Management Letters / Cuadernos de Gestión 25/1 (2025) 37-54

FESIDE
Fundación Emilio Soldevilla para la Investigación y Desarrollo de la Economía de la Empresa

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Management Letters / Cuadernos de Gestión

journal homepage: https://ojs.ehu.eus/index.php/CG

ISSN: 1131-6837 / e-ISSN: 1988-2157

Football clubs' social awareness as a leading strategy for performance: A fan token-based panel data analysis

La conciencia social de los clubes de fútbol como una estrategia para el desempeño: Un análisis de datos de panel basado en fan tokens

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ARTICLE INFO

Received 07 June 2024,
Accepted 05 January 2025

Available online 21 March 2025

DOI: 10.5295/cdg.242230jp

JEL: M21, G41

ABSTRACT

This paper analyses the extent to which football clubs' emotional value —fan token-based— is related to economic value—share-based. Specifically, this research investigates the relationship between fan tokens and stock prices in European football clubs, aiming to discern fan engagement's impact on financial market dynamics. We posit that fan token values are significantly linked to the valuation of clubs' stocks. To assess this, a panel data analysis employing econometric models is conducted on six prominent football clubs that regularly participate in European competitions. The study period covers comprehensive data on fan token values and stock prices from 2022-2023. The findings reveal a positive and statistically significant correlation between fan token evolution and stock price movement. Individual ordinary least squares (OLS) regressions further confirm this trend. Moreover, a long/short strategy backtest emphasizes the substantial relationship between fan token evolution and stock performance. Hence, we demonstrate that clubs' emotional perceptions —for which sustainability plays a key role— help predict clubs' economic results. In other words, we demonstrate that being socially responsible is a strategy that could lead clubs to obtain a competitive advantage by improving fans' perceptions, which in turn would have a positive impact on clubs' performance. This study sheds light on the potential influence of fan engagement on football clubs' financial market standing, offering insights crucial for stakeholders navigating the intersection of sports and finance.

Keywords: Fan Tokens, Football Clubs, Stock Prices, Socially Responsible Investing, Corporate Social Responsibility, Panel Data Analysis.

RESUMEN

Este artículo tiene como objetivo analizar la relación entre el valor emocional de los clubes de fútbol, medido a través de los fan tokens y su valor económico, medido a través de las acciones. La investigación se centra en cómo los fan tokens influyen en los precios de las acciones de los clubes de fútbol, con el fin de discernir el impacto del compromiso de los aficionados en el mercado financiero. Se propone que los valores de los fan tokens están significativamente vinculados a la valoración de las acciones de los clubes. Para evaluar esto, se realiza un análisis de datos de panel en seis destacados clubes de fútbol que participan en competiciones europeas. El período de estudio abarca los años 2022 y 2023, incluyendo datos sobre el valor de los fan tokens y los precios de las acciones. Los resultados muestran una correlación positiva y estadísticamente significativa entre la evolución de los fan tokens y el movimiento de los precios de las acciones. Esta tendencia se confirma mediante análisis de regresión lineal de mínimos cuadrados ordinarios (OLS). Además, una prueba retrospectiva de estrategia *long-short* subraya una relación sustancial entre la evolución de los fan tokens y el rendimiento de las acciones. Se demuestra que las percepciones emocionales de los clubes, donde la sostenibilidad juega un papel clave, ayudan a predecir los resultados económicos. La responsabilidad social es una estrategia que podría proporcionar a los clubes una ventaja competitiva al mejorar las percepciones de los aficionados, impactando positivamente en su rendimiento económico.

Palabras clave: Fan Tokens, Clubes de Futbol, Acciones, Inversión socialmente responsable, Responsabilidad social corporativa, Panel de datos.

1. INTRODUCTION

Millions of people worldwide are fascinated with football as a sport (Cifuentes-Faura, 2022). Football clubs have been acknowledged as cultural entities with the potential to spur favourable change (Giulianotti, 2021). The passion and loyalty that fans have for their teams (Shtudiner *et al.*, 2022) is proof of how well sports can unite people and improve their lives. However, football is a powerful force for social transformation and not merely for entertainment. The capacity of football clubs to better society is becoming more widely understood (Romero-Jara *et al.*, 2023).

In recent years, there has been a growing interest in the role that football clubs can play in promoting social awareness and change (Morrow, 2023). Social awareness refers to a club's ability to understand and respond to social issues, as well as its ability to engage with its fans and foster a sense of community. It is not only a moral obligation for clubs to address social issues but also a key factor in their success (Anagnostopoulos *et al.*, 2022).

Research has shown that clubs that are more socially aware and actively engaged with their fans are likely to see higher levels of fan loyalty, which can translate into better performance on the field (Tachis & Tzetzis, 2015). Fan loyalty is important for clubs, as it leads to increased ticket sales, merchandise purchases, and sponsorship deals (Hyatt *et al.*, 2013). Therefore, it is in a club's best interest to foster a strong sense of community among its fans.

One way that football clubs are achieving brand loyalty in the digital era (Pandita & Vapiwala, 2023) is through the use of fan tokens. Fan tokens are digital assets that allow fans to participate in club decision-making, access exclusive content, and earn rewards for their loyalty (Tachis & Tzetzis, 2015). They are a new and innovative way for clubs to engage with their fans and strengthen their community. Thus, fan tokens have the potential to improve fan engagement and loyalty, which can lead to better club performance (Hyatt *et al.*, 2013).

The use of fan tokens as a tool for measuring social awareness is a relatively new concept, but it has already shown great promise. In recent years, the sports industry has witnessed a fascinating convergence between traditional fandom and modern finance, epitomized by the emergence of fan tokens in the realm of football clubs. This evolution marks a paradigm shift, entwining supporters' passion for and loyalty to financial market dynamics (Ersan *et al.*, 2022). Fan tokens allow clubs to track fan engagement and provide feedback on various social initiatives, which can help them identify areas for improvement (Inoue *et al.*, 2013). Fan tokens can also provide clubs with a new revenue stream and help them to monetize their brand, as happens in other impactful industries such as the music industry (Centorrino *et al.*, 2022).

In turn, stock price prediction is still a popular —yet complex— topic for researchers (Deng *et al.*, 2024). The variety of variables influencing stock prices today, along with the occurrence of unexpected events, plays a significant role in the volatility of financial markets (Dhingra *et al.*, 2024). Not surprisingly, researchers aim to pinpoint variables that can help predict the future trajectory of stock prices. Against this background, our study aims to contribute to the research that links emotional performance, which is based on more intangible aspects such as emotional perceptions and added emotional value, to future stock prices. Specifically, this study adds value to the existing stock price forecasting-related literature by highlighting fan token usefulness for stock price prediction.

A football club's fan tokens and stock prices are closely linked (Demir *et al.*, 2022). Stock prices are mostly based on financial factors —in this case, they are driven mostly by performance-related cash flows— while fan tokens are more prone to the mood effect (Demir *et al.*, 2022) and capture more emotional performance, i.e., not only on the basis of sporting results; in fact, misalignment between clubs' culture, values, and CSR strategy and clubs' actions have a negative impact on fans' emotional perceptions, which in turn helps explain the decrease in stock prices.

Nevertheless, studies investigating the fan token–stock price relationship are lacking. We aim to bridge this gap by examining the extent to which the evolution of fan tokens helps forecast stock price movements in the football industry, where socioemotional benefits are key (Rodriguez-Pomeda *et al.*, 2017) and ESG is gaining more attention (Tettamanzi *et al.*, 2024). Therefore, this study explores the following research questions: Are fan tokens intricately linked to fluctuations in football clubs' stock prices? Does the evolution of a football club's fan tokens have predictive power over the evolution of its stock price? In short, this study examines the relationship between football clubs' fan tokens and their stock prices in the financial market and provides further insights to help mitigate the difficulty of predicting the evolution of stock prices in an industry in which firms operate with various stakeholders (Daddi *et al.*, 2024) and are victory maximizers rather than profit maximizers (Tettamanzi *et al.*, 2024). This study falls within the field of behavioural finance, which assumes that investor rationality is limited. Furthermore, understanding the emotional ties of investors to the club (measured through fan tokens) will provide better insights into the evolution of stock prices. In short, this study aims to develop a leading indicator that enables investors to better understand and predict the evolution of the stock prices of publicly traded football clubs, even for implementing profitable investment strategies.

