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1 Introduction

1.1 Investing rather than betting

This question reflects a broader transformation currently taking place in modern economies, where powerful digital tools enable new, data-driven forms of value creation. Today, continuous flows of data generated by IoT, cloud infrastructures, wearable sensors, and advanced analytics systems allow real-world activities to be measured with unprecedented precision. Within this context, athlete's performance emerges as a particularly suitable domain for the tokenization of real-world assets (RWAs), as they are objectively observable, comparable over time, and directly linked to economic outcomes. Rather than focusing on short-term speculation or purely symbolic ownership, this paper proposes a model that allows users to invest, through the use of decentralized markets (DEX), in professional football players, basing asset valuation on real and measurable on-field performance indicators.

Despite these technological advancements, most existing sport-related economic models still rely on inefficient and structurally limited mechanisms, leaving several market opportunities unexploited, as will be discussed in this paper.

Sports betting remains the dominant channel through which supporters and fans attempt to generate profit mainly from football (as we're operating in the European market), yet it is inherently short-term, highly risky, and driven by probabilistic outcomes rather than rational investment strategies. At the same time, digital collectible platforms such as Sorare have introduced blockchain-based ownership through NFTs, while largely preserving the economic logic of traditional collectible figurines. In both systems, value is primarily driven by artificial scarcity and secondary-market trading dynamics, rather than by direct links to measurable economic fundamentals.

The parallel with traditional figurines lies in their shared collectible nature: ownership is associated with rarity, demand, and exchange activity, whether the asset is physical or digital.

Although Sorare introduces an additional layer of data-driven performance utility through gameplay mechanics, this element only partially translates into price formation, which remains shaped also by scarcity, market sentiment, and trading behavior among users. As a result, a substantial amount of economic potential remains unexploited.

This paper argues that sport should no longer be treated merely as entertainment or gambling, but as a new digital asset class, capable of supporting long-term, data-driven investment opportunities through digital ownership and decentralized financial markets (DEX).

Financial markets emerge when three conditions are satisfied: a well-defined underlying asset, continuous information flows, and a mechanism for price discovery.

Professional sports represent a particularly relevant domain in this context. The sports industry is global on scale, exceeding 600 billion dollars annually, and is characterized by constant information flows, persistent public attention, and measurable performance outcomes. Athletes generate economic value through performance, contracts, media exposure, and sponsorship, even if direct financial exposure to these fundamentals remains largely inaccessible to ordinary investors and therefore remains almost entirely unexploited.

The existing gap is not due to a lack of demand. Blockchain-based platforms have recently attempted to address it by introducing tokenized representations of athletes, primarily in the form of digital collectibles and non-fungible tokens (NFTs), with Sorare being the most prominent example.

At the same time, Sorare raises a fundamental economic constraint. Despite its commercial success as a digital collectible platform within a fantasy gaming framework, it cannot evolve into a complete financial market. It lacks the necessary infrastructures for continuous asset valuation, risk pricing, and efficient capital allocation. The platform is treated as a real-world experiment that highlights both the potential and the constraints inherent in current market designs based on athletes' performances. By analyzing what Sorare demonstrates and what it cannot achieve, the paper motivates the need for an alternative market structure.

2. Blockchain as Enabling Infrastructure

This chapter approaches blockchain technology exclusively as a component of market infrastructure. The focus is on identifying the concrete roles it plays in structuring exchange and on disentangling these roles from the mechanisms that govern asset valuation and price formation. This distinction between infrastructural functionality and economic design establishes the analytical basis for assessing athlete-based platforms through the lens of financial market theory.

2.1 Ledger, Settlement, and State Transitions

Distributed Ledger Technology (DLT) provides a technical infrastructure for implementing ownership, transfer, and settlement in decentralized environments, replacing centralized registries and clearing institutions with a shared system of record whose validity is collectively maintained by a network of participants. Asset

ownership and transaction history are therefore validated without reliance on a central authority.
From a system perspective, a blockchain-based ledger can be formally described as a replicated state machine (RSM, meaning a distributed system in which all nodes maintain and update an identical record of ownership by applying the same ordered set of transactions). The global state at time t, denoted St, consists of ownership records, account balances, and protocol defined metadata.

Transactions are inputs to a deterministic state-transition function:

$$St + 1 = f(St, Tt)$$

Where Tt denotes a valid transaction and $f(.)$is fully specified by the protocol rules. Each admissible transaction maps the system from one valid state to another, and the ordered sequence of such transitions is recorded in an append-only ledger.
Within this framework, the economically relevant object is not the token itself, but the transition function f governing how ownership states evolve over time: tokens merely reference state variables, while economic meaning depends on whether and how the state-transition rule f induces a payoff-relevant mapping
$\pi: St \rightarrow R$
linking state evolution to cash flows, rights or risk exposure. It is important to point out that such mapping does not arise endogenously from the ledger itself but must be explicitly encoded at the protocol or contract level.
In the absence of a state contingent payoff rule, state transitions remain economically neutral. The consistency of these state transitions across distributed replicas requires a coordination mechanism.

Fig. 1

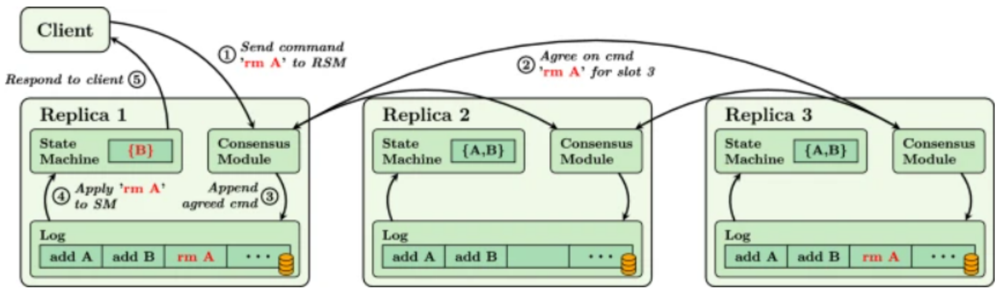

Figure 1: Diagram of Replicated State Machine (RSM) with distributed consensus.

