

From Data Bank to Digital Currency: Evolution of Alternative  
Computing Power System and Innovation of Digital Economy Based  
on Historical Cases



Xinxing Wu<sup>1,a,\*</sup>, Wei Liu<sup>2,b</sup>

<sup>1</sup>Longdong University, Gansu, 745000, China.

<sup>2</sup>Lanzhou Public Security Bureau, Gansu, 730030 China.

<sup>a</sup>Email: [pitt26567@163.com](mailto:pitt26567@163.com)

<sup>b</sup>Email: [13709423766@163.com](mailto:13709423766@163.com)

Acknowledgement

Funding

This work was supported by Gansu Provincial Social Science Fund ( Fund number : 2022YB121 ) ; Gansu Sports Scientific Research and Decision-Making Consultation Project ( Fund number : 2024-C-08 )

Abstract

**Purpose:** This study examines the historical evolution from data banks to digital currencies, analyzing the transformation mechanisms and innovation models that have enabled alternative computing systems to reshape traditional financial intermediation and create new forms of digital economic organization.

**Methods:** A comprehensive historical case study methodology was employed, examining key developments in computing systems and their financial applications over six decades (1960s-2020s). Comparative analysis of three governance models—centralized, hybrid, and decentralized—was conducted using quantitative performance metrics across scalability, security, innovation speed, user autonomy, and economic efficiency dimensions. The research integrated theoretical frameworks from platform economics, institutional economics, and innovation theory to explain the evolution mechanisms.

**Findings:** The research identifies three distinct data valorization pathways: direct monetization through data sales and API services, indirect value creation via business process optimization, and ecosystem value capture through network effects and collaborative platforms. Computing power tokenization mechanisms successfully transform computational resources into liquid, tradeable digital assets through blockchain protocols and smart contract automation. Comparative analysis reveals that centralized models achieve highest overall performance scores (8.0) due to superior

scalability and economic efficiency, while decentralized models excel in user autonomy (9.5) and cryptographic security (9.0), with hybrid models providing balanced performance across multiple dimensions (7.5).

**Conclusion:** The evolution from data banks to digital currencies represents a paradigmatic shift in computing architecture and economic organization. Future digital economies will likely feature diverse governance models coexisting within interconnected ecosystems, with tokenized computing resources and algorithmic governance mechanisms fundamentally altering value creation, distribution, and governance in digital economic systems.

**Keywords:** Digital Currency; Computing Power Tokenization; Decentralized Finance; Data Valorization; Blockchain Governance; Alternative Computing Systems

# 1. Introduction

The shift to digital systems in finance has transformed the global economy, moving away from a traditional, centralised banking system towards a more innovative, decentralised system. It is considered one of the most profound technological changes in the twenty-first century, where immense computing power, data analysis, and innovative monetary systems come together to provide new avenues for change in the financial industry [1]. The different forms of computing that have recently emerged challenge traditional economic centralisation and infrastructure, giving rise to new methods for value creation, distribution, and governance on a multidimensional scale.

The Central Bank Digital currencies can be considered the culmination of this shift, as they combine traditional monetary authority with modern digital technology [2]. The competition to issue CBDCs demonstrates that they are not only technological advancements, but a complete reconstruction of the existential relationship between sovereign states, financial authorities, and citizens. This constructive change goes further than the simple alteration of physical currency into digital forms; rather, it proposes new paradigms for monetary systems, financial inclusion, and overarching economic governance[3].

Tracing the journey from early data banks to modern-day digital currencies reveals a systematic refinement of computing technologies that have increasingly enhanced productivity in value creation and its distribution [4]. This evolution includes several stages, starting from the emergence of centralised data processing systems within financial institutions to the development of distributed ledger technologies that allow value transfer on a peer-to-peer basis, independent of conventional mediation. Every stage has been marked by advances in computing system architecture, data governance frameworks, economic modelling, and innovative alternative financial systems[5].

Smart contracts and blockchain technology constitute the two major cornerstones of this evolution allowing the development of programmable money and automated financial services detached from the traditional banking system [6]. This development empowered the creation of decentralised finance ecosystems replicating and extending traditional financial services while providing new value creation, risk, and capital management frameworks [7]. Moreover, the digital economic systems have been widened further through the tokenisation of assets which allows representation of various forms of value with digital tokens and their transfer [8].

The importance of the research lies in how different computing systems have evolved in regard to challenging traditional financial intermediation models and crafting new forms of economic organisations. Such an economic transformation bears notable consequences for monetary policy, financial stability, and economic development, especially in the context of growing digitalisation, along with the proliferation of platform-based economic models [9]. Studying this evolution is crucial for understanding the ever-changing dynamics of financial systems and the capacity of technology to drive economic change in addressing enduring issues of financial inclusion and economic efficiency.

Current research gaps are found in the comprehensive study on the history of data banks and digital currencies as a singular phenomenon centred on alternative computing systems. There is abundant literature focusing on the components, including CBDCs, blockchain technology, and digital financial ecosystems; however, few researchers have explored the interdependent development of these systems as expressions of fundamental shifts in computing architecture and economic organisation [10]. Addressing these gaps in research helps analyse something of fundamental importance to the digital age: the relationship between technological innovation and economic change.

The primary research questions seek to explicate the evolution of alternative computing systems from historical data banks to modern digital currencies, the forces that facilitated this shift, along with how these factors fostered innovation in the digital economy. More specifically, the analysis focuses on these forms of distributed computing pertaining to non-traditional financial intermediation, the role of programmable money on organisational structure within economies, and the consequential byproducts of these paradigm shifts on prospective designs of financial systems [11]. All these angles necessitate a unified approach across disciplines such as computer science, economics, and institutional theory.

The methodology of the study is based on the historical case study method, focusing on significant milestones in relation to the development of computing systems and their use in servicing the finance industry over the last sixty years. This method aids in the realization of specific central mechanisms, processes, and structures that account for the shift from the centralised data processing paradigm to the distributed financial networks model [12]. The analysis considers a wide array of viewpoints, including technological innovation, economic paradigms, and changes in social institutions,

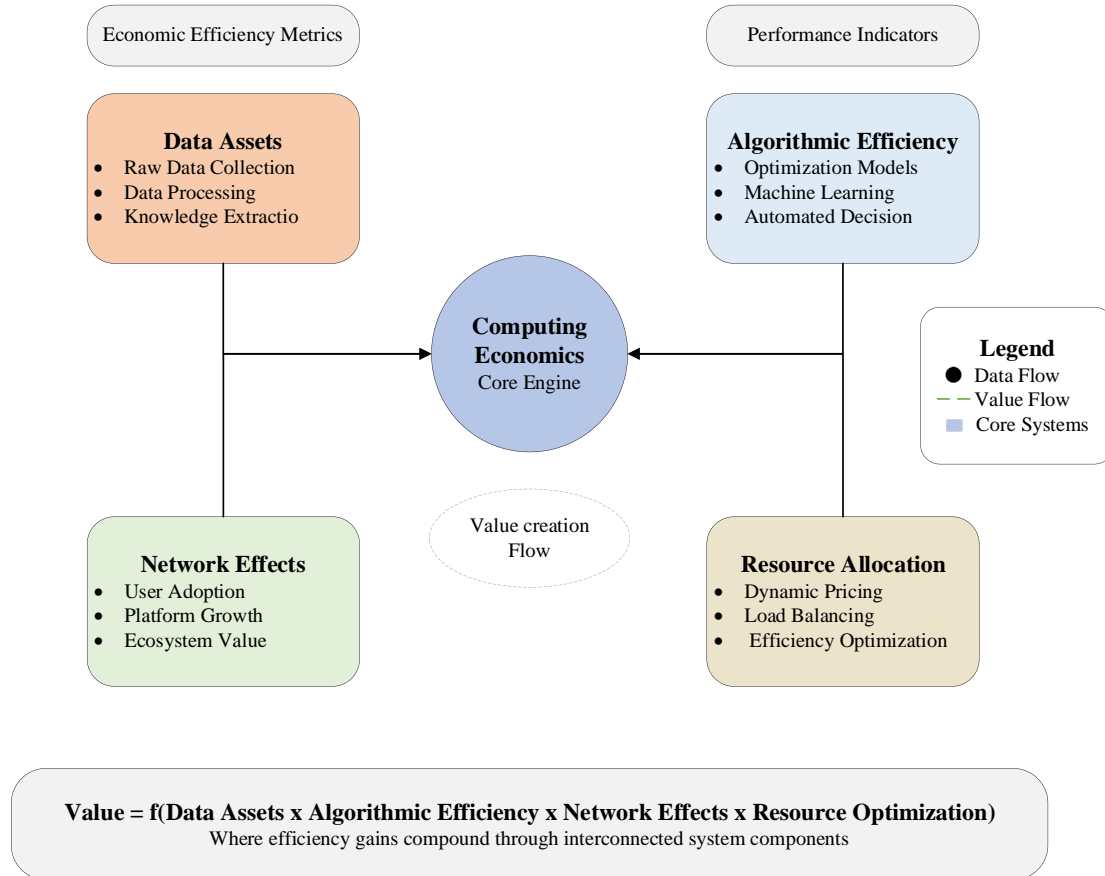
thereby enriching the comprehension of the transformation process. The framework integrates literature on platform economics, institutional economics, and innovation theory to analyse the ways in which different computing systems have shifted economic organisation and value creation [13]. It focuses on the relationship between technological affordances and institutional innovation, as well as the cyclical relationships between technological advancement and economic organisation that has defined this evolution. This approach underscores the multifaceted phenomena of technology and economics in the context of developing digital financial systems and sheds light upon the pathways for prospective innovations in finance and transformations of the economy in the context of digitisation.

