether the technology delivers measurable financial benefits.

Conducting a thorough cost-benefit analysis helps an organization identify short-term and long-term

costs, including hardware investments, software licensing, node maintenance, and integration with legacy systems (Bünger, 2017). It also accounts for potential revenue streams – such as creating new services, monetizing data, or reducing fraud and counterfeiting in supply chains (Kshetri, 2018).

A significant element of economic efficiency involves predicting how costs evolve over time. For instance, as transaction volumes grow, network fees may inflate, and system capacity might need expansion. Evaluating whether the blockchain solution can efficiently scale under higher loads is crucial for sustaining economic efficiency.

From a corporate finance perspective, implementing blockchain can redirect capital allocation. Understanding how blockchain deployment might free up or tie down liquidity is vital. Some companies might utilize blockchain to create new financing channels directly influencing their balance sheets.

Economic efficiency provides a foundation for justifying the initial investment in blockchain. Nonetheless, standalone financial metrics might overlook the broader organizational and technological factors that also drive success.

Organizational efficiency examines how blockchain affects a company's internal dynamics – its processes, workforce, and decision-making structures. By employing smart contracts, organizations can reduce manual interventions, lower error rates, and minimize administrative overhead (Koteska, Karafiloski, & Mishev, 2017). A classic example is supply chain management, where real-time tracking of goods and automated payments via blockchain can dramatically improve operational flow.

Adopting blockchain requires workforce training and mindset shifts. Employees must adapt to decentralized workflows, cryptographic security practices, and new forms of data governance (Philip Boucher, Susana Nascimento, Mihalis Kritikos, 2017). Organizational efficiency is thus directly tied to an enterprise's cultural readiness and ability to integrate blockchain into existing or evolving business processes. Resistance from staff or insufficient training can negate blockchain's potential benefits.

Organizational efficiency also correlates with governance structures. Some blockchains feature on-chain governance protocols, enabling stakeholders to vote on protocol changes. Understanding how these new governance models interface with traditional corporate governance is integral. The synergy (or conflict) between decentralized decision-making and hierarchical corporate structures can significantly influence blockchain's organizational impact.

While organizational efficiency can yield substantial improvements in productivity and stakeholder trust, it requires careful planning around change management, training, and process reengineering.

Technological efficiency focuses on how well blockchain solutions integrate with existing IT infrastructures and scale to meet growing demands. Issues such as throughput (transactions per second), latency, and data storage limitations are pivotal in assessing the technology's viability (Koteska, Karafiloski, & Mishev, 2017).

In many enterprises, blockchain systems must communicate with conventional databases and other emerging technologies (e.g., the Internet of Things). Interoperability solutions, such as cross-chain communication protocols or enterprise integration platforms, help mitigate silos and maximize technological efficiency.

While blockchain is praised for robust security, vulnerabilities can still emerge at application layers or through inadequate smart contract coding. Privacy considerations are equally critical, especially in regulated environments like healthcare (HIPAA) or finance (GDPR). A technologically efficient blockchain system must incorporate robust encryption, permissioned access (where required), and compliance with regulatory mandates (Tapscott & Tapscott, 2016).

Technological efficiency ensures that a blockchain solution remains robust, adaptable, and secure. Any shortcomings in this domain can undermine even the most economically and organizationally sound projects.

Although each dimension – economic, organizational, and technological – offers distinct perspectives on blockchain efficiency, they are deeply interrelated. Economic benefits may not materialize without proper organizational alignment and a secure, scalable technological foundation. Evaluating all three dimensions comprehensively is pivotal, yet it poses challenges due to blockchain's decentralized nature, intangible benefits (such as trust or brand enhancement), and ever-changing external factors like regulations or market conditions.

3. Key Economic Metrics for Blockchain Evaluation

The assessment of blockchain implementation necessitates a robust set of economic metrics that can effectively quantify its financial impact. These metrics provide a structured approach to evaluating the feasibility and profitability of blockchain projects. ROI, TCO, and NPV are most commonly employed.

ROI is a widely used metric that evaluates the immediate financial benefits of blockchain initiatives relative to their costs. It is calculated by dividing the net profit generated by the project by the total investment cost and multiplying the result by 100 (Scaling Parrots, 2023). While ROI is a valuable tool for assessing short-term profitability, it does

not account for long-term financial implications or intangible benefits.

Intangible benefits such as enhanced transparency, customer trust, and improved brand reputation are significant contributors to blockchain's overall value. For instance, supply chain companies implementing blockchain to reduce counterfeit products experience increased customer satisfaction and loyalty. Though these benefits are difficult to quantify, they can be assessed qualitatively and incorporated into ROI calculations using multi-criteria decision analysis (MCDA). MCDA involves assigning weights to various criteria – both tangible and intangible – to compute a weighted average score for blockchain projects. For example, factors such as cost savings, enhanced security, and customer satisfaction can be weighted according to their perceived importance (Scaling Parrots, 2023). The resulting score enables organizations to rank blockchain initiatives and identify the most promising investments.