As illustrated in Figure 1, agreement on the validity and ordering of state transitions is ensured through consensus protocols such as Proof-of-work (PoW) or Proof-of-stake (PoS), which allow the network to converge on a single, consistent view of the ledger without reliance on a central authority.

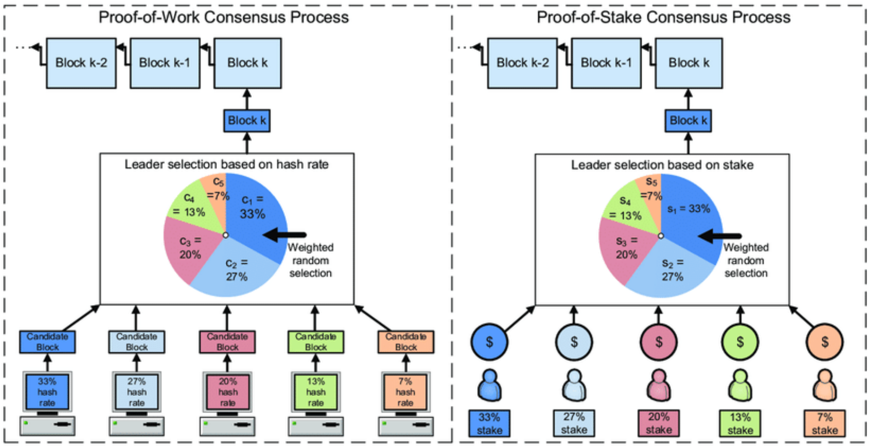

Figure 2: Comparison of Proof-of-Work (PoW) and Proof-of-Stake (PoS) consensus processes. Leader selection is weighted randomly based on hash rate (PoW, left) or stake (PoS, right), leading to block finalization. This ensures agreement on state transitions across replicas without a central authority.

Transaction finality in blockchain-based systems is not enforced by making reversals technically impossible, but by making them unattractive at the system level. Protocol rules allow alternative histories to exist, yet once a transaction has been confirmed by the network, deviating from the accepted history requires incurring substantial costs. In Proof-of-Work systems this takes the form of repeated computational effort, where the cost of electricity discourages dishonest behaviors, while in Proof-of-Stake systems it involves the risk of losing staked capital through slashing (part of their stake is destroyed). In both cases, the protocol embeds economic constraints that discourage deviations from the agreed sequence of state transitions.

Cryptographic mechanisms play a complementary role by ensuring that all state transitions are transparent and verifiable. Hash-linked data structures bind blocks and state updates together in such a way that any modification of past records necessarily alters all subsequent hashes.

As a result, attempts to rewrite history cannot be concealed and are immediately recognizable by network participants. Cryptography therefore does not prevent changes from being attempted but ensures that deviations from the agreed state are observable.

Taken together, these elements explain why immutability in distributed ledgers is not a purely technical guarantee but a property of the system as a whole. The combination of observable state transitions and incentive structures that penalize deviation leads participants to coordinate on a single history. This is what allows distributed ledger systems to function as shared registries and settlement layers, providing reliable records of ownership and transfer without relying on a central authority.

Through this combination of replicated state transitions, consensus, and economic finality, DLT substitutes for traditional registry, clearing, and settlement infrastructures. In this sense, blockchain technology does not introduce a new economic paradigm, rather, it standardizes registry and settlement at the protocol level while remaining neutral with respect to the economic interpretation of the assets recorded on the ledger. Accordingly, assets in blockchain-based systems should be understood not as tokens per se, but as protocol-defined state machines, whose admissible state transitions determine whether economically meaningful claims can exist.

2.2 Necessary but Not Sufficient Conditions for Market Formation

Having established the role of blockchain as market infrastructure, we have to assess whether these infrastructural functions are sufficient to generate a financially meaningful market.

A minimal market structure requires that ownership must be clearly defined, transferable across agents, and tradable in a secondary market. These conditions ensure exchangeability and liquidity, but they do not imply that prices convey information about future payoffs, economic states, or underlying fundamentals. In the absence of an explicit linkage between asset ownership and state-contingent payoffs, market prices tend to reflect demand, scarcity, and speculative expectations rather than performing a genuine financial pricing function.

Within blockchain-based systems ownership is implemented through cryptographic control of private and public keys, while transferability and settlement are enforced through deterministic programs executed by the network; these programs encode predefined transfer rules and eliminate discretionary intervention.

2.3 Enforcement, Settlement Frictions and Price Decomposition

Public blockchains such as Ethereum rely on asymmetric cryptography for transaction authentication. Specifically, Ethereum employs the Elliptic Curve Digital Signature Algorithm (ECDSA) over the secp256k1 curve to verify wallet ownership and authorize asset transfers.

To improve scalability and reduce transaction costs, Layer 2 solutions such as zk-rollups process transactions off-chain, aggregate them, and submit zero-knowledge validity proofs to the main chain. Instead of re-executing each transaction, the base layer verifies the proof of correctness, significantly increasing throughput while preserving security guarantees.