## **2. Theoretical Framework of Alternative Computing Systems**

### **2.1 Fundamental Theories of Computing Economics**

Computing economics marks a departure from older economic models which regarded technology as an external factor, in favour of models where technology is seen as resources essential to production processes and value creation [14]. The theory is based on the assumption that combinations of computing power, data processing capabilities, and algorithms can be refined and optimally utilised as economic assets that are tradable within a competitive marketplace. From this standpoint, the growing phenomenon of digitalisation shifts technology in the form of computing resources from being secondary peripherals towards becoming core production factors.

The paradigm shift in computing economics policy stems from the understanding that the digital shift fundamentally transforms old economic paradigms and value generation processes [15]. Unlike traditional models which view tangible capital and human labour as the main inputs, computing economics gives primacy to information processing, data analytics, and algorithmic decision-making as the generators of economic value. This change in theory embodies the fact that contemporary economic activities rely more on the capability to gather, process, and analyse massive volumes of data to improve the precision of resource allocation.



**Figure 1. Computing Economics Value Creation Framework**

In Figure 1, computing economics and its components are depicted in relation to value creation alongside relevant literature [16]. The described model also shows how data assets, algorithmic efficiency, network effects, and resource allocation function as self-contained constituents working towards a singular goal. The system illustrates a clear mathematical relationship in which the total value creation is the product of all components divided by algorithmically defined interdependable efficiency cascading gains from their coordinated systematic structuring, thus forming a beneficial feedback loop.

## 2.2 Conceptual Connotations and Operating Mechanisms of Data Banks

Data banks are advanced systems for gathering and keeping images that serve as the infrastructure of today's digital economies, supporting the gathering, keeping, processing, and distributing of large amounts of structured and unstructured data. The conceptual framework of data banks transcends the mere storage of data to include sophisticated ecosystems for enabling automated processing and decisions, as well as processing value creation through advanced data mining, analytics, and machine learning algorithms. These systems have evolved from serving as centralised

repositories to organised networks that now serve multiple stakeholders and enable sharing and exchange of data across institutional boundaries.

The actions of data banks are supported by intricate organisational frameworks that mediate an equilibrium between data accessibility, information security, privacy, and compliance requirements, including laws and regulations [17]. Modern data banks provide flexible and scalable multi-layered systems that separate data storage, processing, and access control functions, allowing them to adapt to evolving technological and regulatory factors. Such data banks also rely on economic models that facilitate the monetisation of data assets through direct data sales, analytics services, and revenue-sharing on platforms which provide value to multiple stakeholders.

The shift from centralised systems to distributed networks in the structure of data banks depicts the transition in the computing architecture and the economic organisation as a whole [18]. More contemporary systems have started adopting the federated models which allow a collaborative environment through shared data while retaining local control and governance. Such models also address privacy and sovereignty concerns and are aimed at collaborative analytics and innovation. The evolution of these models stems from the advances in technology regarding distributed computing, decentralised cryptographic protocols, and automated governance systems that allow secure and efficient interorganisational boundary data sharing.

## **2.3 Distributed Governance and Platform Economy Theory**

Decentralised governance embodies a shift from conventional organisational structures based on vertical hierarchies to a new approach based on fully automated self-organisation and collective intelligence. The scope of distributed governance theory includes such models as governed blockchain systems, governance through algorithms, and community-based self-governance systems which enable massive coordination without a central hub. Such systems provide security and transparency along with safeguarding trust and diverse stakeholder interests through cryptography, consensus protocols, and incentive mechanisms.

The theory of platform economy sheds light on the mechanisms of value creation by digital platforms through their interaction with multiple stakeholders, as well as how they utilise network effects to attain enduring competitive advantages [19]. The platform economics theory focuses more on the platform's role as an intermediary which integrates disparate participants and therefore lowers transaction costs, promotes innovation, and creates new markets as a value-adding intermediary. Platform businesses shift away from linear models with one-to-one value creation to ecosystem orchestration where value emerges through complex interactions.

**Table 1: Comparison of Governance Models in Alternative Computing Systems**

Governance Model	Decision Making	Coordination Mechanism	Incentive Structure	Scalability
Centralized	Hierarchical	Command & Control	Employment Contracts	Limited by Management Capacity
Federated	Distributed	Negotiated Protocols	Partnership Agreements	Moderate
Decentralized	Consensus-based	Algorithmic Protocols	Token Economics	High
Hybrid	Multi-layered	Mixed Mechanisms	Flexible Incentives	Variable

The evolution from a characterised centre command-and-control structure to a consensus model based on decentralisation is depicted in Table 1 with various governance models used in alternative computing systems. The table illustrates the distributed governance models and contrasts them with outdated approaches, illustrating their flexibility and scalability in comparison to the centralised model.

## 2.4 Computing Resource Allocation and Value Creation Mechanisms

In alternative systems, computation resource allocation is done through advanced methods which manage the distribution of computational power, storage, network bandwidth, and other resources among various applications and users [20]. The overarching resource allocation framework for distributed computing systems is supported by auction theory, mechanism design, and game theory to devise sophisticated mechanisms that allocate computing resources while considering performance, fairness, cost, and resource allocation challenges. These mechanisms are required to solve problems of resource allocation challenges of resource heterogeneity, varying supply and demand, or strategic actions by remaining anonymous participants or ‘players’ in the system.

In computing systems, alternative mechanisms for creating value operate through direct resource use, network effects, value capture from ecosystems, or data monetization. An economic model for these systems states value creation happens not only through optimal resource allocation, but network effects also come into play where better utilisation increases the value of the system as more users join the ecosystem. This leads to positive feedback dynamics which enhances system growth and innovation, driving sustainable revenues for the stakeholders.

The convergence of blockchain technology and smart contracts has created new avenues for the unmediated automated allocation and distribution of resources and value [21]. These systems provide automated programmable resource allocation based

on rules and conditions (transaction costs) which provide efficiency in the market mechanisms. Through tokenisation, computing resources can be traded at a more granular level while also allowing other ecosystem participants to profit from their roles, thus improving the diversity and resilience of resource allocation mechanisms.

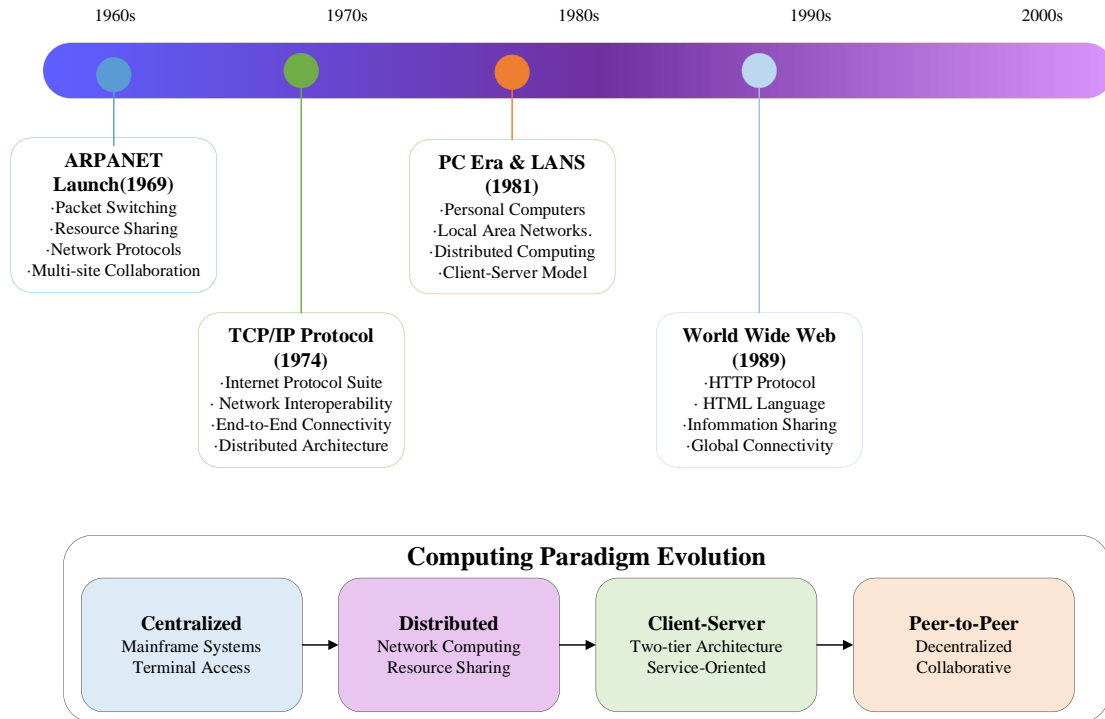
## **3. Historical Evolution Trajectory of Data Banks**