NPV provides a more comprehensive perspective by evaluating the long-term financial viability of blockchain projects. It considers the time value of money by discounting future cash flows to their present value. A positive NPV indicates that the projected benefits of a blockchain initiative exceed its costs, making it a financially sound investment. Selecting an appropriate discount rate is critical, especially for blockchain projects subject to regulatory uncertainties or market volatility. NPV assessments should factor in the possibility of incremental upgrades or expansions to the blockchain network, which may either enhance or complicate cash flow estimations.

TCO evaluates the full cost of implementing and maintaining blockchain systems throughout their lifecycle. This metric encompasses initial deployment costs, ongoing operational expenses, and indirect costs such as cybersecurity expenditures, personnel training, upgrades to hardware, and potential regulatory filing (Koteska, Karafiloski, & Mishev, 2017). By providing a holistic view of financial commitments, TCO enables organizations to make informed decisions about the long-term sustainability of blockchain projects. TCO analysis is especially relevant when comparing different blockchain solutions. For instance, a public blockchain might have lower upfront costs but higher operational fees (e.g., gas costs), while a permissioned blockchain might entail significant licensing costs but offer more predictable expenses and regulatory compliance.

Each financial model offers valuable yet partial insights. ROI highlights immediate returns, TCO provides a holistic cost perspective, and NPV illuminates long-term viability. Since blockchain projects often span several years and yield intangible benefits, relying exclusively on any single model may

yield incomplete evaluations. Instead, organizations benefit most from a combined approach that integrates multiple metrics with qualitative assessments.

4. Barriers and Strategies for Blockchain Evaluation

Many of the economic models used for project evaluation, such as ROI, NPV, and TCO, were designed to operate within centralized frameworks. These models generally assume a top-down hierarchy where decision-making authority is vested in a central figure or governing body. Blockchain's distributed nature eliminates the reliance on central intermediaries, making it challenging to apply these conventional models without extensive modifications. For instance, ROI and NPV calculations often rest on the assumption that costs and benefits can be clearly traced to a central party that invests capital and derives revenue. However, decentralized networks are built on peer-to-peer interactions and shared governance, which may not fit neatly into centralized accounting structures. In this regard, the inability of traditional metrics to capture decentralized decision-making and communal ownership can lead to underestimation of blockchain's true value.

A key dimension that traditional models struggle to capture is the intangible benefits of blockchain, particularly transparency and trust. These intangible advantages are rarely quantified in monetary terms, yet they can be pivotal in certain industries. For example, a pharmaceutical company tracking its supply chain data on a blockchain could reduce the likelihood of counterfeit drugs entering circulation, thus enhancing patient safety and corporate reputation. Standard cost-benefit analyses may overlook these qualitative benefits because they are difficult to translate into financial metrics. Nevertheless, the organizational reputation, brand loyalty, and long-term consumer trust gained can be significant. Failing to incorporate these elements into economic assessments often means that blockchain's real potential impact remains only partially recognized.

In addition to intangible benefits, brand and reputation gains can be significant byproducts of blockchain adoption. An organization that pioneers blockchain solutions in its sector may enjoy a first-mover advantage, reinforcing customer loyalty and enhancing public perception. However, such benefits are likely to manifest in the long run, which can be at odds with the short-term horizons of ROI or payback period analyses. As with transparency and trust, these factors demand specialized approaches, such as qualitative scoring mechanisms. In practice, this might involve conducting periodic surveys or analyzing social media sentiment to approximate shifts in brand perception. Although such methods

introduce subjectivity, they allow decision-makers to incorporate intangible benefits that might otherwise be ignored.

Beyond the intrinsic challenges associated with blockchain's decentralized architecture and intangible benefits, external forces further complicate evaluation. Legislative and regulatory environments can shift rapidly, affecting the legal feasibility of certain blockchain applications or imposing additional compliance costs. An organization that invests heavily in developing a blockchain platform under permissive regulations might need to pivot or abandon its efforts if new legislation restricts decentralized frameworks. Additionally, market volatility – particularly with regard to cryptocurrency tokens used in some blockchain networks – can abruptly alter a project's projected profitability. Fluctuations in token prices may affect funding, operational costs, or user adoption, hence distorting any straightforward ROI or NPV calculations. Consequently, businesses must account for both regulatory changes and market instability when gauging blockchain's performance.