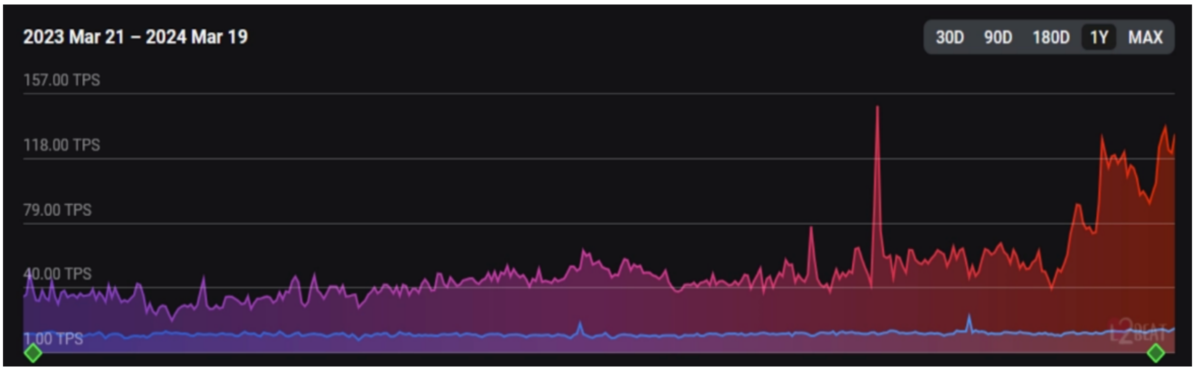

Figure 3: Transactions Per Second (TPS) trend on StarkNet (zk-Rollup) from 2023 to 2024 (observed until June 2024). It demonstrates progress in scalability and cost reduction, while remaining neutral with respect to the economic valuation of assets.

From an economic perspective, these architectural enhancements affect the enforcement dimension of exchange rather than the structure of asset valuation.

Let the price of an asset at time t be expressed as

$$P_t = \phi \sum_{s \in S} \pi_s X_s$$

where:
-Xs denotes the payoff in state s
-πs denotes the probability of state s
-$\phi \in (0,1]$ captures enforcement and settlement frictions.

Distributed ledger systems reduce enforcement risk by pushing ϕ toward unity through predictable and non-discretionary execution of transfers. However, neither the structure of state-contingent payoffs Xs nor agents' beliefs πs are affected by the ledger itself. In the absence of a protocol-enforced payoff mapping $f: St \rightarrow R$, linking ledger states to economically meaningful outcomes, the payoff vector Xs remains external to the ledger state, preventing prices from being anchored to state evolution. As a result, valuation risk remains unchanged, while only the reliability of execution is improved. While an increase in ϕ may affect price levels by reducing enforcement risk, it does not alter the informational structure of payoffs nor the mapping between state realizations and economic outcomes.
When transferable ownership is combined with trading mechanisms, secondary markets emerge and prices form endogenously through buyer–seller interactions. While the infrastructure guarantees settlement integrity and transparency of ownership history, it does not impose constraints on the informational content of prices, therefore price efficiency, stability, and linkage to fundamentals are not

properties of the protocol, but outcomes determined by asset design and market expectations.

2.4 Tokens standards and constraints on state evolution

To understand why some blockchain-based markets (Coinbase, Binance, Kraken...) generate purely speculative trading while others may support more informative price dynamics, it is necessary to examine how token standards constrain the evolution of asset states on-chain.

Token standards play a decisive role in shaping market outcomes by constraining how asset states are represented and updated on chain. From a system perspective, token standards restrict the admissible form of the state-transition function f, limiting how ownership states can evolve in response to transactions.

Non-fungible standards such as ERC-721 encode ownership as a discrete, indivisible state variable associated with a unique token identifier, with scarcity enforced directly at the protocol level. As a consequence, admissible state transitions correspond exclusively to full transfers of ownership, and partial adjustments of positions are not representable within the ledger.

Fungible standards such as ERC-20, by contrast, represent ownership as a continuous balance variable that can be incrementally updated through state transitions of arbitrary granularity. Divisibility and aggregation are native properties of the ledger state, allowing positions to be adjusted incrementally and enabling a denser sequence of observable state updates. Divisibility and continuous balances are necessary but not sufficient for financial valuation, as payoff relevance still depends on the existence of state-contingent transition rules linking balance updates to economically meaningful outcomes. Token standards therefore determine the granularity of state updates, but do not by themselves generate economically meaningful claims unless state transitions are explicitly linked to payoff-relevant variables.

This structural difference has direct implications for price dynamics. Continuous state updates support smoother position adjustments and a more gradual incorporation of information into prices, facilitating a more continuous process of price discovery. Although both standards rely on the same settlement infrastructure, they impose fundamentally different constraints on state evolution. Consequently, identical trading mechanisms built on different token standards can exhibit markedly different market dynamics and valuation behavior.

Taken together, these observations establish the central claim of this chapter: blockchain enables market formation by providing the infrastructure for ownership, transferability, and exchange, while remaining economically neutral with respect to asset definition and pricing mechanisms. Identical infrastructures can therefore support markets with fundamentally different economic properties, determined by asset design rather than by the underlying ledger. Consistent with the framework developed above, a system is treated as a financial market when its assets embody economically interpretable claims, and its prices are expected to convey information about future states or payoffs. On this basis, the following chapter applies this framework to a concrete case, examining how specific asset-design choices shape price formation, market behavior, and the informational content of prices within an otherwise robust blockchain-based infrastructure.

3. SORARE: More than your traditional fantasy game.

As established in Chapter 2, blockchain infrastructure provides ownership registration, transferability, and settlement while remaining economically neutral with respect to asset definition and valuation logic. Identical technological foundations can therefore support markets with fundamentally different economic properties, depending on how assets are designed and how state transitions are linked (or not linked) to economically meaningful outcomes. The case of Sorare provides a concrete implementation of this shared infrastructure, allowing us to observe how specific asset-design choices shape market dynamics within a robust blockchain-based settlement layer.