### **3.1 Early Data Sharing and Computing Collaboration Experiments (1960s-1990s)**

The foundational principles of modern banking databases can be traced to the early attempts at data exchange and computation collaboration which began between the 1960s and 1990s. This era signified the transformation from solitary computing systems to a networked computing paradigm that supported resource sharing and collaborative computation. The creation of packet switching systems was a crucial innovation that permitted the development of distributed computing architectures which could function as decentralised alternatives to centralised mainframe systems. All these early projects contributed to building the technological and mental frameworks needed for modern data banking systems.

Initiated in 1969, the Advanced Research Projects Agency Network (ARPANET) proved the concept of geographically separated research institutions being linked for collaborative computing by freely sharing resources across network boundaries and thus pioneered distributed computing collaboration. With packet switching, the network provided better access to computing resources to multiple users than the old time-sharing systems and their redundant structures confined to single institutions. This was a shift to distributed systems which made cross-organisational and even international usage of computing resources possible.





**Figure 2. Timeline of Early Data Sharing and Computing Collaboration Evolution (1960s-1990s)**

Figure 2 captures the timeline of significant early milestones of data sharing and collaborative computing systems. It shows the progress made from the first implementation of packet switching on ARPANET to the later development of its protocols and distributed computing systems. The lower half illustrates the shifting nature of the computing paradigms from centralised mainframe systems to peer-to-peer collaborative networks and distributed systems.

The advanced distributed computing systems in this period were motivated by the realisation that processing resources had a higher utilisation efficiency when leveraged through collaboration over a network rather than standalone computing [22]. Initial efforts in grid computing as well as distributed databases showed that virtual computing environments could be created beyond physical boundaries. These projects established many principles upon which cloud computing and modern data bank architectures would be built.

## 3.2 Data Governance Transformation in the Internet Era (1990s-2000s)

The creation of the Internet as a means of communication across the globe advanced sharply, changing the information sharing framework and access control systems of data governance models [23]. The hypertext information system offered interlinked decentralised document repositories for retrieval and browsing of documents that were

previously situated in different locations. This helped in the development of the World Wide Web, created by Tim Berners-Lee, enhancing accessibility of information. The explosive growth of the internet in the 90s brought with it unmatched opportunities for information technology collaboration alongside novel challenges pertaining to security, privacy, and access control [24]. The traditional central governance structure, however, was incapable of controlling the scattered information systems that were inter-organisational and cross-jurisdictional in nature, leading to the development of federated governance frameworks which balanced local freedoms with global coordination needs.

**Table 2. Comparative Analysis of Data Governance Models Between Pre-Internet and Internet Eras**

Governance Aspect	Pre-Internet Era (1960s-1980s)	Internet Era (1990s-2000s)	Key Changes
Access Control	Centralized, Institutional	Distributed, Network-based	Authentication protocols, Digital certificates
Data Standards	Proprietary formats	Open standards (HTML, XML)	Interoperability, Cross-platform compatibility
Security Model	Physical security, Isolated systems	Network security, Encryption	Cryptographic protocols, Secure communications
Governance Structure	Hierarchical, Centralized	Federated, Multi-stakeholder	Distributed decision-making, Consensus mechanisms
Resource Allocation	Administrative allocation	Market-based mechanisms	Dynamic resource discovery, Service-oriented architecture
Information Discovery	Manual cataloging	Automated indexing	Search engines, Metadata standards

Table 2 illustrates the change in the principles of data governance during the transition from computing systems of the pre-Internet era to the Internet era. It shows the evolution of data governance from fully centralised and institutionally controlled to distributed and networked. This change also required new standards and organisational models to secure and provide reliability in heterogeneous environments.

With the Internet came new economic paradigms for sharing data and allocating resources [25]. Unlike the previous systems that relied solely on administrative resource allocation within bounded institutions, Internet systems provided the possibility of resource allocation through market-based mechanisms, enabling dynamic discovery and utilisation. Such a transformation served as a precursor to the platform-based economic models that were later manifested in cloud computing and digital banking.

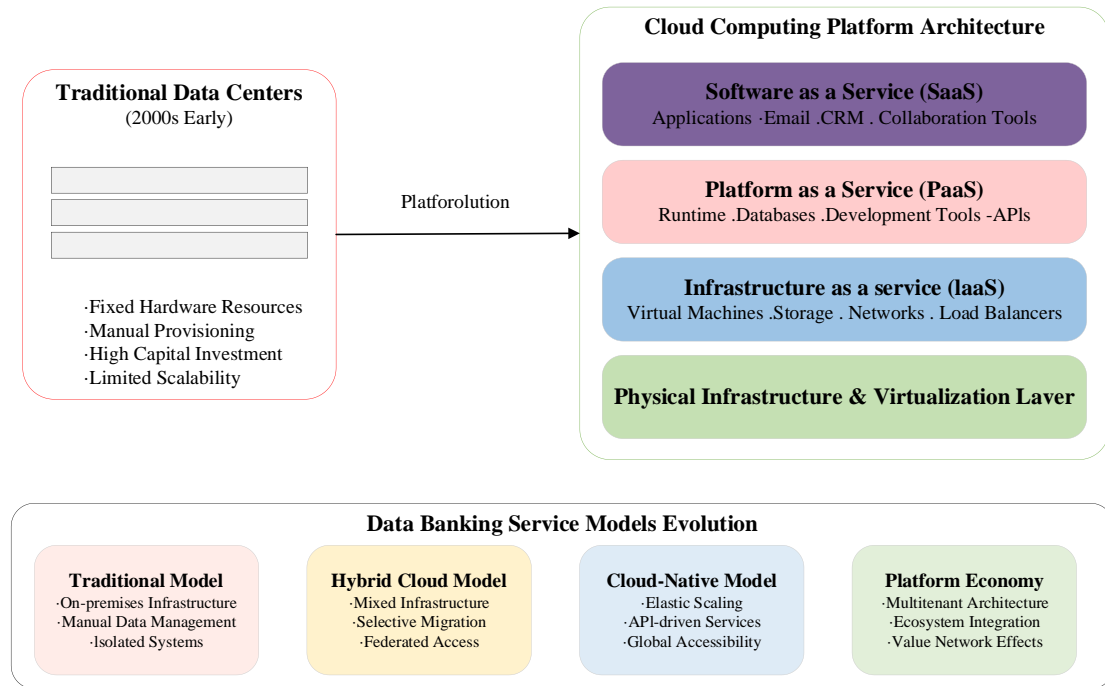
The defined communication methods and data formats created during this epoch laid out the groundwork for complex levels of data integration, large-scale interoperability [26]. The invention of markup languages, such as HTML and XML, allowed for the

representation of data in a form that is machine-processable and can be read easily by humans. These emerged standards have made it possible to design distributed information systems which could integrate data from heterogeneous sources while maintaining the underlying semantics and structural relationships.

### **3.3 Cloud Computing Platformization of Data Bank Models (2000s-2010s)**

The evolution of cloud computing in the 2000s marked a turning point in the platformisation of data banking services. Cloud computing provided scalable and on-demand access to computational resources and data storage capabilities. During this time, traditional data centres started undergoing a metamorphosis into service-oriented platforms capable of agile resource allocation in response to user demand while ensuring stringent availability and reliability benchmarks. The emergence of computer resource virtualisation enabled more efficient sharing of physical computing resources among numerous users, thus giving rise to novel data processing and storage service economic paradigms.