The primary hypothesis driving this study suggests that the value and trajectory of a football club's fan token are intricately linked to fluctuations in the club's stock prices. This hypothesis arises from the underlying belief that heightened fan participation, as manifested through fan tokens, might exert a discernible influence on the club's financial market standing.

To examine this relationship, a thorough investigation is warranted. By employing panel data techniques and econometric modelling, this study analyses the correlation between fan token metrics and stock price movements across a select group of European football clubs. The choice of these clubs, guided by their consistent participation in prestigious European competitions and the availability of comprehensive fan token data, offers a valid setting generalizability within the football landscape.

By assessing the explanatory and predictive power of fan tokens on stock price evolution, this research aims to uncover potential indicators and trends within the financial market. Understanding the implications of greater fan involvement for club valuation holds relevance not only for financial analysts but also for club management, investors, and the broader spectrum of stakeholders involved in the intersection of sports and finance.

The findings and insights from this study are anticipated to contribute a valuable perspective to the ongoing discourse surrounding the influence of fan engagement on the financial dynamics of football clubs, paving the way for further exploration and strategic decision-making in both sporting and financial domains.

In short, this study explores the relationships among fan engagement, social awareness, and economic performance in football clubs, emphasizing the role of fan tokens. The study highlights that clubs actively engaging with fans and adopting sustainable practices can enhance their brand reputation and financial performance. Fan tokens serve as a tool to foster fan engagement, offering both explanatory and predictive power over stock prices. The study contributes to the literature on sports management, CSR, and SRI, offering insights for both academia and industry.

The paper is organized as follows. Section 2 provides an overview of the existing literature and develops the research hypotheses. Section 3 describes the method used; specifically, the sample and how the data are collected are described. Section 4 outlines the main results obtained. In Section 5, the main conclusions are discussed. Section 6 explains the theoretical contributions and practical implications of the study. Finally, the main conclusions, limitations, and future lines of research are addressed in Section 7.

2. LITERATURE REVIEW AND HYPOTHESES

Stakeholder theory posits that companies are responsible for all stakeholders, including shareholders, employees, customers, and the community (Freeman & Phillips, 2002). This theory argues that companies should consider the interests of all stakeholders rather than just focus on shareholder value. In other words, according to stakeholder theory, different stakeholders exert pressure on the organization itself so that the needed actions are taken.

The stakeholder landscape in today's professional football is quite heterogeneous (Jaeger, 2021). Thus, stakeholder theory has both conceptual and empirical value and can be used to clarify key issues in sport management (Walters & Tacon, 2010).

The European sports ecosystem has often been approached through stakeholder theory (Jaeger, 2021) since football clubs must meet the expectations of a wide range of stakeholders (Babiak & Kihl, 2018) (see Jaeger, 2021, for a literature review on stakeholder classification criteria). Stakeholder dialogue is a form of CSR action that firms can adopt (Babiak & Kihl, 2018). As stated by Jaeger (2021), professional football teams in Europe are utility maximizers rather than profit maximizers while focusing on success.

The literature on CSR and SRI has extensively discussed the impact of sustainability practices on company performance (Alikaj *et al.*, 2017; Beloskar *et al.*, 2023). CSR refers to a company's commitment to act responsibly towards its stakeholders, including its employees, customers, and environment. SRI, on the other hand, refers to investment strategies that consider companies' social and environmental impact alongside financial performance.

In the context of football clubs, CSR and SRI practices have become increasingly important due to the growing social awareness of fans and stakeholders. Football clubs are not only economic entities but also cultural and social entities, with a significant impact on the communities in which they operate. Since football clubs can be seen as brands themselves, brand image is an important concern (Blumrodt *et al.*, 2013). Therefore, clubs that adopt sustainable practices and engage with their fans and stakeholders have a competitive advantage in terms of building brand reputation and loyalty (Marrucci *et al.*, 2023).

Overall, the literature suggests that football clubs' social awareness and sustainability practices are essential for building brand reputation, loyalty, and economic performance. The adoption of sustainable practices and engagement with fans and stakeholders can have a positive effect on clubs' fan perceptions, which can translate into better economic results. The use of fan tokens can also be a valuable tool for clubs to measure fan perceptions and engagement while monetizing their brand. Studies suggest that fan tokens represent a new competitive landscape for the football industry, which can enhance brand loyalty and create new revenue streams for clubs (Солнцев *et al.*, 2022; Hasan Gözkonan *et al.*, 2022).

2.1. Corporate social responsibility and football clubs

The development of responsible management practices has gained increasing interest (Preget, 2023). Specifically, CSR is becoming increasingly important in the corporate and sporting worlds since it is motivated by profit or philanthropic reasons (Kulczycki & Koenigstorfer, 2016). CSR, in its broadest meaning, has arisen as an umbrella word for a concept in which corporations voluntarily integrate social and environmental issues into their business operations and interactions with their stakeholders (Zeimers *et al.*, 2019). The growing importance of the relatively new CSR phenomenon in the sports industry around the world (Hallmann *et al.*, 2024) has led to insights into the motivations (Babiak & Kihl, 2018; Manoli & Hodgkinson, 2021), practices (Walker & Parent, 2010), communications (Kolyperas & Sparks, 2011), club ownership and governance systems related to financial outcomes and performance (Hamil & Walters, 2010; Inoue *et al.*, 2013), program evaluations (Kihl *et al.*, 2014), and stakeholders' attitudes and behaviours (Tapp, 2004; Walker & Kent, 2009). We focus on the football sector, which has significant societal relevance through its CSR-related initiatives (Houben *et al.*, 2021).

In Europe, sports account for more than 2% of the gross domestic product (Houben *et al.*, 2021). Sports organizations need to operate in an increasingly competitive environment (Anagnostopoulos *et al.*, 2017). Football has long been viewed as the most popular entertainment activity in Europe (Blumrodt *et al.*, 2013). Furthermore, it is considered to be the world's leading, most commercialized and mediated sport (Houben *et al.*, 2021). Football clubs exhibit advanced management practices (Manoli & Hodgkinson, 2021) and are characterized by an over-investment environment (Rohde & Breuer, 2017). Several of the world's most successful football clubs are now controlled by global corporations, and diversified international investors are pouring in (Plumley *et al.*, 2017; Rohde & Breuer, 2017; Wilson *et al.*, 2013).

The football industry has evolved significantly over recent years and has long prioritized profitability (Beek *et al.*, 2018) on the basis of professionalization, commercialization, and internationalization (Rohde & Breuer, 2017), which is not incompatible with focusing on sustainability-related aspects; in fact, sports teams aim to be perceived as socially responsible to meet stakeholders' expectations (Babiak & Kihl, 2018).

Analysing CSR in professional football clubs is a relatively new topic (Jenkins & James, 2012; Ribeiro *et al.*, 2019). Football clubs traditionally engage with different stakeholders (Walters & Chadwick, 2009). To be successful, football clubs must fulfil the expectations of a wide range of stakeholders, including fans. Football fans, according to Senaux (2008), are definite stakeholders and they meet all three stakeholder categorization criteria (legitimacy, power, and urgency) provided by Mitchell *et al.* (1997). Recently, it has been emphasized that football fans' powerful role as stakeholders warrants further scientific investigation (Jaeger, 2021), and experimental models should be used to assess clubs' overall success (Plumley *et al.*, 2017). In truth, most football clubs may be guided by a set of financial and sports goals. Nonetheless, there has been a significant increase in awareness and initiatives by football clubs to include sustainability in their work and actions (Breitbarth *et al.*, 2015; Hugaerts *et al.*, 2021).

The importance of CSR and its reporting is growing but is still low in the football industry (Raimo *et al.*, 2021), for which football clubs' websites are efficient (Ribeiro *et al.*, 2019), even when not much sustainability-related information is disclosed on clubs' websites (Raimo *et al.*, 2021).