3.1 Technological and Ownership Infrastructure

Sorare goes beyond the traditional fantasy sports model by introducing on-chain ownership of in-game assets, fundamentally changing the relationship between users and the platform. Unlike conventional fantasy games, where digital items remain locked within the platform and users hold no transferable rights, Sorare tokenizes player cards as NFTs, granting users full ownership. These assets can be used in competitions, held as collectibles, transferred across wallets, traded on secondary markets, or potentially integrated into other applications. As a result, Sorare operates not merely as a game, but as a global marketplace for tradable digital assets, where card values are not centrally determined but instead emerge organically through supply, demand, and user interaction, giving player cards economic characteristics similar to marketable instruments.
To support this model at scale, in October 2025 Sorare migrated its entire card collection from Ethereum (previously managed through StarkEx) to Solana. This transition was driven primarily by performance and cost considerations: Solana enables near-instant transaction finality and extremely low fees, significantly improving usability for frequent in-game actions and secondary-market trading. By contrast, Ethereum’s higher gas fees and slower settlement times posed structural constraints to a mass-market fantasy platform. Following the transition, Sorare cards are technically Solana-based NFTs, allowing users to manage them through Solana wallets and trade them on external Solana marketplaces, reinforcing liquidity and interoperability. At the same time, Sorare maintains compatibility with Ethereum for payments and legacy users through a multichain architecture, leveraging Ethereum and its Layer-2 Base network for auctions, rewards, and value settlement, while bridging assets to Solana for gameplay and trading. This hybrid design preserves ecosystem flexibility while aligning the core

asset layer with a blockchain infrastructure better suited for high-frequency, consumer-scale digital ownership and liquid secondary markets.
Sorare issues player cards in the form of non-fungible tokens (NFTs), which are registered on a public blockchain. This design ensures transparent verifiability and cryptographically enforceable ownership, allowing users to retain full control over their assets independently of the platform. Because NFTs are recorded on a public and immutable ledger, ownership is not merely licensed by the application provider but is instead natively enforced at the blockchain protocol level.

3.2 Asset Design and Price Formation

By recording player cards on a public blockchain, Sorare enables their circulation on liquid secondary markets, both internal and external to the platform. Given the platform's large and active user base, card demand remains consistently high, fostering continuous trading activity. Consequently, users can buy and sell cards with relatively low transaction frictions, allowing them to frequently rebalance and adjust their teams in response to market conditions or strategic considerations.
One of the main challenges faced by Sorare concerns the pricing of player cards, namely the definition of a standardized and credible performance evaluation framework. With NFTs recorded on a public blockchain, prices are not centrally determined but emerge through a decentralized price discovery process driven by continuous interactions between supply and demand. Card valuations are influenced by multiple factors, including perceived scarcity determined by card rarity levels defined by Sorare itself, and expectations regarding players' on-field performance.
Performance is quantified through a standardized scoring system ranging from 0 to 100 in each game played by the card's player, where specific in-game actions contribute predefined bonuses or penalties (goals, assists, missed penalties), starting from a default value of 35 points. This scoring mechanism is designed to resemble index-based evaluation models observed in financial markets, thereby shifting the user experience away from purely gaming-oriented environments toward a more market-driven and financially inspired framework.
By leveraging public blockchain infrastructure, Sorare enables global market access with minimal geographical constraints. Public blockchains provide decentralized and permissionless access, allowing users from different jurisdictions to participate in the same marketplace, trade assets, and compete under a unified and transparent set of rules.
This design contrasts with traditional platforms that operate across multiple jurisdictions under fragmented regulatory and contractual frameworks. Instead, Sorare relies on a shared protocol layer, ensuring consistent access conditions and market rules at the global level.

Key features of Sorare:

- ownership on-chain

- Secondary liquid market
- Price discovery
- Global participation

Country	Traffic Share	Change
France	29.28%	↑ 3.34%
Italy	13.33%	↓ 27.42%
United Kingdom	8.89%	↓ 36.99%
Germany	8.46%	↓ 12.56%
Spain	5.63%	↓ 34.84%

Figure 4: Approximate geographical distribution of Sorare web traffic by country (based on public analytics data, 2025 estimates).

3.3 Scale, Adoption and Market Volume

The relevance of Sorare's model is further supported by the size and continued growth of its user base, as well as by the benefits derived from operating at scale. As of January 2025, Sorare counted approximately 460,000 users holding at least one player card, while the total number of registered users exceeded 3 million globally by the end of 2023. The platform is accessible in more than 180 countries worldwide, underscoring its broad international reach and low barriers to participation. Sorare has exhibited significant growth dynamics, with the number of users holding at least one card increasing by approximately 72% year-over-year in 2024, reaching roughly 460,000 card-owning users.
To contextualize the adoption of asset-based fantasy platforms within a broader economic framework, it is useful to consider the scale of the global sports betting market. In 2022, total global sports betting volume reached approximately €1.41 trillion, with football alone accounting for around €730 billion, confirming its role as the dominant segment worldwide. Europe and South America represent the most significant regional markets, while national-level data further highlights the magnitude of economic engagement: in Italy, football betting generated an estimated €16.13 billion in betting volume in 2024.
These figures indicate the existence of a large and economically relevant audience that is already accustomed to allocating capital based on athletes' performance-related outcomes.
Within this context, Sorare captures only a small share of the overall market, yet its growth trajectory and international user base demonstrate that blockchain-based platforms can successfully channel this demand into asset-oriented digital environments.