The launch of Amazon Web Services (AWS) in 2006 marked the inception of the Infrastructure-as-a-Service (IaaS) paradigm. AWS enabled organisations to access high-grade computing resources without incurring massive capital expenditures on physical infrastructure. As vividly evidenced by the cloud data banking services AWS provided, great organisational flexibility, rapid scalability, and unrestricted global access were facilitated by standardised APIs and web interfaces. Early cloud platform success tested and affirmed the economic feasibility of utility computing paradigms and established design patterns that would serve as the foundations for future innovations in distributed computing framework evolution.



**Figure 3. Cloud Computing Platform Architecture and Data Banking Service Models Evolution**

Figure 3 shows how the architecture evolved from traditional data centres to cloud computing platforms within the 2000s to 2010s. It also shows the service-level model (SaaS, PaaS, IaaS) which served as the basis for contemporary cloud frameworks, in addition to showing the evolution of the data banking service models from closed subsystems to ecosystem-based platforms. Such transformation facilitated the development of new economic paradigms predicated on utility computing and network effects.

As described in reference [27], the governance issues which stem from the platformisation of data banking services are multi-tenancy, data sovereignty, and service-level agreements. Cloud platforms had to isolate different users robustly, yet allow dynamic scaling and efficient resource sharing. This drove the emergence of advanced virtualisation and container-based architectures that could ensure security and performance guarantees in shared computing resources.

### 3.4 Data Bank Innovation Practices in the Big Data Era (2010s-Present)

The introduction of big data technologies in the 2010s made it possible to process and analyse enormous volumes of structured and unstructured data, transforming data banking practices permanently [25]. During this period, frameworks for distributed data processing developed, such as Apache Hadoop and Spark, which were capable of petabyte-scale datasets on clusters of commodity hardware. The emergence of NoSQL databases alongside distributed storage systems allowed data banks to accommodate

various types of data and access patterns while still ensuring high availability and strong consistency.

The rapid expansion of mobile technologies and IoT sensors generated new kinds of data that needed refreshed methodologies concerning ingestion, processing, and storage [28]. Existing batch processing systems struggled to accommodate data streams that required urgent analysis, instantaneous response, and real-time reaction capabilities. This triggered the creation of event-driven systems and stream processing architectures capable of real-time data processing under strict latency and throughput constraints.

**Table 3. Technology Evolution in Data Banking Systems: Pre-Big Data vs. Big Data Era**

Technology Category	Pre-Big Data Era (2000s)	Big Data Era (2010s-Present)	Innovation Impact
Storage Systems	Relational Databases	Distributed NoSQL, Data Lakes	Horizontal scaling, Schema flexibility
Processing Models	Batch ETL	Stream processing, Real-time analytics	Low-latency insights, Event-driven architecture
Data Integration	Point-to-point connections	API-first, Microservices	Loose coupling, Service composition
Analytics Capabilities	Reporting, OLAP	Machine Learning, AI/ML	Predictive analytics, Automated insights
Governance Frameworks	Policy-based	Automated, ML-driven	Dynamic compliance, Intelligent classification
User Interfaces	Desktop applications	Mobile-first, Cloud-native	Ubiquitous access, Context-aware services

Table 3 illustrates the profound effects of big data technologies on a data banking system's multifaceted functionalities. The evolution from conventional relational databases to NoSQL models brought about a shift towards distributed systems with the ability to scale out horizontally and offer more flexible schemas accommodating heterogeneous data types and evolving requirements. The introduction of real-time data analytics provided unprecedented insight from continuous data streams, offering immediate insights.

According to reference [10], the application of AI and ML into data banking technology has refined automated data classification, intelligent caching, and predictive resource allocation. Modern data banks can autonomously tune their systems for optimal performance based on real-time usage patterns, forecast resource needs, and thus reduce operational costs and improve user experience. These functionalities turned data banks from passive systems used for mere storage to active intelligence systems that can engage in business analytics and contribute to the decision-making processes of enterprises.

The advent of blockchain technology has enabled a new form of data banking that is fully decentralised and does not rely on intermediaries [28]. Distributed ledger technologies allow for automated execution of data sharing agreements through smart contracts, leading to secure data storage that is invulnerable to tampering. These advancements have resulted in new monetisation methods and inter-organisational collaboration while ensuring the sovereignty of data and enabling value creation through sharing.

The shift towards edge computing and more distributed methods of processing data exemplifies the requirement for faster data retrieval and real-time responsive decision-making capabilities [25]. The latest architecture designs for data banking give greater incorporation to edge nodes which are capable of processing data closer to the source to improve network latency and turn-around times for critical applications. This allows data banks to support advanced emerging applications including autonomous vehicles, smart city infrastructure, and industrial Internet of Things systems, which require sub-millisecond response times.

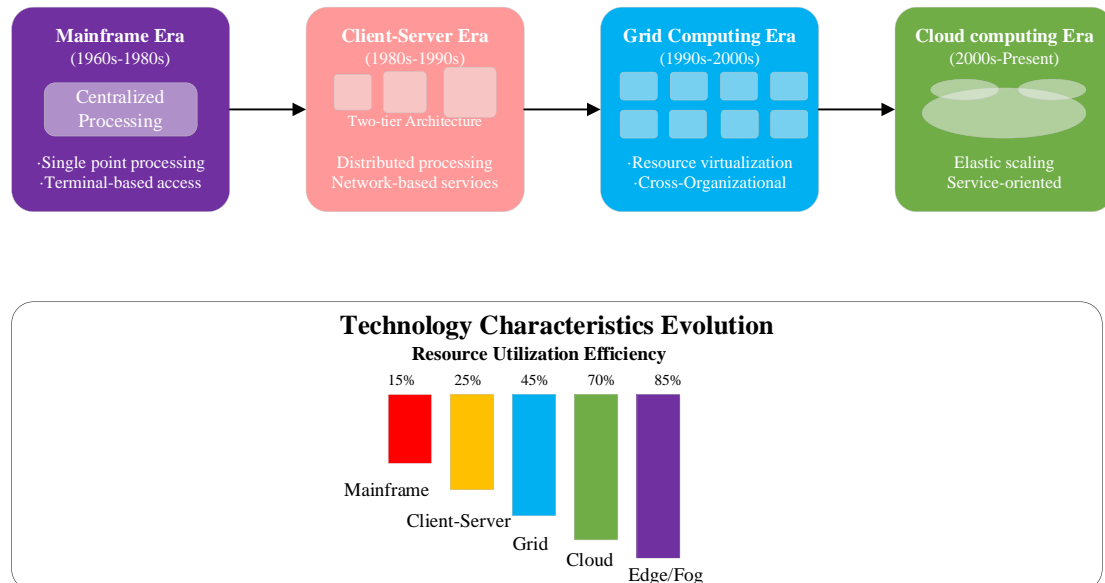
## **4. Technological Evolution and Economic Transformation of Computing Systems**

### **4.1 Development History of Distributed Computing Technologies**

The emergence of distributed computing technologies marks an evolution from centralised processing architectures to more complex interconnection systems which utilise various computational nodes for improved performance and dependability [22]. The first attempts at distributed computing stemmed from realising that many computational problems can be split into smaller, parallel tasks that can be executed simultaneously on several processors which is far more efficient than a sequential, one after the other approach. The change from tightly coupled multiprocessor systems to loosely coupled distributed networks created scalable computing infrastructures capable of accommodating shifting workload demands.

In the 1990s, grid computing became one of the first large scale implementations of distributed computing as it allowed institutions to share computing resources beyond organisational boundaries [28]. These systems showed that it was possible to create virtual supercomputers by aggregating computing resources spread over different

geographical locations and providing them as unified supercomputing platforms. The initiatives of grid computing demonstrated the resource sharing economy, its technical advantages, and established the basis on which cloud computing architectures would be later built.



**Figure 4. Evolution of Distributed Computing Technologies and Resource Utilization Efficiency**

As shown in Figure 4, the timeline of the distributed computing paradigm starts with the cloud computing system all the way back from the centralised mainframe systems. The diagram illustrates how resource utilisation efficiency was earned from each technological era, cloud computing reaching approximately 70% efficiency in contrast to 15% in traditional mainframe systems. The evolution also shows increased scalability and accessibility paired with an unprecedented level of resource optimisation which has shifted the fundamentals of computing economies.