2.2. Socially responsible investment and football clubs

SRI is a type of investment that focuses on companies that demonstrate strong social and environmental practices, as well as good corporate governance, commonly known as ESG factors (Palma-Ruiz *et al.*, 2020). Currently, football clubs are increasingly under pressure to satisfy their fans' participation and demands (Manoli, 2015). Fan participation in clubs has a considerable effect on fan engagement and satisfaction, audience levels, and all types of merchandise consumption, which favour or detriment the club's long-term financial performance (Cleland, 2010; Hyatt *et al.*, 2013). Even when extensive research has been conducted on the market response to various favourable announcements, such as sponsorships, conflicts and tensions develop when fans are dissatisfied with the way teams are managed (Numerato & Giulianotti, 2018). As a result, fans play an important role in football club decision-making processes since they are important stakeholders to consider (García & Welford, 2015; Uhrich, 2021).

Vale and Fernandes (2018) explored sports fan engagement with their favourite teams, particularly focusing on social media interactions. Drawing on the Uses and Gratifications approach and the Consumers' Online Brand-Related Activities framework, they identified seven motivations (information, entertainment, personal identity, integration and social interaction, empowerment, remuneration, and brand love) and three dimensions of online engagement behaviours (consumption, contribution, and creation). A web-based survey of football club fans in a major UEFA league on Facebook, with 562 responses, revealed that the need for information, empowerment, and brand love drive consumption, contribution, and creation, respectively. Integration and social interaction emerged as the second most important motivation overall. This study contributes to understanding social media use in the sports marketing literature, providing insights for managers to effectively engage their fan base online. In a recent study, Fathy, Elsharnouby and AbouAish (2022) investigated fan engagement behaviours in sports marketing, employing mixed methods. Qualitative and quantitative findings identify team jealousy, competitiveness, and morality as new predictors of fan engagement. Fan role readiness and team identification significantly influence management cooperation and prosocial behaviour. Notably, team morality positively impacts performance tolerance. Despite existing research, further exploration is needed to understand fan engagement. This study contributes by shedding light on fans' unique behavioural responses, offering insights that are valuable for enhancing organizational performance in the sports industry. The main conclusions drawn from these studies highlight key factors influencing fan engagement in sports marketing.

Open innovation is felt in many other aspects of fan engagement. For example, influencer marketing has emerged as a potent strategy for open innovation. Ingrassia *et al.* (2022) assessed the impact of evocative elements as a novel model for leveraging influencer marketing in advertising and revitalizing the tourism and catering sectors. Cooke *et al.* (2022) contributed to open innovation and fan engagement by exploring digital reality replication for cultural consumption and green-digital open-system innovation in the context of post-COVID-19 sustainability. This study addresses issues such as unsustainable tourism practices, urban rebranding, fast fashion, and overtourism; analyses the role of digital media in conserving natural and cultural environments; and proposes strategies for sustainable intervention in over-touristed city centres.

2.3. Fan tokens and football clubs

A token is a digital representation of asset ownership that can be traded. Tokens can be fungible (such as Bitcoin, where any bitcoin can be exchanged for another; see Rao *et al.*, 2022) or nonfungible (such as Ethereum) with property rights over such assets (Kugler, 2021). The act of transforming a real or virtual asset into a digital representation (a token such as an image, video, artwork, ticket, sports card, etc.) that can be purchased and sold is a popular pursuit among individuals (Behl *et al.*, 2023) and is known as tokenization (Aki, 2021; Kugler, 2021).

Fan tokens have emerged as a new way for football clubs to engage with fans —they provide ways of participating in decision-making, minor remuneration can be accessed and financial benefits can be achieved through trading (Chen, 2024)— and measure their social awareness. Fan tokens are digital assets that provide fans with voting rights and exclusive access to club merchandise, events, and experiences. Fans are not only mere spectators but also active decision-makers (Ante *et al.*, 2024). The value of fan tokens is based on fans' emotional perceptions of the club, which are influenced by the club's sustainability practices and social responsibility (Baker *et al.*, 2022).

Fan tokens are fungible tokens that allow supporters to participate in club decision-making and offer feedback (e.g., uniform design or selection, player honours), which in turn increases engagement (Ante *et al.*, 2024). Chiliz, a blockchain startup, has teamed with high-profile teams such as FC Barcelona, A.C. Milan, Paris Saint-Germain FC, and Juventus FC to introduce fan tokens, which have generated millions of dollars in income (Evans, 2021). The value of fan tokens is a result of fans' perceptions of clubs' behaviour and performance (Anagnostopoulos *et al.*, 2022).

The importance of investors gathering, evaluating, and weighting information on ESG aspects is explicitly represented by fan tokens. This statement is supported by previous studies on the importance of ESG factors in investment decisions. For example, Capelle-Blancard and Petit (2019) examined the performance of ESG funds and reported that they can provide competitive returns, indicating the importance of considering ESG aspects in investment decisions. Similarly, Gödker and Mertins (2018) reported that ESG ratings can have a positive influence on the financial performance of firms. In the case of football clubs and fan tokens, the inclusion of ESG factors in the valuation of fan tokens highlights the importance of social responsibility and sustainability for both investors and fans. ESG factors, fan tokens, and football club stocks are interconnected, as fan engagement through tokens can influence club performance, impacting investor perceptions and stock value on the basis of sustainability.

As previously discussed, on the one hand, shares reflect the economic performance of a football club as a company. Therefore, the share price will appreciate when higher turnover and better profits are expected. However, fan tokens are based on fans' emotional perceptions of the club. Within this emotional assessment, the results of the club's main team are surely decisive, but it is also observed that when large signings or relevant news for the club occur, the price of the fan token is affected. We could say that in the emotional assessment of the club, measured by the price of fan tokens, fans consider, in addition to the sporting results, whether the club acts in a way aligned with its values or not, which implies that it would be acting in a socially responsible way or not.

According to the previous theoretical framework, the main hypothesis of this research is that the value of fan tokens, as a measure of community engagement and commitment among football club supporters, is significantly related to the evolution of clubs' stock prices in the financial market. It is proposed that greater fan participation and involvement, represented by fan tokens, positively influences the valuation of clubs' stocks in the market.

Hence, on the basis of the above discussion, we hypothesize the following:

H1: The evolution of a football club's fan tokens has explanatory power over the evolution of its stock prices.

Stakeholder theory emphasizes that companies must consider the interests of all stakeholders, including shareholders, employees, and customers (Freeman & Phillips, 2002). In the case of football clubs, fans play a pivotal role as stakeholders whose emotional engagement can directly impact the club's financial performance (Jaeger, 2021). Fan tokens, which allow fans to participate in decision-making and express their loyalty, represent a tangible connection between fan engagement and the club's value (Ante *et al.*, 2024). As fan engagement increases through fan tokens, it positively influences stock prices, demonstrating the relevance of stakeholder involvement in driving financial outcomes.

This hypothesis directly addresses the research question by asserting that the evolution of fan tokens influences the valuation of football club stocks in the financial market. By testing this hypothesis, the study aims to determine whether fan engagement, as measured by fan tokens, impacts the economic performance of football clubs.

By incorporating a lagged variable as an explanatory variable, we assess the ability of fan tokens to predict the evolution of stock prices. Therefore, we propose the following hypothesis:

H2: The evolution of a football club's fan tokens has predictive power over the evolution of its stock prices.

H2 posits that the evolution of a football club's fan tokens has predictive power over its stock prices. Stakeholder theory emphasizes that a company must cater to all its stakeholders, including fans, who significantly influence the club's brand and financial performance (Freeman & Phillips, 2002). In football, fan engagement is crucial, and fan tokens provide an innovative way to measure it. As these tokens reflect fans' emotional and social perceptions, they serve as indicators of clubs' sustainability practices and social responsibility (Ante *et al.*, 2024). Therefore, the value of fan tokens, driven by fan sentiment, can predict stock price movements by reflecting broader investor perceptions of the club's performance and reputation.