A central element enabling this outcome is the presence of a functioning secondary market. Unlike traditional fantasy games, where in-game items remain non-transferable and fully controlled by the platform, Sorare issues player cards as on-chain NFTs, granting users direct ownership and the ability to freely exchange assets after their initial acquisition. This design allows card values to emerge through voluntary exchanges between users rather than being administratively defined by the platform.

Following the migration of its card infrastructure to Solana in October 2025, this market dynamic has been further reinforced. Cards can now be traded not only within Sorare's internal marketplace but also across external Solana-based marketplaces, using standard wallets and open protocols. As a result, liquidity is no longer confined to a single platform, and price signals increasingly reflect broader market expectations. Card valuations adjust continuously in response to real-world sporting information, such as changes in player performance or career prospects, in a manner comparable to information-driven price discovery in financial markets.
Taken together, the scale of existing sports-related capital allocation, combined with Sorare's demonstrated secondary-market liquidity and interoperable asset structure, suggests that both market demand and technological foundations are already well established.

3.4 What is the limit of Sorare?

Despite the presence of active trading and observable prices, Sorare cannot be classified as a financial market, as the value of its assets is not derived from underlying economic fundamentals, but is instead closely tied to the valuation dynamics of NFTs and cryptocurrencies. Player cards do not generate cash flows, nor do they provide contingent payoffs linked to contractual claims. Their value is therefore not anchored to expected income streams, but rather to expectations about platform growth, user participation, and broader sentiment in crypto markets. This dependence introduces an additional layer of volatility, as card prices are indirectly exposed to fluctuations in the value of the underlying blockchain ecosystem, even when the sporting performance of players remains unchanged.
Moreover, Sorare's market structure implies that not all participants can achieve positive outcomes simultaneously. The platform follows a persistent supply expansion model: each season introduces a new issuance of cards while previously issued cards remain in circulation. As a result, total supply increases structurally over time, whereas rewards and prize pools do not expand at the same rate. This creates a deteriorating ratio between available cards and attainable rewards, implying that competitive returns become increasingly concentrated among a smaller subset of users. In such a setting, aggregate gains are mathematically constrained, and losses are an inherent feature of the system rather than an anomaly.

Historical price appreciation observed until early 2021 can largely be attributed to a phase in which demand growth significantly outpaced supply expansion, supported by lockdown conditions and a broader boom in crypto-related assets. As user inflows slowed and card issuance continued to rise, this imbalance reversed providing an increase in supply while demand stagnated or also declined, leading to an unavoidable downward pressure on prices

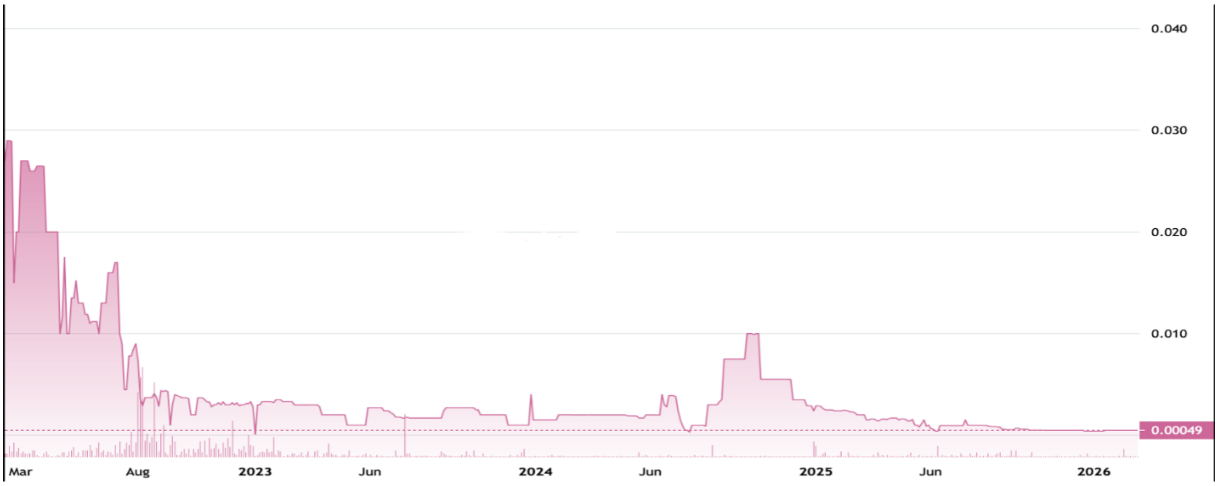

Figure 5: Historical trend of Sorare card floor price (in ETH). Peak before 2021 followed by structural decline (due to supply expansion + crypto market sentiment), reaching a low of approximately ~0.00049 ETH in 2026.

From a revenue perspective, Sorare remains highly dependent on continuous capital inflows. Rewards distributed to users either exit the ecosystem through withdrawals or are recycled internally via new card purchases and secondary-market trades. This creates a self-referential cycle in which long-term growth depends primarily on new deposits rather than on internally generated economic value. Consequently, any platform decision that affects card valuations carries systemic implications, as declining prices may undermine user incentives to reinvest. In this context, Sorare's core proposition of asset ownership represents both its greatest strength and its principal structural challenge. Without the introduction of alternative revenue mechanisms or value-generating features beyond card issuance, the sustainability of the current model remains sensitive to shifts in user sentiment, crypto-market conditions, and demand growth.