The shift from grid computing to cloud computing marked a notable change in the economic model of distributed computing from resource sharing among collaboration institutes to serving commercial utility computing services [25]. With the cloud platforms came the introduction of standardised APIs as well as Service Level Agreements (SLA) which guaranteed secured retrieval to computing resources while disconnecting the infrastructure complexity. Due to this change, high-performance computing capabilities became accessible for less powerful organisations, provided they do not need to undertake major capital expenditures.

## 4.2 Commoditization Process and Market Formation of Computing Power

The ability to purchase computing power as a commodity shifted the paradigm of computational resources from intricate specialised assets to more simplified configurable tech services with interfaces and pricing models available on the market [29]. This started with the standardisation of hardware, including operating systems, which served as the foundation for software portability, thus lowering the entry thresholds for a computing service provider. Virtualised systems themselves further fostered this proprietary commoditisation trend by allowing multiple users to efficiently share a single physical computing resource while providing isolation and performance guarantees.

Market formation for computing power followed patterns similar to other utility industries, with early fragmentation giving way to platform-based consolidation as network effects and economies of scale favored large providers [30]. The introduction of cloud computing offered particularly powerful remote data centres serving business and government agencies software and pricing models. It became possible to purchase computing resources just like one buys electric energy or telecommunications services. This paradigm shift fundamentally transformed technological expenditures by shifting IT compute resources from a capital expense to an operational expense that can be scaled in real time according to demand.

**Table 4. Computing Power Market Evolution and Economic Models**

Market Development Phase	Time Period	Key Characteristics	Economic Model	Market Structure
Proprietary Systems	1960s-1980s	Vendor lock-in, Custom solutions	Capital-intensive, Long-term contracts	Oligopoly with high barriers
Standards Emergence	1980s-1990s	Interoperability, Open architectures	Mixed models, Service agreements	Competitive differentiation
Platform Consolidation	2000s-2010s	API standardization, SLAs	Utility pricing, Pay-per-use	Platform-based competition
Commodity Markets	2010s-Present	Price transparency, Elastic demand	Spot markets, Real-time pricing	Multi-sided platforms

The change from proprietary computing systems to more transparent and elastic demand-driven commoditised priced markets is illustrated in Table 4. The shift from capital intensive to utility pricing models, from an organisation's perspective, mitigated risks related to technological investments, as access to computing resources became easier. This transformation unlocked new possibilities for innovation and entrepreneurship by lowering the barriers of high-performance computing.



The establishment of spot markets for computing power enabled real-time supply and demand responsive dynamic pricing. These markets subsidised the intelligent distribution of computing workloads in times and places where resources were abundant by directing computing workloads during periods of limited availability. The automated self-bidding and algorithmic resource allocation enhanced market efficiency by minimising the cost burden of servicing transactions and increasing responsiveness to changing market conditions.

## **4.3 Blockchain-driven Decentralized Computing Networks**

The emergence of blockchain technology has led to the development of computing networks that are decentralised and operate without historical mediators or centralised control systems [21]. Such systems coordinate the allocation of resources and ensure appropriate payment to the computing service providers using cryptographic protocols with layered trust guarantees and consensus mechanisms. Smart contracts allow automated execution of computing assignments with payment release in accordance with the agreed terms, including performance indicators and automation level, minimising manual control and disputes.

Decentralised computing networks employ a token-based incentive system to motivate participation while ensuring the security and reliability of the network [20]. Network participants can contribute computing resources and earn tokens, providing economic incentives for proper network capacity and performance upkeep. Their geographic distribution, as compared to traditional cloud computing services, allows these networks to achieve significantly higher reliability and lower expenses, unlike traditional cloud computing services, where intermediaries add considerable costs.

The development of computing networks based on blockchain technology marks a critical progression towards resource sharing on a peer-to-peer basis, potentially disrupting the monopoly of established cloud computing services [31]. These systems facilitate resource provisioning and consumption to occur independently of trust-based systems that rely on centralised, third-party systems. Blockchains augment trust in transactions by providing auditable records of usage and settlement, which introduces novel auditability and control mechanisms in distributed computing systems.

Existing forms of decentralised computing networks suffer from critical issues of scalability, latency, and energy efficiency which greatly restrict their applicability to specific workloads [28]. Meanwhile, certain blockchain technologies are addressing some of these issues, such as layer-2 scaling and proof-of-stake consensus mechanisms, thereby increasing the possible use cases for decentralised computing architectures. The persistent advancements of such systems may foster new computing economic paradigms which focus on the decentralisation, transparency, and sovereignty of users rather than the traditional convenience and efficiency metrics.

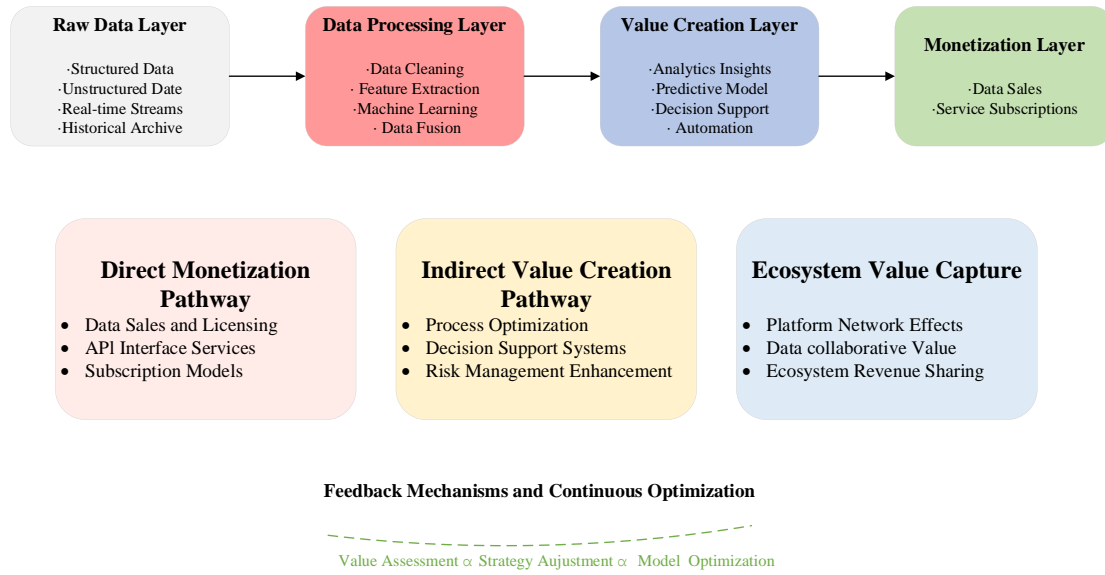
# **5. Evolution Mechanisms and Innovation Models from Data Banks to Digital Currencies**

## **5.1 Implementation Pathways and Mechanisms of Data Valorization**

In the context of data valorisation, data is seen as an economic asset, undergoing processes that extract value from it, unlike traditional storage systems, which perceive data as an inactive resource [9]. The primary framework of data valorisation contains data collection, cleaning, analysis, monetisation, and several more, all of which require a multidisciplinary IT infrastructural and governance system to ensure data integrity for maximised valorisation. Banking data systems have incorporated sophisticated automated data governance systems that control and enhance processes related to the automated management of the data lifecycle to improve the efficiency and dependability of the data valorisation processes [17].

Pathways for implementing data valorisation span three models: direct monetisation, indirect value creation, and ecosystem value capture. Monetisation through subscriptions, service data leasing or selling are classified as direct monetisation; while optimisation of business processes through derived insights exemplifies indirect value creation; ecosystem value capture demonstrates value multiplication through platform and network effects [9]. These pathways are influenced by a combination of conditions such as the type of data and its context of use alongside market needs, and the most optimum technical solutions and economic advantages.

As noted in reference [21], the use of data banks and their subsequent evolution to digital currencies serve to highlight how, through blockchains and smart contracts, data assets can be transformed into programmable financial instruments. This evolution creates new types of digital economies which function outside the boundaries of traditional financial intermediaries, as value exchange automation based on data usage patterns and algorithmic governance is possible. The combination of data valorisation and tokenisation creates self-sustaining digital ecosystems.



**Figure 5. Data Valorization Implementation Framework and Mechanisms**

Turning raw data into a monetisation layer comes with a series of changes, which are vividly displayed in figure 5. This explains the entire implementation framework for data valorisation. From this framework, three value realisation pathways can be made: Direct monetisation pathway is enabled through revenue generation from data sales and API services; indirect value creation pathway which optimises processes and provides decision support; and ecosystem value capture pathway which multiplies value through network effects. Continuous valorisation process refinement is enabled through the feedback system at the bottom.