3. METHOD

3.1. Methodology

Panel data analysis is a statistical method widely employed in the social sciences. Working with panel data and variables in growth rates rather than raw data can provide several advantages, such as stationarity (change rates can often render data more stationary than raw data), normalization (which makes comparisons more meaningful by removing the scale effect), better trend and pulse detection, easier interpretation of data, and reduced autocorrelation, among others.

Hence, panel data analysis offers a valid framework for examining the relationship between fan tokens and stock prices over time and among different clubs. This methodological approach provides new insights into the evolving dynamics of fan engagement and its impact on football club economics. The panel data analysis involves statistical techniques examining the potential influence of fan tokens on the evolution of clubs' stock prices. Econometric models, such as fixed or random effects regressions, are used to control for unobserved individual and time-specific factors that may affect both fan tokens and stock prices.

The model used is as follows:

$$Y_{it} = a + b\,X_{it} + u_{it} \qquad \textit{(Model 1)}$$

where:

— Y_{it} is the weekly return of the shares of the "i" team in period "t".
— X_{it} is the weekly return of the fan token of the "i" team in period "t".

We will validate H1 if the b parameter is significantly different from 0.

The second hypothesis of this study extends the investigation by examining whether changes in fan token values precede changes in stock prices, thus serving as a predictive indicator. By testing this hypothesis, the study seeks to assess the predictive power of fan tokens in forecasting future movements in football club stock prices.

The model used is as follows:

$$Y_{it} = a + b\, X_{it-1} + u_{it} \qquad \textit{(Model 2)}$$

where:

— Y_{it} is the weekly return of the shares of the "i" team in period "t".
— X_{it-1} is the weekly return of the fan token of the "i" team in the period "t-1".

We will validate H2 if the b parameter is significantly different from 0.

The objective is to rigorously and systematically examine whether the value of fan tokens can serve as a leading or explanatory indicator of the evolution of football club stock prices in the financial market. However, if the previous hypotheses are validated, a deeper analysis will be conducted. An individual ordinary least squares (OLS) study of both models will be carried out to identify in which clubs the relationship is stronger. Additionally, a long/short strategy simulation will be performed where the positions in the football club's stocks will be taken on the basis of the previous week's fan token evolution.

3.2. Sample and data collection

To assess the hypotheses, a panel data approach is employed, incorporating historical data on fan token values and the stock prices of various European football clubs. Data are collected over a specific period, enabling the analysis of relationships over time and among different clubs.

Data selection focuses on six football clubs for the following reasons. First, they are clubs that hold significance by regularly participating in European competitions. Second, these clubs have had their fan tokens listed and traded for at least the past two years, providing a substantial historical dataset for analysis. Third, these clubs' fan tokens are listed on prominent exchanges such as Binance, ensuring accessibility and reliability in market data. Consequently, the football clubs that meet these criteria are FC Porto (Portugal), S.S. Lazio (Italy), Juventus FC (Italy), Galatasaray S.K. (Turkey), Trabzonspor (Turkey), and Fenerbahçe S.K. (Turkey).

Juventus FC is a very geographically diversified club that has expanded to new markets outside the home country in Italy (Fühner *et al.*, 2021). Additionally, Juventus is one of the first football clubs in the world to integrate sustainability into its business, embracing sustainability practices and social responsibility (Juventus, 2023).

FC Porto (Portugal) currently announced its adherence to and participation as a pilot partner in the ACCESS project to acquire skills to become the beacon of environmental sustainability in Portugal.

As stated by Binance, S.S. Lazio is raising funds for Binance Charity's Fight Hunger Worldwide project, which seeks to assist the UN's Sustainable Development Goal (SDG) of eradicating hunger by 2030.

If we focus on Turkish teams, for example, we could state that Galatasaray S.K. has recently made it into the Guinness World Records by having the "most powerful solar-powered stadium". Trabzonspor and Fenerbahçe S.K. are also very important teams in Turkey, where they have an impact on society.

There is a two-year historical record of weekly quotations covering the entirety of 2022 and 2023. The selection of a two-year sample period is attributed to the nascent nature of the fan tokens under examination and their recent introduction into the market. As a relatively new phenomenon in the realm of football club economics, fan tokens have only gained traction and garnered attention from investors, clubs, and fans alike over the past few years. Consequently, the availability of comprehensive historical data on fan token values and associated financial metrics is confined to a relatively short timeframe.

Given the limited duration since their inception, the dataset for this study encompasses the entirety of available data, spanning from 2022 to 2023. This period represents the only window during which the selected football clubs' fan tokens have been fully listed and actively traded on prominent exchanges. As such, this timeframe offers a unique opportunity to analyse the relationship between fan token dynamics and football club stock prices within the context of their emerging presence in the market.

While the truncated sample period may impose constraints on the depth of analysis and generalizability of findings, it is nevertheless reflective of the current landscape of fan token adoption and integration within the football industry. Despite its limitations, this study endeavours to provide valuable insights into the evolving dynamics of fan engagement and its implications for football club economics during this pivotal juncture of technological innovation and market evolution.

The research is based on a dataset with weekly observations over two years and six entities (in this case, football clubs). The number of observations can be calculated by multiplying the number of weeks in two years (approximately 104) by the number of entities. This gives us a total of approximately 624 observations in the dataset. The data are transformed into weekly return observations.

4. RESULTS

We opted to use Gretl for the regressions because it is an open-source software, making it both accessible and cost-effective. Additionally, Gretl is widely regarded as reliable and robust for statistical analysis, providing a wide range of features for econometric modelling; its transparency, being open source, allows for easy verification of results and methodologies, which is crucial for maintaining the integrity and replicability of our analyses. Furthermore, its user-friendly interface and comprehensive documentation make it a suitable choice for conducting the required regressions in a clear and efficient manner.

The estimation of the panel data model described above uses the following fixed effects algorithm (Model 1) (Table 1):

Table 1
Model 1 results

Model 1: Fixed effects			Value	
Number of observations			624,000	
Cross-sectional units included			6,000	
Time series length			104,000	
Variable	**Coefficient**	**Standard deviation**	**t statistic**	**p value**
Const	0,5730910	0,2820670	2,032	0,0426 **
Fantoken	0,0695554	0,0225184	3,089	0,0021 ***
Dependent variable mean			0,550	
Dependent variable standard deviation			7,100	
Sum of squared residuals			30617,640	
Regression standard deviation			7,040	
MCVF R-squared			0,030	
Intra R-squared			0,020	
F(6, 617) MCVF			2,770	
F value p			0,010	
Log-likelihood			–2100,090	
Akaike criterion			4214,180	
Schwarz criterion			4245,230	
Hannan-Quinn criterion			4226,250	
Rho			–0,090	
Durbin-Watson			2,150	
Test			**Test statistic**	**p value**
Joint test of regressors (excluding constant)			F(1, 617) = 9,54084	0,00209982
Test of different intercepts by groups			F(5, 617) = 1,43369	0,21012

Source: Authors' own research.

Using the aleatory effects algorithm, the model is as follows (Model 2) (Table 2):

Table 2
Model 2 results

Model 2: Random effects (GLS)			Value	
Number of observations			624	
Cross-sectional units included			6	
Time series length			104	
Variable	**Coefficient**	**Standard deviation**	**z statistic**	**p value**
Const	0,5730230	0,3719250	1,541	0,1234
Fantoken	0,0693063	0,0224906	3,082	0,0021 ***
Dependent variable			**Value**	
Mean			0,5543430	
Standard deviation			7,1041080	
Sum of squared residuals			30973,3600000	
Regression standard deviation			7,0509910	
Log-likelihood			–2103,6940000	
Akaike criterion			4211,3880000	
Schwarz criterion			4220,2610000	
Hannan-Quinn criterion			4214,8360000	
Rho			–0,0889050	
Durbin-Watson			2,1499870	

Variance	Value	
Between variance	0,3537830	
Within variance	49,6234000	
Theta for quasidemeaning	0,2422180	
Corr(y, yhat)^2	0,0148981	
Test	**Test statistic**	**p value**
Joint test of regressors	Chi-square(1) = 9,49608	0,00205911
Breusch–Pagan test	Chi-square(1) = 0,114422	0,73516500
Hausman test	Chi-square(1) = 0,117004	0,73230700

Source: Authors' own research.