Despite the structural limitations discussed above, Sorare remains a highly relevant case study because it provides a concrete proof of market for blockchain-based digital assets with functional utility. The platform demonstrates that users are willing to allocate significant real-world capital to digital items when these assets combine utility within a competitive environment, enforced scarcity, and official licensing, rather than relying solely on aesthetic or speculative appeal. In addition, Sorare validates the economic importance of licensed digital assets, showing that partnerships with major sports leagues significantly enhance trust, legitimacy, and user engagement in digital markets. Perhaps most importantly, the platform provides empirical evidence of demand for true digital ownership, as users can hold, trade, or transfer assets independently of the platform itself.

At the same time, Sorare's model highlights the inherent trade-offs of asset-based ecosystems, where ownership and liquidity coexist with depreciation and supply expansion. For these reasons, Sorare is not interpreted as a mature financial market, but rather as a foundational experiment that reveals both the strengths and the constraints of utility-driven digital asset economies, making it a natural starting point for the analysis of more advanced performance-linked and ownership-based market structures.

4. Designing an Athlete's Stock Market

The preceding analysis has shown that blockchain technology can successfully support decentralized ownership, transferability, and market exchange for athlete-related digital assets, but that infrastructure alone is insufficient to generate a financially meaningful market. Building on the limitations identified in existing platforms, this chapter introduces a framework for constructing an athlete-based market that would make it possible for individuals to invest directly on athletes' performances through continuous valuation, informational sensitivity, and decentralized price discovery, working as a real financial system. Addressing the shortcomings of current platforms, this chapter proposes a framework for an athlete-centric market.

4.1 From Collectible Tokens to Performance Exposure

In NFT-based systems such as Sorare, tokenization is used to create scarce and transferable digital items whose value is shaped by fixed scarcity constraints, platform-specific utility, and user expectations. While these assets support ownership exchange (where digital ownership refers solely to the NFT itself, without conferring any economic rights over the underlying athlete, and enables the transfer of that digital item between blockchain-registered users in a publicly verifiable manner), and decentralized price discovery, their on-chain state remains largely invariant with respect to new performance-related information. Performance influences prices indirectly through belief updating and market sentiment rather than through protocol-embedded, state-contingent payoff rules or automatic settlement mechanisms. Therefore, price dynamics reflect demand conditions and expectations without constituting a continuous valuation process anchored to observable fundamentals.

Designing an athlete stock market requires a fundamentally different conception of the underlying asset; rather than a discrete digital object, the asset must be defined as an economic position whose state and valuation evolve endogenously as performance-related information is incorporated into market prices. In this framework, value formation is driven by the aggregation of performance metrics through market interaction, allowing prices to adjust continuously and proportionately as expectations and perceived risk change.

Before formalizing the performance-index structure, it is useful to distinguish between alternative asset typologies that may appear similar at the technological level but differ fundamentally in their economic substance.

1**. Collectible-based assets** represent discrete non-fungible tokens whose value is primarily driven by predefined scarcity, transferability, and secondary-market demand. Although such assets may reference an athlete's identity, their valuation is not formally contingent on the realization of future performance states. No explicit payoff function or state-contingent settlement rule is embedded at the protocol level. As a result, price dynamics reflect resale expectations and speculative demand rather than exposure to a measurable performance process.

2. **Fractional ownership** structures divide a reference asset into tradable units, increasing accessibility and liquidity. However, fractionalization alone does not define the economic nature of the claim. In the absence of enforceable performance-linked payout rules, token holders possess divisible representations without clearly specified rights to performance-based cash flows. Price formation remains driven by trading expectations rather than by a formally defined payoff structure.

3. By contrast, **performance-index synthetic assets** define the underlying as exposure to a stochastic performance process. In this structure, economic value is explicitly linked to the realization of future performance states through a predefined and verifiable payoff rule. The token therefore functions as a synthetic financial instrument whose valuation depends on expectations regarding performance outcomes and associated risk. Only this configuration embeds a state-contingent payoff logic capable of supporting continuous, analytically tractable valuation within a financial framework.

Among these structures, only performance-index synthetic assets embed a state-contingent valuation rule capable of supporting continuous valuation.

4.2 What does it mean to tokenize an athlete?

Tokenizing an athlete refers to the construction of a digital asset whose value is systematically linked to observable athletes' performances through a predefined and verifiable mapping, where the athlete serves as a reference entity, while the token represents an abstract economic position based on performance-related information. In this context, tokenization is best understood as a process that maps real-world, performance-related statistics, such as match performance, playing time, injuries, or transfers, into on-chain or market-relevant variables that can be priced, traded, and continuously re-evaluated by market participants. The object of tokenization is therefore a performance-indexed informational process associated with that athlete.

The tokenization of an athlete relies on three main layers: the definition of the underlying asset, the formalization of performance through transparent statistical metrics, and the tokenization of such performance data into a tradable digital representation:

- **Asset definition (underlying reference):** Specify *what* is being tokenized by clearly identifying the athlete, the sport/competition scope (league, season, match types).
- **Performance formalization (measurement layer):** Convert real-world athletic performance into a transparent and verifiable statistical framework by selecting relevant metrics (goals, assists, minutes, xG, defensive actions).
- **Tokenized economic representation (market layer):** Issue a tradable digital token whose valuation is primarily anchored to the athlete's quantified performance, while secondary market dynamics provide liquidity and short-term price discovery. This layer enables programmable ownership, on-chain transferability, and market-based price discovery.

Building on this framework, the central question becomes how quantified athletic performance can be translated into a consistent and theoretically grounded pricing mechanism. The following analysis introduces a formal valuation framework designed to link performance metrics, information updates, and market dynamics into a coherent model of price formation for athlete-linked tokens.

4.3 Why Performance-Index Tokens Are the Appropriate Design Choice

After having defined the three main types of possible assets, it follows that performance index tokens are the appropriate design choice for an athlete stock market, and the only possible structure that makes the economic definition of the underlying (future performance as a stochastic state variable) enforceable through a rule-based and verifiable valuation mechanism.