## 5.2 Theory and Practical Exploration of Computing Power Tokenization

The tokenisation of computing power signifies the change of computing resources from a conventional form into a tokenised and tradable form, allowing computing capabilities to be exchanged in standard units which are divisible and liquid [20]. The tokenisation method achieves granular precision in capturing, auto-distribution, and clear settlement of computing resources using smart contracts, thereby creating balanced and efficient resource markets. This model enhances the cost efficiency for obtaining computing resources and introduces novel economic reward models for users in the distributed computing network [21].

The convergence of blockchain technology with token economics forms the theoretical groundwork for computing power tokenisation by turning computing capabilities into verifiable digital assets to enable standard pricing and market-driven distribution of computational resources [32]. Computing measurement, value assessment, token issuance, and trading circulation comprise the various stages of the computing power tokenisation ecosystem. Each stage demands specific technical protocols and

governance frameworks to preserve the system’s integrity and trustworthiness with regard to its security. In the context of computing power tokenisation, modern systems utilise consensus protocols such as proof-of-work and proof-of-stake to confirm computational contributions and reward tokens to participants in the network as incentives [20].

The hands-on study of computing power tokenisation shows great promise in establishing self-sustaining digital economies where computational resources are the foundational building blocks for value creation [33]. Within these systems, detailed and advanced levels of resource trading are possible, and monetisation of participation within computing ecosystems became possible, increasing the diversity and resiliency of resource allocation mechanisms. The inclusion of decentralised finance protocols also enhances the usefulness of computing tokens by allowing lending, staking, and yield generation linked to the computation contributions.

**Table 5. Comparative Analysis of Computing Power Tokenization Models**

Tokenization Model	Technical Foundation	Incentive Mechanism	Application Scenario	Key Advantages
Proof-of-Work Tokens	Hash computation verification	Computing contribution rewards	Cryptocurrency mining	High security, strong decentralization
Proof-of-Stake Tokens	Staking validation mechanism	Token holding incentives	Blockchain validation	Low energy consumption, good scalability
Utility Tokens	Smart contract execution	Service usage incentives	Cloud computing platforms	Rich application scenarios, high practical value
Hybrid Tokens	Multiple consensus mechanisms	Composite incentive models	Comprehensive computing platforms	High flexibility, broad adaptability

The comparative review of the four significant computing power tokenisation models is described in Table 5 along with their features. The hashing performed for verification on proof-of-work tokens provides very strong security guarantees though it is expensive in terms of energy expenditure. Energy expenditures are lower for proof-of-stake tokens due to their staking features. Utility tokens aim at value creation through practical application focused on usefulness directly. Combining multiple mechanisms to cater to diverse application needs is done by hybrid tokens. Each model has distinctive technical underpinnings and corresponding situations, thus optimal tokenisation model selection is critical to ensuring desired computing system performance.

## **5.3 Smart Contract and Decentralized Governance Innovation**

Coded complex governance systems on smart contracts can enforce automated execution and oversight with precise automation in decentralised governance provided by the underlying technology [6]. This novel model eliminates the trust gap and human interference mechanisms utilised in traditional models of governance by automating the entire landscape of governance activities as well as resource allocation based on set criteria and rules. Smart contracts guarantee the transparency and immutability required in the governance processes, thus providing indisputable, auditable systems which can be used for proper governing large-scale distributed systems [34].

Decentralised governance innovation is fundamentally concerned with converting a community-spiral hierarchical decision structure into a community consensus-based decision framework. Participants govern the system through token voting, proposal debates, and supervision of execution [5]. This model strengthens the democratisation and transparency of the decision process while at the same time ensuring active participation and accountability through incentives. This governance innovation is exemplified by modern Decentralised Autonomous Organisations (DAOs) which fully automate organisational operation and decision execution via smart contracts [35].

The execution of smart contracts in the context of decentralised finance exhibits great governance innovation potential, spanning from basic token exchanges to intricate financial derivative trades [31]. With this form of innovation, trust and transaction costs are diminished, as well as granting opportunities for financial innovation to emerge beyond the reach of traditional financial service providers. In addition, advancing financial innovation becomes possible through the programmable characteristics of smart contracts which support advanced governance models like multi-signature approval, governance by time locks, or conditional execution based on external data feeds.

The shift toward algorithmic governance marks a distinct change from human decision-making to decision-making dictated by lines of code, where governance parameters such as system performance and stakeholder preferences can be dynamically altered in real time [35]. This eliminates the possibility of governance capture and ensures that system evolution supports the collective interests of participants instead of centralised power systems.

## **5.4 Computing Economic Models in Decentralized Finance (DeFi)**

Decentralised Finance (DeFi) signifies the shift towards computing-based models of financial services, automating intermediary roles using smart contracts and distributed networks [7]. The computing economic framework of DeFi systems relies on pioneering mechanisms like automated market makers, liquidity mining, and yield farming, which control speculative trading and quantifiable returns algorithmically [19]. While this model enhances the effectiveness and inclusivity of financial services, it also establishes advanced mechanisms for value distribution, allowing users to actively engage in protocol revenue sharing [29].

The computing economic model of DeFi accomplishes a high degree of uninterrupted interaction between computation and finances by means of tokenised incentive mechanisms where users can win tokens by providing liquidity, validating, governing, and other activities [7]. This model enables the formation of economically self-sufficient ecosystems within DeFi in which computing providers, liquidity providers, and users create mutually dependent networks of value. Protocol tokens are not purely governance instruments; they are also holders and mediums of value transfer and exchange, thus creating closed systems of economic circulation [36].

The contemporary DeFi protocols utilise advanced computer economic frameworks which provide automated and disaggregated automated financial services, with the frameworks capable of making parameter changes and optimising resources automatically based on the environment [37]. For instance, pricing and liquidity distribution in order books are handled algorithmically by automated market makers, and with yield optimisers, return on investment for users is maximised through strategical yields. These changes showcase the immense possibilities that computing economic models have in restructuring financial services and indication for strategic evolution of financial systems.

As a result of the DeFi systems, the composability characteristics allow different protocols to integrate with one another and work together, forming diverse and more powerful financial ecosystems [19]. Through the financial LEGO model, "finances" are perfectly linked with every protocol using smart contracts, which gives the possibility for multi-protocol transactions within a single execution that provides for enhanced optimisation of financial transactions. This model shows the powerful benefits provided by decentralised systems which erase boundaries towards innovations and increase productivity.

The emergence of cross-chain DeFi protocols further expands the computing economic model by enabling value transfer and liquidity sharing across different blockchain networks [36]. This is further evidence showcasing the potential of computing resources tokenisation and the distributed governance systems to construct an operationally unhinged infrastructured decentralised financial system transcendently autonomous from the conventional situational norm of political borders and legal boundaries, signifying the utmost evolution from datacentres to smart currencies.

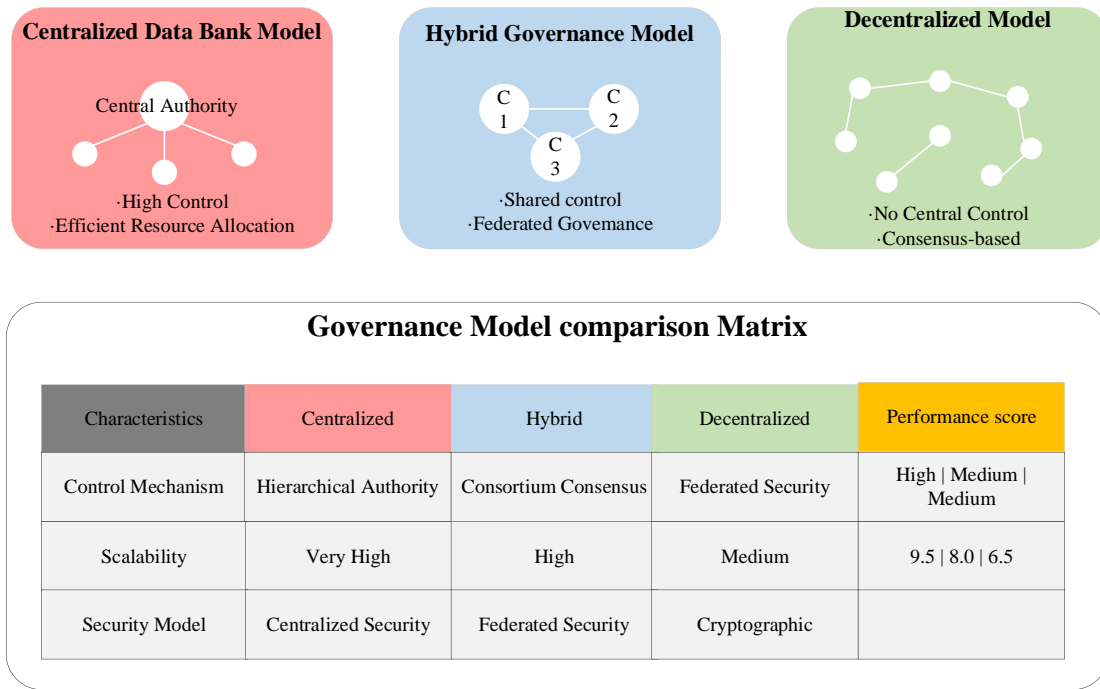
## **6. Comparative Case Studies and Model Analysis**