Although the Hausman test indicates that we should choose the random effects model, both show a similar b parameter, which is significantly different from 0 within a 99% confidence interval.

The parameter is positive, which indicates that the evolution of fan tokens has explanatory power over the evolution of football clubs' stocks, which supports H1.

If we estimate Model 2 by adding a lag to the explanatory variable, we obtain Models 3 (Table 3) and 4 (Table 4).

Table 3
Model 3 results

Model 3: Fixed effects	Value			
Number of observations	618			
Cross-sectional units	6			
Time series length	103			
Variable	**Coefficient**	**Standard deviation**	**t statistic**	**p value**
Const	0,5184900	0,283119	1,831	0,0675 *
Fantoken_1	0,0648752	0,022502	2,883	0,0041 ***
Dependent variable mean	0,502702			
Dependent variable standard deviation	7,000000			
Sum of squared residuals	30255,62			
Regression standard deviation	7,000000			
R-squared MCVF (LSDV)	0,025091			
R-squared 'intra'	0,013422			
F-statistic (6, 611)	3,000000			
P value (F statistic)	0,016215			
Log-likelihood	–2.079,000			
Akaike criterion	4.172,000			
Schwarz criterion	4.203,000			
Hannan-Quinn criterion	4.184,000			
Rho	–0,071984			
Durbin-Watson	2,000000			
Joint test of regressors (excluding constant)				
Test statistic	F(1, 611) = 8,31218			
P value	0,00407654			
Test of different Intercepts per groups				
Null hypothesis	[Groups have a common intercept]			
Test statistic	F(5, 611) = 1,49125			
P value	0			

Source: Authors' own research.

Table 4
Model 4 results

Model 4: Random effects (GLS)		Value		
Number of observations		618		
Cross-sectional units		6		
Time series length		103		
Variable	**Coefficient**	**Standard deviation**	**z statistic**	**p value**
Const	0,5184600	0,3847120	1,348	0,1778
Fantoken_1	0,0647528	0,0224736	2,881	0,0040 ***
Dependent variable mean		0,502702		
Dependent variable standard deviation		7,092158		
Sum of squared residuals		30624,84		
Regression standard deviation		7,045217		
Log-likelihood		–2082,955		
Akaike criterion		4169,91		
Schwarz criterion		4178,763		
Hannan-Quinn criterion		4173,352		
Rho		–0,071984		
Durbin-Watson		2,105619		
Between variance		0,408482		
Within variance		49,51820		
Theta used for quasidemeaning		0,264718		
Corr(y, yhat)^2		0,0131937		
Tests				
Joint test of regressors (excluding constant)		Chi-square(1) = 8,30177		0,00396065
Breusch–Pagan test		Chi-square(1) = 0,17709		0,67388600
Hausman test		Chi-square(1) = 0,0313362		0,85949200

Source: Authors' own research.

Again, we observe that the estimated parameter is positive and significant at 99%, thus confirming H2.

In the Appendix, we present the OLS regressions conducted to individually validate H1. We observe that H1 is rejected for FC Porto and Juventus FC, accepted at 90% for Galatasaray S.K., and accepted at 95% or higher for the other three analysed teams, namely, S.S. Lazio, Trabzonspor, and Fenerbahçe S.K.

If we add a lag to the regressor, we obtain the models outlined in the annex to validate H2. We observe that this hypothesis is accepted only for the Turkish teams, more precisely, for Galatasaray S.K. at 90% and for Trabzonspor and Fenerbahçe S.K. at least at 95%.

Considering that H2 has been supported, we conduct a back test to assess the potential return of a long/short strategy. This strategy would have opened a long position weekly if the fan token had appreciated in the previous week or a short position if it had depreciated. The normalized graphs comparing the evolution of the stock (orange) and the strategy (blue) are as follows (Figures 1 to 6).

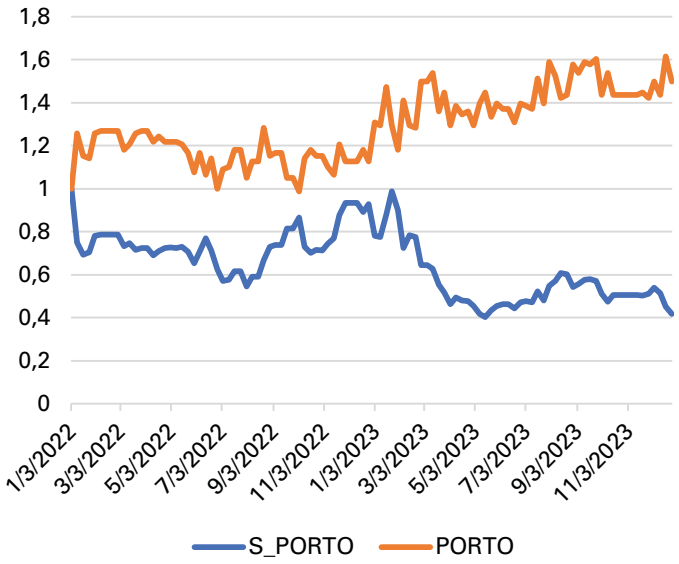

Figure 1
The evolution of the stock and the strategy for FC Porto
Note: In blue (lower line): the strategy. In orange (upper line): the stock.
Source: Authors' own research.

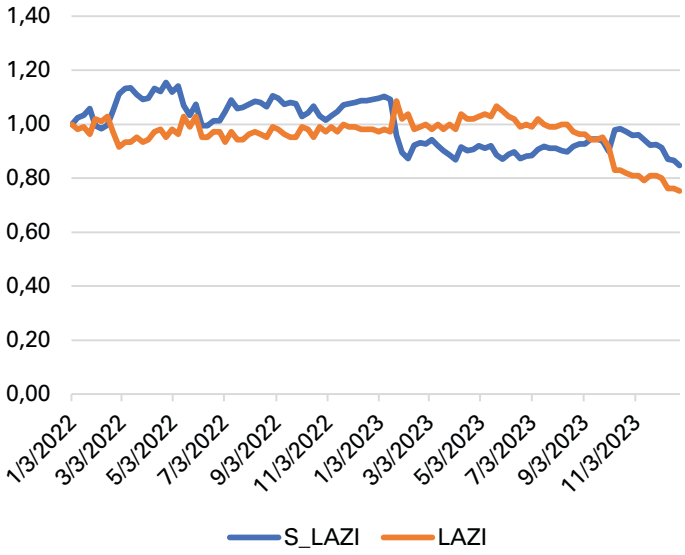

Figure 2

The evolution of the stock and the strategy for S.S. Lazio

Note: In blue (upper line at the beginning): the strategy. In orange (lower line at the beginning): the stock.

Source: Authors' own research.

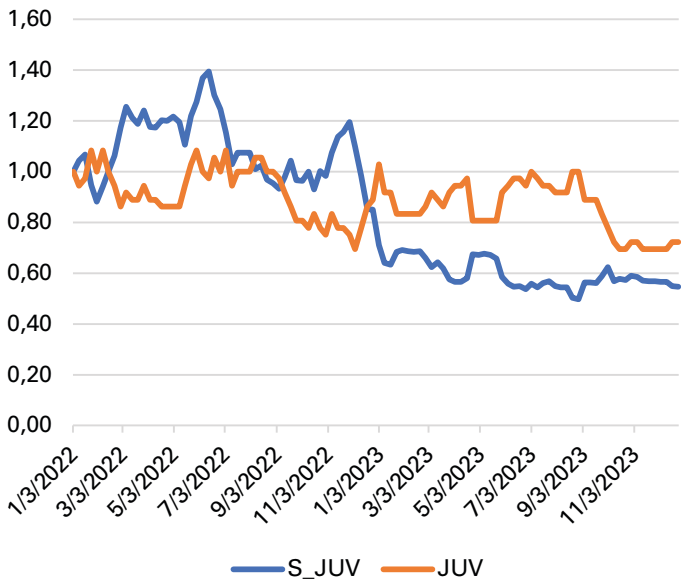

Figure 3

The evolution of the stock and the strategy for Juventus FC

Note: In blue (upper line at the beginning): the strategy. In orange (lower line at the beginning): the stock.