Performance index tokens encode a formal mapping from observed performance to economic outcomes and can therefore be implemented as a replicated state machine: given the same performance input, all nodes can verify the same valuation update. Here blockchain does not create value; it rather enables credible commitment to the valuation rule and tamper-resistant state updates and record-keeping.

Formal Valuation Mapping

Consistent with the framework developed in Chapter 2, the proposed design assumes protocol-level enforcement of the valuation rule, implying that settlement frictions are minimized ($\phi \approx 1$) and that valuation depends primarily on expectations over future performance outcomes rather than on enforcement risk.

Let xt denote an observable performance index constructed from measurable and verifiable metrics such as goals, assists, minutes played, injuries, expected goals, defensive actions, or other sport-specific indicators.

Define a deterministic and publicly specified transformation:

- $g(Xt)$

where $g(\cdot)$maps realized performance into an economically interpretable contribution to the athlete's long-term value trajectory. Importantly, $g(Xt)$ does not represent a contractual cash distribution to token holders, but rather it represents a performance-based economic contribution that enters the athlete's fundamental value trajectory. While no mechanical cash settlement occurs, these contributions determine the expected evolution of the asset's economic value.

The token's price at time t is determined by forward-looking expectations over the athlete's future performance trajectory:

$$P_t = E_t \left[\sum_{k=1}^{\infty} m_{t,t+k} \, g(X_{t+k}) \right]$$

Where:

- $Et[\cdot]$ denotes conditional expectations on information available at time t. This implies that market participants continuously update their beliefs as new performance data becomes observable.
- $Xt + k$ represents the performance index at future time $t + k$
- $g(.)$ aggregates measurable and verifiable metrics into a state variable describing the athlete's performance realization.
- $G(Xt + k)$ should not be interpreted as a direct cash payout, but as a fundamental value contribution derived from observable performance realizations
- $mt, t + k$ represents the stochastic discount factor capturing time value of money, systematic risk, idiosyncratic performance uncertainty, and liquidity premia. It reflects the fact that future performance contributions are uncertain and must be discounted to present value.
- The infinite summation highlights that the token reflects exposure to the entire expected future performance path of the athlete, not just one single event.

The token does not grant ownership rights over the athlete, nor does it represent a contractual claim on salary, transfer of fees, or external revenues. Its value is determined within the market as exposure to the expected performance trajectory. If the underlying performance process terminates permanently, the expected stream of future contributions collapses, and the asset's valuation converges toward zero in present value terms, as no further economically relevant performance realizations can occur.

Under a simplified approximation, the pricing relation can be expressed as:

$$P_t \approx \frac{E_t[g(X_{t+1})]}{r + \lambda_t}$$

where:

- r reflects the time value of money, meaning that future performance contributions must be discounted relative to the present.
- λt captures performance risk and market illiquidity premia.

This reduced form illustrates that valuation increases with expected performance and decreases with risk and illiquidity.

The term $Et[g(Xt + 1)]$ represents the market's expectation, at time t, of the next-period performance-adjusted contribution. As new information becomes available, such as match outcomes, injuries or transfer developments, this expectation is revised and so price movements reflect these revisions, letting the valuation increase when expected performance contributions rise and decrease when perceived risk or uncertainty increases.

In this context, adopting a fungible token standard is economically coherent. Since the asset represents exposure to a single underlying performance process, each unit must reflect the same economic position. Fungibility ensures that all tokens are interchangeable and contribute to the formation of one unified market price.

By avoiding differentiation at the unit level, the structure prevents liquidity from being fragmented across multiple price paths and allows expectations about future performance to be aggregated efficiently.

Unlike non-fungible representations, which assign unique characteristics to each token, a fungible structure preserves the idea of the asset as standardized exposure to a shared and evolving performance trajectory.

Under these conditions, the performance-index token can function as a consistent and scalable foundational unit within an athlete's stock market.

4.4 From asset design to market structure

While the previous section established the internal economic and technological coherence of performance-index tokens, a functional athlete stock market requires a broader market architecture capable of supporting liquidity, price discovery, and continuous information incorporation.

The transition from asset design to market structure involves a shift from the internal logic of the token to the external dynamics of trading and information aggregation. A performance-index token represents homogeneous exposure to a stochastic performance process; this is valuable only within a properly structured market environment, where the exposure can be continuously priced and updated as new information becomes available.

Therefore, a functional athlete's stock market must operate within a structure that supports continuous trading, enabling real-time incorporation of new information into prices. Liquidity must be sufficiently concentrated to avoid fragmentation, ensuring that price signals reflect aggregated market beliefs rather than isolated bilateral exchanges. At the same time, transparency and rule-based interaction are essential, so that valuation emerges from decentralized information aggregation rather than discretionary adjustment by a central authority.

Within such an architecture, performance data alters expectations regarding future performance outcomes; expectations influence demand and supply conditions, and prices adjust accordingly. The resulting price dynamics reflect forward-looking assessments of performance trajectories and associated risk, rather than speculative resale behavior detached from fundamentals.

Importantly, this structure differentiates the proposed system from betting or fantasy-sports mechanisms. Unlike discrete-event wagers with binary resolution, performance-index tokens provide continuous exposure to an evolving stochastic process. The only circumstance under which value would converge toward zero is the structural termination of the underlying performance process itself, for example, if the athlete retires and ceases to generate measurable performance data. In this case, the asset's economic relevance ends because the stochastic process underlying its value formation no longer exists.