### **6.1 Centralized Data Bank Model: Cloud Service Platform Cases**

The centralised data bank model illustrates the advanced stage of monetisation of computing resources and is epitomised by the [29] cloud service giants that have turned the computational backbone into utility services. These platforms illustrate the contextual efficiency that can be obtained from centralised governance systems in streamlined governance frameworks coupled with strict security and compliance controls. The achievement of the market provided by the centralised cloud platforms substantiates the business feasibility of computing-as-a-service models while also setting industry standards on service, cost, and user interface for the rest of the computing economy [30].

Examples of the centralised data bank model are Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform. They demonstrate a comprehensive service ecosystem that encompasses the infrastructure, platform, and software as core services [29]. These platforms attain economical scales on aggregate computing resources and offer them monetarily through standard APIs and service-level agreements. The centralised model makes it possible to achieve accelerated innovation cycles, uniform service quality, and integrated security frameworks than what is possible in distributed systems [30]. On the other hand, this model poses some myriad risks pertaining to vendor lock-in, data sovereignty, and critical single points of failure which in turn restricts user autonomy and system resilience.

The economic framework of the more advanced cloud systems illustrates highly developed pricing systems which seek to achieve an equilibrium between profit maximisation and optimisation of resource use [27]. These systems allocate resources efficiently with maintained income flows by applying dynamic pricing, reserved capacity, and spot market models simultaneously. The application of artificial intelligence and machine learning technologies facilitates automated performance tuning and resource provisioning which curbs operating expenses while enhancing the user experience [10].



**Figure 6. Comparative Analysis of Computing System Governance Models**

In Figure 6, all three computing governance systems and their respective structural features alongside performance metrics have been compared holistically. While achieving centralisation yields the greatest economic efficiency and scalability due to the hierarchical control structure, decentralisation affords the maximal user freedom and cryptographic security through the use of distributed consensus algorithms. Any combination of these two approaches yields a hybrid model that provides moderate performance in all categories standing as a balance of trade-offs. Overall, the comparison matrix presents quantitative evaluations in six critical dimensions revealing greatest optimisation advantages for centralised governance systems that received the highest score (8.0) and strong autonomy and security for decentralised systems that placed close behind (7.3).

## 6.2 Hybrid Governance Model: Consortium Blockchain Computing Network Cases

Consortium blockchain networks are advanced versions of a combination governance approach that integrates the centralisation's efficiency advantages with the dispersed system's resilience benefits [17]. These networks often have a predetermined set of trusted participants within a certain organisational boundary who jointly share governance through consensus mechanisms, albeit retaining their autonomous organisational structures. This blended framework allows specialised computing networks to reach a greater transaction throughput and lower operational costs relative to fully decentralised systems while retaining rudimentary elements of transparency and collaborative governance frameworks [18].



Well-known examples of consortium blockchain computing networks are the Hyperledger Fabric implementation within supply chain management and the R3 Corda networks in the financial services sector. They exemplify how cross-organisational collaboration within one company utilises integrated governing hybrid systems to balance intricate compliance frameworks [17]. Security guarantees are maintained while rapid transaction processing is achieved through the utilisation of practical Byzantine fault tolerance algorithms on the consortium blockchain computing networks. These platforms' governance structures utilise multi-signature authorisation coupled with voting proportional to the importance and knowledge the participants possess to the consortium [18].

The economic framework of consortium computing networks optimises the computational overhead by consolidating resource allocation. Unlike self-serving organisations, collaborative entities are capable of leveraging cross-associative synergies to yield unparalleled value [27]. Benefits of network usage are apportioned according to the provided resource, transaction volume, and governance involvement in a network participation model which ensures collaboration continuity. Additionally, that mixed framework allows creating tailored compliance regimes adaptable to different jurisdictions [38].

**Table 6. Comparative Performance Analysis of Governance Models in Computing Networks**

Governance Dimension	Pure Centralized	Consortium Hybrid	Pure Decentralized	Hybrid Advantages
Decision Speed	Very Fast (1-2 days)	Fast (3-7 days)	Slow (weeks-months)	Balanced efficiency and consensus
Consensus Mechanism	Administrative	Multi-party PBFT	Global PoW/PoS	Trusted participant model
Resource Efficiency	95%+ utilization	85-90% utilization	60-75% utilization	Optimized for known participants
Regulatory Compliance	Single jurisdiction	Multi-jurisdiction	Regulatory uncertainty	Structured compliance framework
Innovation Flexibility	High within limits	Medium-High	Variable	Coordinated innovation cycles
Network Resilience	Single point failure	Distributed resilience	Maximum resilience	Balanced risk distribution

The operational performance metrics of various governance models are captured in Table 6. The consortium hybrid model demonstrates near centralised decisional agility while being far more resilient than any single-authority system. Resource efficiency is still competitive with 85-90% utilisation, which is a major improvement over purely

decentralised networks. Compliance captures the hybrid model's distinctive strength; structured systems coping with many jurisdictions can operate and align strategically.

## **6.3 Decentralized Model: Public Blockchain Computing Markets and Digital Currency Cases**

Public blockchain computing markets demonstrate the most advanced form of decentralised governance as proprietary computational assets are distributed through a consensus algorithm with no central authority [20]. These systems exemplify the coordination of large-scale distributed computing systems with security and fairness constraints using cryptographic protocols and economic incentives. The bitcoin and Ethereum networks are the primary examples of self-sustaining digital economies driven by computation through proof-of-work and proof-of-stake systems [33].

These Ethereum-based smart contract ecosystems serving as decentralised computing marketplaces are an additional example illustrating the complex automation which programmable currency can perform [31]. Such systems provide sophisticated automation which allows for the granular computational task pricing, decentralised payment systems, and self-regulating quality reputation systems. The transforming of computing resources into tokens facilitates these computing markets turning them into instant trades of processing power which enhances efficiency in determining prices and resource allocation [32].

The smart contracts managing the multi-billion pound asset pools in Decentralised Finance (DeFi) protocols showcase the most advanced examples of algorithmic governance within digital currency ecosystems and are fully automated IoT systems governed by pre-set parameters and market fluctuations [7]. DeFi protocols are composable to an unparalleled degree, enabling complex cross-protocol interactions to form myriad sophisticated financial instruments and services. Governance tokens provided by DeFi protocols allow stakeholders to participate in system evolution while maintaining a perpetual incentivisation structure ensuring system health for the decades to come [19].

The fully decentralised computing models capture the attention of economists not for their technological features, but for the essential aspects of modern monetary policy and the mechanisms of creating value in digital economies [13]. Decentralised digital currencies, unlike traditional fiat currencies which are backed by a sovereign authority, result in value from network effects, utility functions, and algorithmic mechanisms of scarcity [16]. Such a system is capable of providing entirely new paradigms for monetary systems devoid of geographical constraints and traditional banking architecture [39].

The scaling challenges unsolved in decentralised consensus models have spurred creativity in layer-2 systems, sharding frameworks, and hybrid consensus models all aimed at preserving the corners of decentralisation slack and higher transaction throughput [20]. Such advancements in technology reveal that there is a persistent movement of decentralised systems toward practicality for mainstream computing markets while preserving the core values of trustlessness and censorship resistance.

The decentralised computing markets still face prominent unsolved problems regarding energy efficiency, transaction fees, cost, and the overall interface which pose barriers for widespread adoption [28]. The ongoing innovation of proof-of-stake consensus models, state channels, and other framework driving technologies, however, follows a direction of decentralised computing designs that are more practical and enduring. The combination of these technical enhancements with a rising need for digital sovereignty and financial inclusion underscores increased adoption of central-less models in future computing economies.