Source: Authors' own research.

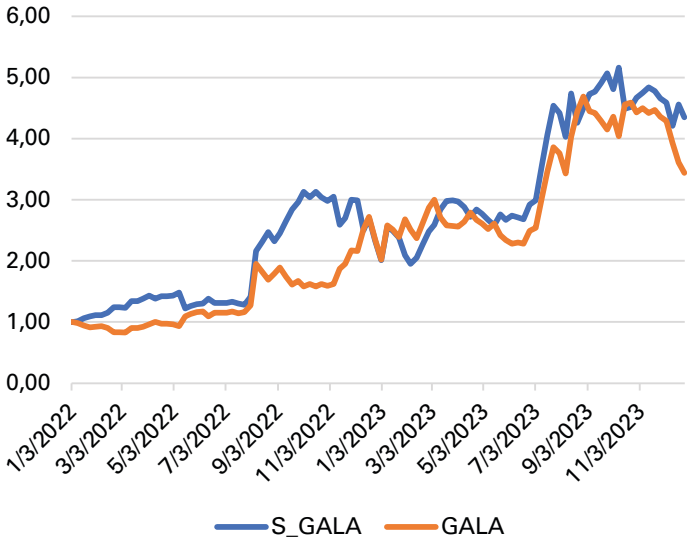

Figure 4

The evolution of the stock and the strategy for Galatasary S.K.

Note: In blue (upper line at the beginning): the strategy. In orange (lower line at the beginning): the stock.

Source: Authors' own research.

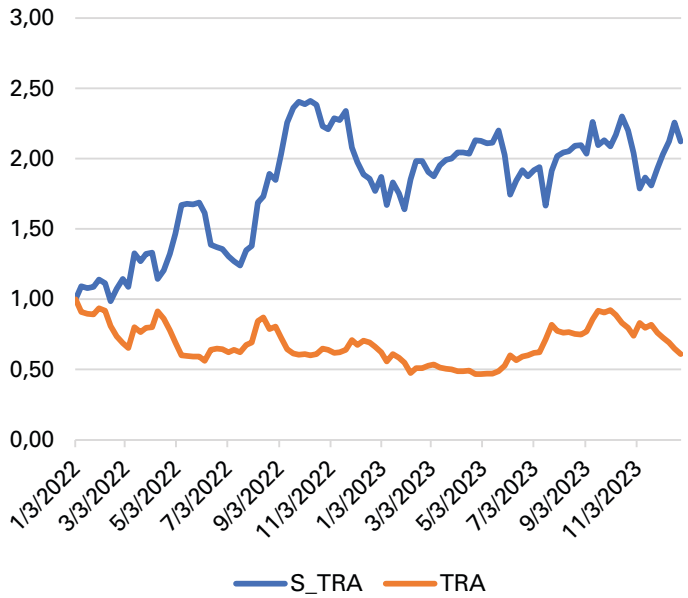

Figure 5

The evolution of the stock and the strategy for Trabzonspor

Note: In blue (upper line): the strategy. In orange (lower line): the stock.

Source: Authors' own research.

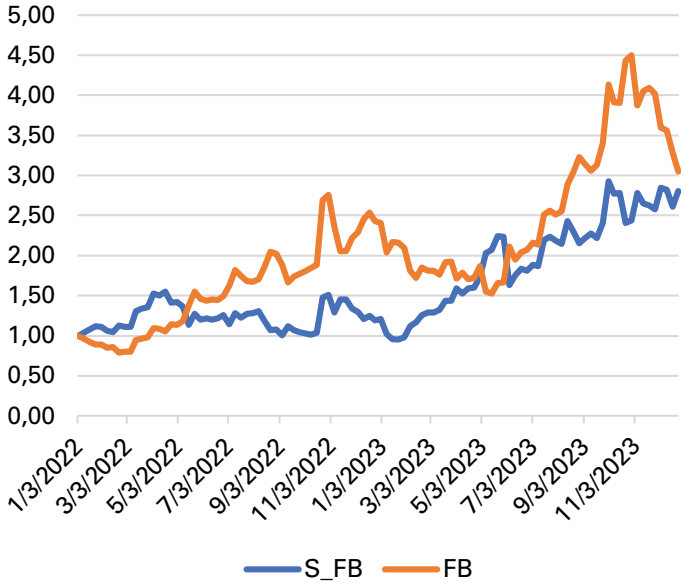

Figure 6
The evolution of the stock and the strategy for Fenerbahçe S.K.
Note: In blue (upper line at the beginning): the strategy. In orange (lower line at the beginning): the stock.
Source: Authors' own research.

The panel data analysis provides robust evidence that fan token evolution has a significant effect on the stock prices of football clubs. The results from the fixed effects (Model 1) and random effects (Model 2) models both confirm the positive relationship between fan token prices and football club stocks, as indicated by the statistically significant positive coefficients for the variable "Fantoken". The Hausman test suggests a preference for the random effects model, yet both models yield similar coefficients, reinforcing the reliability of the findings.

The inclusion of lags in the explanatory variable (Models 3 and 4) strengthens the evidence for this relationship, particularly for Turkish clubs such as Galatasaray S.K. and Trabzonspor, where the link is stronger. The models further validate the hypotheses, with significant coefficients indicating that fan token performance can predict stock price movements.

Additionally, the backtesting of a long/short strategy demonstrates the potential for profitable investment decisions on the basis of fan token price trends. In particular, Galatasaray S.K. showed the strongest correlation between fan token evolution and stock prices, highlighting the importance of fan perception in shaping financial outcomes for clubs.

In short, the results from the panel data models support the hypotheses. The estimated parameters, although indicated for choosing the random effects model per the Hausman test, displayed similarity and significance, confirming that fan token evolution has explanatory and predictive power over football clubs' stock prices. The positive parameter values suggest a meaningful relationship between fan token evolution and stock price. Individual OLS regressions validate H1 and H2 for different clubs, highlighting the varying strengths of this relationship across teams. The study's backtesting of a long/short strategy, which is based on previous fan token performance, underscores the profitability of strategies implemented on Galatasaray S.K.'s stock, emphasizing a strong and significant link between fan token evolution and stock price.

The analyses provide evidence for the potential implementation of a long–short trading strategy for football clubs' stocks on the basis of fan token prices. The significant relationship between fan token prices and share prices indicates that changes in fans' perceptions of football clubs' social awareness influence clubs' financial performance. Therefore, if the price of football clubs' fan token increases, it may be an indication of positive fan perception, and an investor could hold a long position on the club's stock. Conversely, if the price of the fan token drops, it may signal negative fan perception, and an investor could open a short position.

5. DISCUSSION

Sustainability is an effective driver of fan engagement in sports (Daddi *et al.*, 2024). Clubs that embrace ESG management foster a positive brand image among fans, which can lead to increased fan loyalty (Myung, 2024). Specifically, in the football sphere, audiences' growing interest in sustainability and social responsibility issues (Romero-Jara *et al.*, 2024) opens new avenues of research. As a way of engaging stakeholders, environmental issues have become crucial to most football organizations (Daddi *et al.*, 2024). According to stakeholder theory, companies must cater to all their stakeholders, which, in this context, include fans, who significantly impact clubs' performance (Freeman & Phillips, 2002). In other words, in addition to other stakeholders, such as institutional actors (Daddi *et al.*, 2021), the role of football fans in driving responsible practices among football clubs needs to be put forwards.