CONCLUSION

This paper has explored whether the tokenization of professional athletes' performances can move beyond digital collectibles and evolve into a structurally coherent financial market. Blockchain technology provides the necessary infrastructure for ownership, transferability, and decentralized exchange, but infrastructure alone does not create economic substance. The nature of the asset itself ultimately determines whether meaningful valuation can emerge.

Platforms such as Sorare have demonstrated that global participation, active secondary markets, and digital ownership are viable at scale, however, when value is primarily driven by scarcity and speculative resale dynamics, price formation remains loosely connected to the athlete's measurable performance. In such settings, volatility reflects market sentiment more than underlying fundamentals.

The framework proposed in this paper redefines the asset not as a rare digital object, but as exposure to an evolving performance trajectory. By structuring the token as fungible, fixed-supply exposure to a stochastic performance process, valuation becomes forward-looking and expectation-based. Performance does not trigger mechanical payouts; rather, it continuously reshapes beliefs about the athlete's future path, and prices adjust accordingly.

In this architecture, blockchain serves as a transparent and reliable registry, while economic value emerges through decentralized information aggregation. The token does not grant ownership rights over the athlete, nor does it constitute a contractual claim on revenues. Instead, it represents standardized exposure to measurable performance dynamics.

The distinction between betting or fantasy mechanisms is therefore structural. Value does not depend on the outcome of a single event, but on the anticipated evolution of performance over time. As long as the athlete continues to generate measurable output, the economic relevance of the asset persists.

This paper therefore represents a starting point rather than a definitive solution. It proposes a conceptual architecture through which the performance of professional football players may become accessible as a tradable financial exposure, opening the door to a broader and more diverse pool of investors. In doing so, decentralized infrastructures and tokenized assets could provide a simplified, secure, and transparent mechanism through which capital markets engage with real-world athletic performance.

BIBLIOGRAPHY

- Arrow, K. J. (1964). The role of securities in the optimal allocation of risk-bearing. *Review of Economic Studies*, 31(2), 91–96.
- Becker, D., & Stefanidis, M. (2023). How Sorare demonstrates a sustainable Web3 model. *Naavik Digest*.
- Buterin, V. (2014). *A Next-Generation Smart Contract and Decentralized Application Platform* (Ethereum White Paper).
- Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (1997). *The Econometrics of Financial Markets*. Princeton University Press.
- Catalini, C., & Gans, J. S. (2016). Some simple economics of the blockchain. *MIT Sloan Research Paper*.
- Chiliz. (2026). *Chiliz Manifesto 2026–2030: Building the SportFi Financial Infrastructure*.
- *Statista (2023-2024). Global sports betting market size.*
- *H2 gambling capital (2023).*
- *Football betting share, Sorare blog (2025). Migration to Solala announcement.*
- Cochrane, J. H. (2001). *Asset Pricing*. Princeton University Press.
- Cochrane, J. H. (2005). *Asset Pricing*. Princeton University Press.
- CoinDesk. (2026, February 20). SportFi's next act: From fan tokens to on-chain markets built around match-day results.
- Cong, L. W., Li, Y., & Wang, N. (2021). Tokenomics: Dynamic adoption and valuation. *Review of Financial Studies*, 34(3).
- Debreu, G. (1959). *Theory of Value*. Yale University Press.
- Dobson, S., & Goddard, J. (2011). *The Economics of Football*. Cambridge University Press.
- Duffie, D. (2001). *Dynamic Asset Pricing Theory*. Princeton University Press.
- European Parliament. (2023). *Markets in Crypto-Assets Regulation (MiCA)*. Regulation (EU) 2023/1114.
- Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance*, 25(2), 383–417.
- Financial Stability Board (FSB). (2023). *Crypto-Asset Activities and Markets Regulation Report*.
- Glosten, L. R., & Milgrom, P. R. (1985). Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. *Journal of Financial Economics*, 14(1), 71–100.
- Grossman, S., & Stiglitz, J. (1980). On the impossibility of informationally efficient markets. *American Economic Review*, 70(3), 393–408.
- H2 Gambling Capital. (2023). *Global Gambling Market Report: Football Betting Share and Insights*.
- Howell, S., Niessner, M., & Yermack, D. (2020). Initial coin offerings: Financing growth with cryptocurrency token sales. *Review of Financial Studies*, 33(9), 3925–3974.
- Hull, J. C. (2018). *Options, Futures, and Other Derivatives*. Pearson.
- Kuper, S., & Szymanski, S. (2014). *Soccernomics*. Nation Books.
- Kyle, A. S. (1985). Continuous auctions and insider trading. *Econometrica*, 53(6), 1315–1335.

- Merton, R. C. (1973). An intertemporal capital asset pricing model. *Econometrica*, 41(5), 867–887.
- O'Hara, M. (1995). *Market Microstructure Theory*. Blackwell.
- Snowberg, E., Wolfers, J., & Zitzewitz, E. (2013). Prediction markets for economic forecasting. In *Handbook of Economic Forecasting*.
- Sorare Blog. (2025). *Sorare's Migration to Solana: Accelerating Our Work to Bring Sports Onchain*.
- Statista. (2023–2024). *Global Sports Betting Market Size and Forecasts*.
- Szabo, N. (1997). Formalizing and securing relationships on public networks. *First Monday*.
- Szymanski, S. (2003). The economic design of sporting contests. *Journal of Economic Literature*, 41(4), 1137–1187.
- Wolfers, J., & Zitzewitz, E. (2004). Prediction markets. *Journal of Economic Perspectives*, 18(2), 107–126.
- Wu, M. (2025). Real-world assets tokenization in sports industry: Valuation, opportunities, and challenges. *Advances in Economics, Management and Political Sciences*, 27607.