In response to these multidimensional challenges, several strategies have emerged. For example, scenario planning emerges as another essential tool. Instead of relying on a single predictive model, organizations generate multiple scenarios: best-case, base-case, and worst-case, and estimate how various regulatory changes or market shifts might impact their blockchain initiatives. By doing so, they can stress-test their models and develop contingency plans that mitigate the risks of unexpected developments. Regulatory uncertainties are particularly well-suited to scenario planning, as they can drastically affect the viability of blockchain projects. Potential scenarios might examine changes to privacy regulations, limitations on token usage, or increased scrutiny on data storage practices. Similarly, market scenarios could consider drastic shifts in cryptocurrency valuations or changes in consumer adoption patterns. Overall, scenario planning enforces a dynamic perspective, forcing regular updates to assumptions and providing decision-makers with an agile framework for responding to change.

Continuous monitoring and iterative evaluation complete the toolkit for rigorous blockchain assessment. Blockchain projects rarely remain static; they evolve through pilot projects, expansions in user base, and technology upgrades. Pilot studies can be invaluable for refining assumptions, as they generate tangible data on costs, user engagement, and technical performance. By deploying blockchain in a constrained environment – such as a single department or a small subset of the supply chain – organizations can gather evidence to calibrate the assumptions in their ROI or TCO models. If initial findings reveal that implementation is more complex than projected, or that certain intangible benefits are more pronounced,

these insights can be fed back into the assessment process. Thereafter, periodic updates to ROI, NPV, and TCO calculations ensure that the evaluation reflects evolving regulatory conditions, technical developments, and market realities.

Comparative analyses of different evaluation metrics in real-world scenarios further underscore the need for adaptability. Supply chain management applications might prioritize throughput and security, whereas financial services may focus on transaction costs and regulatory compliance. Healthcare projects could be more attentive to patient data privacy, consent management, and interoperability with existing medical record systems. A single metric like ROI would only offer partial insight for such diverse use cases. Implementing a unified framework that ties together financial, organizational, and technological indicators is thus crucial for capturing the multifaceted nature of blockchain's value. Moreover, industry-based case studies suggest that specialized indicators often outperform generic models, especially when intangible benefits such as consumer trust are pivotal.

Integrating traditional metrics with intangible benefits is a promising approach to addressing these gaps. While these scores remain somewhat subjective, they can offer structured ways to factor intangible considerations into an otherwise quantifiable analysis. Additional techniques, such as sensitivity analyses, can gauge how robust the investment is under various external conditions. Adjusting discount rates, cost assumptions, or weightings for intangible benefits can help illustrate the range of possible outcomes.

Blockchain's decentralized system design creates further complexity. The success of a blockchain project often hinges on achieving critical mass – a sufficient number of participants willing to adopt the system. This attribute, known as network effects, cannot be easily translated into traditional ROI or NPV formulas. Projects that fail to reach a threshold of user participation may never deliver meaningful returns, whereas those that surpass this threshold might experience exponential growth in value. Any evaluation framework must therefore address the question of how many nodes or participants are required to unlock the benefits of network effects.

Identifying and acknowledging these challenges is the first step toward performing more realistic assessments of blockchain initiatives. A careful balance between quantitative metrics and qualitative measures can prevent organizations from

underestimating costs or overestimating returns. Practical frameworks combine preliminary feasibility analyses with ongoing evaluations, capturing the evolving technical, regulatory, and market landscapes that shape blockchain deployments. By applying a dynamic, multi-faceted evaluation process, companies stand a better chance of making strategic, well-informed decisions that align with long-term organizational goals.

5. Conclusions

Evaluating blockchain technology requires a balanced integration of traditional financial tools and more nuanced, qualitative approaches. While ROI, NPV and TCO remains a valuable indicator for capturing financial gains, it does not fully account for blockchain's extended lifecycle costs or intangible advantages. Hence, broader metrics are indispensable for understanding the long-term sustainability and comprehensive cost structures involved.

Given blockchain's decentralized governance, novel consensus mechanisms, and potential regulatory volatility, industry-specific metrics should be developed to capture the diversity of outcomes across different sectors. Moreover, intangible benefits – encompassing transparency, trust, and brand reputation – are pivotal elements that conventional financial indicators generally fail to measure. Multi-Criteria Decision Analysis (MCDA) offers an effective solution by blending tangible factors (e.g., ROI, NPV, TCO) with qualitative considerations, thus creating a more holistic picture of blockchain's overall value proposition.

Additionally, the integration of financial, organizational, and technological indicators into a unified evaluation system enables stakeholders to recognize interdependencies that might otherwise be overlooked. This multidimensional framework accommodates the dynamic nature of blockchain projects, which often evolve amid shifting market demands and developing regulatory environments. As the technology continues to mature, future research should focus on refining standardized methodologies, formulating industry-specific indicators, and clarifying legislative guidelines to enhance the consistency and reliability of evaluations. Ultimately, adopting a flexible yet standardized, multi-metric approach ensures a more accurate representation of blockchain's transformative potential and lays the groundwork for sound, strategic decision-making.

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