Football supporters' sustainable participation can take many forms (Bauers *et al.*, 2024). One of the newest tools is fan tokens, through which fans can assess sustainable aspects of their clubs. The use of fan tokens as a tool for measuring social awareness is a relatively new concept but offers a promising avenue for research. While numerous scholars have utilized stakeholder theory in their research on sport management (Daddi *et al.*, 2024), a cohesive framework that integrates digitalization and sustainability in sports management is still lacking (Glebova & Madsen, 2024). By acknowledging the importance of fans in the sport value chain (Pal Singh *et al.*, 2023) and using fan tokens, this study is able to shorten that gap; in short, we argue that fan tokens help predict future economic outcomes.

The findings of this study resonate with the broader literature on CSR, SRI, and stakeholder theory in the context of sports management. Shareholder primacy theory, which advocates for maximizing shareholder value, has long dominated business ideology. However, stakeholder theory offers a more holistic perspective, emphasizing the importance of considering the interests of all stakeholders, including fans. This resonates with the heterogeneous stakeholder landscape prevalent in professional football today.

Moreover, the study highlights the significance of CSR and SRI practices in football clubs, underscoring their role beyond mere economic entities. Football clubs, which are cultural and social institutions with profound community impacts, are in-

creasingly expected to demonstrate social responsibility and sustainability practices. This aligns with previous studies discussing the impact of sustainability practices on company performance, emphasizing the importance of CSR in enhancing brand reputation, loyalty, and economic performance.

The adoption of fan tokens as a mechanism for measuring fan engagement and monetizing brand value is another area where this study contributes to the literature. Fan tokens represent a novel approach to fan engagement, offering clubs a means to interact with fans while potentially enhancing brand loyalty and creating new revenue streams. This aligns with prior studies highlighting the emergence of fan tokens as a new competitive landscape in the football industry.

6. THEORETICAL CONTRIBUTIONS AND PRACTICAL IMPLICATIONS

This study contributes to the growing body of literature on sports management, CSR, and SRI by elucidating the complex relationships among fan engagement, social awareness, and economic performance in football clubs. In general, the findings of this study have significant implications for the football industry. Football clubs that actively engage fans and adopt sustainable practices are likely to enjoy enhanced brand reputation and economic returns. In this context, fan tokens are key players. Fan tokens are becoming effective mechanisms for football clubs to engage with fans, subsequently enhancing firm performance. Therefore, fan tokens should attract the attention of both managers and researchers. By establishing a positive relationship between fan tokens and stock prices, this study underscores the importance of fan engagement and social awareness in driving economic performance.

Thus, the study offers valuable insights with implications not only for academia but also for industry stakeholders; actually, football clubs' practitioners can gain valuable insights to improve good governance, and in the same vein, investors can make better-informed decisions.

From a theoretical perspective, the study offers interesting insights. On the basis of stakeholder theory, we build bridges between sports, finance and fan tokens —a new form of fan engagement (Ante *et al.*, 2024)— by exploring the explanatory and predictive power of fan tokens on football clubs' stock price evolution. Fans' tokens promote a paradigm shift in which fans are no longer passive stakeholders (Ante *et al.*, 2024) and have tools to punish or reward their teams on the basis of their behaviour, leveraging fan engagement to the next level. In this context, this study helps address the lack of environmental governance mechanisms in football clubs (Daddi *et al.*, 2024) by stressing fan tokens' role in football clubs' responsible behaviour, which in turn favours economic performance.

From a practical perspective, our results are also useful for managers, especially in industries such as the football industry, in which managers struggle to balance different interests when managing the coexistence of different institutional logics (Carlsson-Wall *et al.*, 2016). Football fans are already considered to play an important role since they can push football organizations towards sustainability (Daddi *et al.*, 2024). Hence, we suggest not underestimating the power of football fans and considering their priorities, which are increasingly aligned with responsible issues, resulting in higher levels of economic performance. Similarly, our results underscore the importance of fan tokens as a potential market signal for football clubs' stock prices. Hence, investors could also leverage this information to inform trading strategies, particularly in markets where fan engagement plays a crucial role in a club's financial performance.

7. CONCLUSIONS, LIMITATIONS AND FUTURE LINES OF RESEARCH

The findings of this study suggest that fan tokens, as a measure of fan engagement, significantly influence football clubs' stock prices. The positive relationship observed underscores the potential impact of fan participation on club financials, indicating a valuable avenue for financial analysis and investment strategies. The comprehensive approach of this study, which uses panel data and econometric modelling, offers insights into the dynamics between fan tokens and stock prices across different football clubs. In short, the evolution of a football club's fan tokens has both explanatory and predictive power over the evolution of its stock price. Our findings suggest that being socially responsible is not only the right thing to do but can also lead to improved economic performance and a competitive advantage for football clubs, not only in the short term but also in the long term. Hence, our work underscores the importance of fan involvement in driving club success and advocates for responsible management practices in the football industry.

Nevertheless, several limitations need to be considered. First, the study's focus on European clubs and the specific timeframe of available fan token data limits generalizability yet paves the way for future studies, which could investigate whether the relationship between fan token prices and share prices is consistent across different sports and industries beyond football clubs. Second, the analysis does not encompass other potential factors affecting stock prices, such as club performance, player transfers, or broader market trends. Third, the study's methodology relies on the assumption that the price of the fan token reflects the emotional perception of the club's social responsibility by its fans, which may not always be the case. Non-sustainability-related aspects might also have had an effect on fan tokens' price. Finally, while the relationship between fan tokens and stock prices is evident, the causal mechanisms underlying this connection require further exploration.

The advent of fan tokens, enabling supporters to partake in club-related decisions and activities, presents an intriguing proposition for financial market analysis. Overall, this study provides insights into the relationship between social responsibility and football clubs' fan perceptions by contributing to the relationship between fan tokens and football clubs' stock prices. However, when the impact of potential fan tokens on the valuation and performance of football clubs in the financial sphere is explored, future research should expand the analysis to incorporate additional factors and explore the causal mechanisms driving this relationship. Further investigation into the mechanisms through which fan tokens influence stock prices could offer deeper in-

sights into the causal relationships at play. Additionally, exploring the role of fan tokens in other sports industries or regions could help generalize the findings beyond European football clubs. Moreover, longitudinal studies tracking the evolution of fan engagement and economic performance over an extended period could provide a more comprehensive understanding of the long-term implications of fan tokens. Finally, qualitative research exploring fan perceptions and attitudes towards fan tokens could complement the quantitative analysis, offering a richer understanding of fan behaviour and preferences.

8. ACKNOWLEDGEMENTS

The authors acknowledge the support received from the University of the Basque Country UPV/EHU, Research Group ECISE (GIU 21/025).

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APPENDIX

OLS models estimated for H1

Model 1: OLS, using observations 2022-01-03:2023-12-25 (T = 104)
Dependent variable: R_PORTO

	Coefficient	Std. error	t statistic	p value
Const	0.6936200	0.7246610	0.9572	0.3407
R_PORTO_FT	−0.0507253	0.0500070	−1.0140	0.3128

Mean dependent var	0.664712	S.D. dependent var	7.385440
Sum squared resid	5561.999	S.E. of regression	7.384403
R-cuadrado	0.009987	Adjusted R-squared	0.000281
F(1, 102)	1.028934	P value (F)	0.312809
Log-likelihood	−354.4943	Akaike criterion	712.9887
Schwarz criterion	718.2775	Crit. de Hannan-Quinn	715.1313
Rho	−0.424421	Durbin–Watson	2.828240

Source: Authors' own research.

Model 2: OLS, using observations 2022-01-03:2023-12-25 (T = 104)
Dependent variable: R_LAZI

	Coefficient	Std. error	t statistic	p value
Const	−0.2368070	0.2777580	−0.8526	0.3959
R_LAZI_FT	0.0493726	0.0191876	2.5730	0.0115**

Mean dependent var	−0.228846	S.D. dependent var	2.908676
Sum squared resid	818.3025	S.E. of regression	2.832415
R-cuadrado	0.060956	Adjusted R-squared	0.051750
F(1, 102)	6.621118	P value (F)	0.011516
Log-likelihood	−254.8373	Akaike criterion	513.6747
Schwarz criterion	518.9635	Hannan-Quinn	515.8173
Rho	−0.296269	Durbin–Watson	2.580803

Source: Authors' own research.