Examining all three governance models in parallel suggests that each approach prioritises different considerations within the framework of digital economy systems. Centralised models lead in operational efficiency and user satisfaction; hybrid models try to accommodate multiple interests and regulatory requirements; while decentralised models enhance user freedom and system robustness. The existence and interplay of these various models form a rich and robust computing system ecosystem for diverse user needs and applications [25].

## **7. Conclusion**

This study illustrates the shift from data banks to digital currencies as a result of new computing models which stand in opposition to established centralised frameworks, representing a radical change to the computing system architecture and the economic structure of an organisation. The investigation outlines three distinct evolutionary pathways: centralised data bank paradigms focusing on efficiency and scalability, hybrid governed models where stakeholder participation is balanced with compliance to regulatory frameworks, and fully decentralised systems where user control is maximised through algorithmic consensus. Through monetisation, creation of ancillary values, and eco-system value realisation, the data valorisation framework illustrates how raw computational resources undergo transformation to become digital assets. The ability to tokenise computational power emerges as an essential mechanism for monetisable markets, while automated governance and allocation of resources is delivered by smart contracts as the technological base for self-regulated systems. The comparative case study provides evidence that every governance model optimises for different ecosystem priorities within the socioeconomic biosystem of the digital economy, where centralised models dominate economic efficiency, hybrids balance multiple stakeholder demands, and decentralised models offer maximum resilience and user control. The combination of blockchain technology and the traditional computing

infrastructure gives rise to programmable money and autonomous financial services which are untethered from the traditional banking framework. These certain developments imply that computing economies of the future will most likely consist of multiple different models of governance existing simultaneously within interdependent ecosystems tailored to particular needs and preferences of users. The move toward computing resources to be tokenised and governed algorithmically suggests there are fundamental changes in the manner value is created, distributed, and controlled within the digital economic systems.

## References

- [1] Carvalho Silva, E. and M. Mira da Silva, *Central Bank Digital Currency: A Multivocal Literature Review*. Journal of Internet and Digital Economics, 2025.
- [2] Agur, I., A. Ari, and G. Dell’Ariccia, *Designing central bank digital currencies*. Journal of Monetary Economics, 2022. **125**: p. 62-79.
- [3] Lloyd, M., *The future of money: central bank digital currencies*. Atlantic Economic Journal, 2022. **50**(3): p. 85-98.
- [4] Werbach, K., *The blockchain and the new architecture of trust*. 2018: Mit Press.
- [5] Zetsche, D.A., D.W. Arner, and R.P. Buckley, *Decentralized finance*. Journal of Financial Regulation, 2020. **6**(2): p. 172-203.
- [6] Khan, S.N., et al., *Blockchain smart contracts: Applications, challenges, and future trends*. Peer-to-peer Networking and Applications, 2021. **14**: p. 2901-2925.
- [7] Ozili, P.K., *Decentralized finance research and developments around the world*. Journal of Banking and Financial Technology, 2022. **6**(2): p. 117-133.
- [8] Tanveer, U., S. Ishaq, and T.G. Hoang, *Tokenized Assets in a Decentralized Economy: Balancing Efficiency, Value, and Risks*. International Journal of Production Economics, 2025: p. 109554.
- [9] Birch, K., D.T. Cochrane, and C. Ward, *Data as asset? The measurement, governance, and valuation of digital personal data by Big Tech*. Big Data & Society, 2021. **8**(1): p. 20539517211017308.
- [10] Dissanayake, H., C. Popescu, and A. Iddagoda, *A bibliometric analysis of financial technology: Unveiling the research landscape*. FinTech, 2023. **2**(3): p. 527-542.
- [11] Avgouleas, E. and W. Blair, *A critical evaluation of Central Bank Digital Currencies (CBDCs): payments’ final frontier?* Capital Markets Law Journal, 2024. **19**(2): p. 103-112.
- [12] Lenis Escobar, A., et al., *The role of complementary monetary system as an instrument to innovate the local financial system*. Journal of Open Innovation: Technology, Market, and Complexity, 2020. **6**(4): p. 141.
- [13] Hofmann, C., *The changing concept of money: a threat to the monetary system or an opportunity for the financial sector?* European Business Organization Law Review, 2020. **21**: p. 37-68.
- [14] Kou, G. and Y. Lu, *FinTech: a literature review of emerging financial technologies and applications*. Financial Innovation, 2025. **11**(1): p. 1.
- [15] Prasad, E.S., *The future of money: How the digital revolution is transforming currencies and finance*. 2021: Harvard University Press.
- [16] Murau, S., A. Haas, and A. Guter-Sandu, *Monetary architecture and the green transition*. Environment and Planning A: Economy and Space, 2024. **56**(2): p. 382-401.
- [17] Basukie, J., Y. Wang, and S. Li, *Big data governance and algorithmic management in sharing*

- economy platforms: A case of ridesharing in emerging markets*. Technological Forecasting and Social Change, 2020. **161**: p. 120310.
- [18] Shen, Y., *Data governance in China's platform economy*. China economic journal, 2022. **15**(2): p. 202-215.
- [19] Chen, Y. and C. Bellavitis, *Blockchain disruption and decentralized finance: The rise of decentralized business models*. Journal of Business Venturing Insights, 2020. **13**: p. e00151.
- [20] Saleh, F., *Blockchain without waste: Proof-of-stake*. The Review of financial studies, 2021. **34**(3): p. 1156-1190.
- [21] Taherdoost, H., *Smart contracts in blockchain technology: A critical review*. Information, 2023. **14**(2): p. 117.
- [22] Dai, F., M.A. Hossain, and Y. Wang, *State of the Art in Parallel and Distributed Systems: Emerging Trends and Challenges*. Electronics, 2025. **14**(4): p. 677.
- [23] Berners-Lee, T., *Weaving the Web: The original design and ultimate destiny of the World Wide Web by its inventor*. 1999: Harper San Francisco.
- [24] Radu, R., *Revisiting the origins: The internet and its early governance*. Negotiating Internet Governance, 2019: p. 43-74.
- [25] Donta, P.K., et al., *Exploring the potential of distributed computing continuum systems*. Computers, 2023. **12**(10): p. 198.
- [26] Leiner, B.M., et al., *A brief history of the Internet*. ACM SIGCOMM computer communication review, 2009. **39**(5): p. 22-31.
- [27] Zafar, U. and E.Y. Li, *Financial inclusion and fintech ecosystems in the digital age: A systematic review and meta-analysis*. 2024.
- [28] Sun, E., et al., *Research on distributed data sharing system based on Internet of Things and blockchain*. Journal of Systems Science and Information, 2021. **9**(3): p. 239-254.
- [29] Almosov, A., et al. *Peculiarities of development of digital financial ecosystem*. in *SHS Web of Conferences*. 2021. EDP Sciences.
- [30] Jagrič, T., et al., *The banking industry in the ecosystem of digital currencies and digital central bank currencies*, in *The New Digital Era: Digitalisation, Emerging Risks and Opportunities*. 2022, Emerald Publishing Limited. p. 89-115.
- [31] Schär, F., *Decentralized finance: on blockchain and smart contract-based financial markets*. Review of the Federal Reserve Bank of St Louis, 2021. **103**(2): p. 153-174.
- [32] Lee, J.Y., *A decentralized token economy: How blockchain and cryptocurrency can revolutionize business*. Business Horizons, 2019. **62**(6): p. 773-784.
- [33] Andolfatto, D. and F.M. Martin, *The blockchain revolution: Decoding digital currencies*. Federal Reserve Bank of St. Louis Review, 2022.
- [34] Lin, S.-Y., et al., *A survey of application research based on blockchain smart contract*. Wireless Networks, 2022. **28**(2): p. 635-690.
- [35] De Filippi, P., *Blockchain technology and decentralized governance: the pitfalls of a trustless dream*. Decentralized Thriving: Governance and Community on the Web 3.0, 2019.
- [36] Far, S.B., A.I. Rad, and M.R. Asaar, *Blockchain and its derived technologies shape the future generation of digital businesses: a focus on decentralized finance and the Metaverse*. Data Science and Management, 2023. **6**(3): p. 183-197.
- [37] Alamsyah, A., G.N.W. Kusuma, and D.P. Ramadhani, *A review on decentralized finance ecosystems*. Future Internet, 2024. **16**(3): p. 76.

- [38] Mittal, P. and R.I. Singh, *Changing Landscape of Financial Inclusion Through FinTech: A Systematic Literature Review*. Paradigm, 2024: p. 09718907241286957.
- [39] Yamaoka, H., *Digital currencies and the future of money*, in *The future of financial systems in the digital age: Perspectives from europe and Japan*. 2022, Springer Singapore Singapore. p. 49-73.