Model 3: OLS, using observations 2022-01-03:2023-12-25 (T = 104)
Dependent variable: R_JUV

	Coefficient	Std. error	t statistic	p value
Const	−0.1116350	0.5583460	−0.1999	0.8419
R_JUV_FT	0.0193179	0.0492561	0.3922	0.6957

Mean dependent var	−0.123077	S.D. dependent var	5.662852
Sum squared resid	3298.020	S.E. of regression	5.686258
R-cuadrado	0.001506	Adjusted R-squared	−0.008283
F(1, 102)	0.153816	P value (F)	0.695733
Log-likelihood	−327.3173	Akaike criterion	658.6346
Schwarz criterion	663.9234	Hannan-Quinn	660.7773
Rho	−0.084281	Durbin–Watson	2.163598

Source: Authors' own research.

Model 4: OLS, using observations 2022-01-03:2023-12-25 (T = 104)
Dependent variable: R_GALA

	Coefficient	Std. error	t statistic	p value
Const	1.583220	0.8569750	1.847	0.0676*
R_GALA_FT	0.128464	0.0711605	1.805	0.0740*

Mean dependent var	1.572115	S.D. dependent var	8.834554
Sum squared resid	7790.179	S.E. of regression	8.739239
R-cuadrado	0.030962	Adjusted R-squared	0.021461
F(1, 102)	3.258985	P value (F)	0.073983
Log-likelihood	−372.0135	Akaike criterion	748.0270
Schwarz criterion	753.3157	Hannan-Quinn	750.1696
Rho	−0.012729	Durbin–Watson	2.020212

Source: Authors' own research.

Model 5: OLS, using observations 2022-01-03:2023-12-25 (T = 104)
Dependent variable: R_TRA

	Coefficient	Std. error	t statistic	p value
Const	0.0404255	0.6857880	0.05895	0.9531
R_TRA_FT	0.1400930	0.0485897	2.88300	0.0048***

Mean dependent var	−0.052885	S.D. dependent var	7.229644
Sum squared resid	4977.893	S.E. of regression	6.985905
R-cuadrado	0.075356	Adjusted R-squared	0.066291
F(1, 102)	8.312749	P value (F)	0.004802
Log-likelihood	−348.7249	Akaike criterion	701.4498
Schwarz criterion	706.7386	Hannan-Quinn	703.5925
Rho	0.000250	Durbin–Watson	1.914165

Source: Authors' own research.

Model 6: OLS, using observations 2022-01-03:2023-12-25 (T = 104)
Dependent variable: R_FB

	Coefficient	Std. error	t statistic	p value
Const	1.832030	0.837190	2.188	0.0309**
R_FB_FT	0.336796	0.117391	2.869	0.0050***

Mean dependent var	1.494038	S.D. dependent var	8.744433
Sum squared resid	7287.792	S.E. of regression	8.452747
R-cuadrado	0.074672	Adjusted R-squared	0.065601
F(1, 102)	8.231241	P value (F)	0.005005
Log-likelihood	−368.5470	Akaike criterion	741.0940
Schwarz criterion	746.3828	Hannan-Quinn	743.2366
Rho	−0.050768	Durbin–Watson	2.087183

Source: Authors' own research.

OLS models estimated for H2

Model 7: OLS, using observations 2022-01-10:2023-12-25 (T = 103)
Dependent variable: R_PORTO

	Coefficient	Std. error	t statistic	p value
Const	0.636158	0.733331	0.8675	0.3877
R_PORTO_FT_1	0.0384218	0.0503621	0.7629	0.4473

Mean dependent var	0.658544	S.D. dependent var	7.421285
Sum squared resid	5585.511	S.E. of regression	7.436537
R-squared	0.005730	Adjusted R-squared	−0.004115
F(1, 101)	0.582035	P value (F)	0.447294
Log-likelihood	−351.8006	Akaike criterion	707.6012
Schwarz criterion	712.8706	Hannan-Quinn	709.7355
Rho	−0.434075	Durbin–Watson	2.737715

Source: Authors' own research.

Model 8: OLS, using observations 2022-01-10:2023-12-25 (T = 103)
Dependent variable: R_LAZI

	Coefficient	Std. error	t statistic	p value
Const	−0.237463	0.2881510	−0.8241	0.4118
R_LAZI_FT_1	−0.0170633	0.0198099	−0.8614	0.3911

Mean dependent var	−0.240388	S.D. dependent var	2.920505
Sum squared resid	863.6496	S.E. of regression	2.924207
R-squared	0.007292	Adjusted R-squared	−0.002537
F(1, 101)	0.741924	P value (F)	0.391085
Log-likelihood	−255.6622	Akaike criterion	515.3245
Schwarz criterion	520.5939	Hannan-Quinn	517.4588
Rho	−0.312775	Durbin–Watson	2.612893

Source: Authors' own research.

Model 9: OLS, using observations 2022-01-10:2023-12-25 (T = 103)
Dependent variable: R_JUV

	Coefficient	Std. error	t statistic	p value
Const	−0.1746700	0.5622140	−0.3107	0.7567
R_JUV_FT_1	−0.0241300	0.0493718	−0.4887	0.6261

Mean dependent var	−0.160874	S.D. dependent var	5.677346
Sum squared resid	3279.933	S.E. of regression	5.698647
R-squared	0.002359	Adjusted R-squared	−0.007518
F(1, 101)	0.238867	P value (F)	0.626085
Log-likelihood	−324.3844	Akaike criterion	652.7688
Schwarz criterion	658.0383	Hannan-Quinn	654.9031
Rho	−0.072747	Durbin–Watson	2.140069

Model 10: OLS, using observations 2022-01-10:2023-12-25 (T = 103)
Dependent variable: R_GALA

	Coefficient	Std. error	t statistic	p value
Const	1.559880	0.8646130	1.804	0.0742*
R_GALA_FT_1	0.131142	0.0715020	1.834	0.0696*

Mean dependent var	1.554466	S.D. dependent var	8.875912
Sum squared resid	7776.730	S.E. of regression	8.774812
R-squared	0.032233	Adjusted R-squared	0.022651
F(1, 101)	3.363955	P value (F)	0.069582
Log-likelihood	−368.8450	Akaike criterion	741.6900
Schwarz criterion	746.9595	Hannan-Quinn	743.8244
Rho	0.004859	Durbin–Watson	1.985062

Source: Authors' own research.

Model 11: OLS, using observations 2022-01-10:2023-12-25 (T = 103)
Dependent variable: R_TRA

	Coefficient	Std. error	t statistic	p value
Const	−0.152509	0.6678570	−0.2284	0.8198
R_TRA_FT_1	0.134802	0.0470953	2.8620	0.0051***

Mean dependent var	−0.240680	S.D. dependent var	7.005460
Sum squared resid	4630.209	S.E. of regression	6.770794
R-squared	0.075031	Adjusted R-squared	0.065873
F(1, 101)	8.192857	P value (F)	0.005113
Log-likelihood	−342.1405	Akaike criterion	688.2811
Schwarz criterion	693.5505	Hannan-Quinn	690.4154
Rho	0.039302	Durbin–Watson	1.899367

Source: Authors' own research.

Model 12: OLS, using observations 2022-01-10:2023-12-25 (T = 103)
Dependent variable: R_FB

	Coefficient	Std. error	t statistic	p value
Const	1.709710	0.853714	2.003	0.0479**
R_FB_FT_1	0.279342	0.119658	2.334	0.0215**

Mean dependent var	1.445146	S.D. dependent var	8.772896
Sum squared resid	7448.390	S.E. of regression	8.587574
R-squared	0.051197	Adjusted R-squared	0.041802
F(1, 101)	5.449867	P value (F)	0.021549
Log-likelihood	−366.6234	Akaike criterion	737.2468
Schwarz criterion	742.5163	Hannan-Quinn	739.3811
Rho	0.037005	Durbin–Watson	1.914914

Source: Authors' own research.