THE REACTION OF STOCK PRICES OF ITALIAN FOOTBALL TEAMS TO THE SURPRISE FACTOR IN MATCH OUTCOMES

Massimo Regalli [*], Giovanni Verga [†**], Evita Allodi [***], Andrea Del Sante [****]

* University of Parma, Parma, Italy
** European College of Parma Foundation, Parma, Italy
*** *Corresponding author*, University of Parma, Parma, Italy
Contact details: University of Parma, Universita' Street 12, Parma 43121, Italy
**** Scenari Immobiliari, Rome, Italy

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Abstract

This paper examines how stock prices of Italian football clubs react to unexpected match outcomes, focusing on Juventus, Lazio, and Roma over the 2013–2014 to 2018–2019 football seasons. According to market efficiency theory, price adjustments should reflect only the "surprise" component of match results — that is, the deviation between the actual outcome and its *ex-ante* expectation. Using betting odds to proxy market expectations, we show that surprises exert a significant and immediate influence on stock prices, which is largely incorporated into opening prices on the first trading day after the match. By analysing both open and close prices, our findings indicate that some irregularities appear at market opening but tend to be corrected during the trading day, suggesting partial but not complete market efficiency. We also document asymmetric effects across clubs and explore whether rival-team results influence price adjustments. Overall, the results highlight the central role of expectation formation and surprise in shaping stock market reactions to sporting events.

Keywords: Italian Football Club, Football Match, Surprise, Stock Price, Efficient Market

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1. INTRODUCTION

This paper investigates the relationship between match outcomes of listed Italian football clubs and their stock price dynamics, with particular attention to Juventus, Roma, and Lazio over the 2013–2014 to 2018–2019 football seasons[1].

[1] Lazio listed its shares on the stock exchange in 1998, and they continue to be publicly traded. The club's honours include two Serie A titles, seven Coppa Italia titles, five Supercoppa Italiana titles, one UEFA Cup Winners' Cup, and one UEFA Super Cup. During the period under analysis, Lazio won the Supercoppa Italiana in 2017 and 2019, and secured the Coppa Italia in the 2018–2019 season. Roma listed its shares on the stock exchange in 2000, and they remained publicly traded until 2022. The club's honours include three Serie A titles, five Coppa Italia titles, two Supercoppa Italiana titles, and one UEFA Europa Conference League title. However, during the period under analysis, Roma did not secure any major trophies. Juventus, the only one of the three clubs to own its stadium, listed its shares on the stock exchange in 2011, and they remain publicly traded. The club's honours include 36 Serie A titles, two European Champion Clubs' Cups (UEFA Champions League titles), 15 Coppa Italia titles, two Intercontinental Cups,

According to the theory of market efficiency, stock prices reflect all publicly available information, and price changes are the result of new information that was previously unexpected and not taken into account by investors (Fama, 1965, 1970).

The speed with which investors assimilate and respond to this new information determines the dynamics of financial markets.

In this context, the listed football clubs are an interesting object of study. The fervent participation of fans in sporting events, the pressure of matches, and the constant media exposure of the vicissitudes of players and their teams all create a unique environment. Investor investment decisions can be influenced by such factors and lead to changes in stock prices. The timing of football matches during weekends or evenings, while the financial markets are closed, ensures that scores are announced at the same time for everyone, preventing possible opportunistic behaviour on the basis of insider information and information asymmetries. This aspect not only ensures fairness and transparency but also ensures the integrity of the betting environment.

Moreover, the sports betting environment also offers a unique perspective for investigating the dynamics of market response to new information, and contributes to a deeper understanding of how such data impact the financial valuations of listed football teams (Thaler & Ziemba, 1988; Stadtmann, 2006). For every match, predictions on the results, and thus the related odds, are widely available, and these forecasts can help to capture market expectations of the win, lose or draw outcome before it occurs.

The aim of this study is to examine the stock price reactions of the three listed Italian football clubs, Roma, Lazio and Juventus, to their sporting performance in the period 2014–2019. In those years, the teams were listed on the Milan Stock Exchange (Borsa Italiana) and played throughout in Serie A, the first league of the Italian championship. This period also has the advantage of being fairly homogeneous, not characterized by particular economic and/or sporting events, and, above all, not affected by the COVID-19 pandemic.

If, following the "semi-strong" definition, it is true that markets are efficient, all public information, including football match scores, should be incorporated into market prices. Therefore, price reaction should be sensitive only to the "surprise" factor in the result, i.e., the difference (error) between the actual result of the match and the *ex-ante* expectations, rather than to the simple *ex-post* results. Moreover, price adjustment should be immediate, i.e., incorporated into the stock price at the opening on day $t + 1$ after the match.

The study examines how football match outcomes influence the stock prices of the three Italian football clubs listed on the stock exchange (Juventus, Lazio, and Roma). Unlike most existing studies, we focus on "surprise" match results and on the formation of expectations. We further address the issue that these expectations do not coincide with true market expectations. Our analysis tests whether it is the surprise element -rather than the result itself — that drives stock price adjustments.

To check adjustment speed, we examine the change in both the open and close stock prices, and find that the main effect of surprise is incorporated into the open price as soon as the day after the match. In line with previous findings, we identify some irregular behaviour in market reaction, which is, however, no longer visible in the closing price at the end of the day. Irregular behaviour in prices is not detected in all our models.

The paper is organized as follows. Section 2 reviews the relevant literature on the relationship between football match outcomes and stock market reactions. Section 3 presents the research methodology, including the construction of expectations and the measurement of the surprise factor. Section 4 reports and discusses the empirical results, while Section 5 provides several robustness checks, including alternative estimators and different specifications of market index effects. Finally, Section 6 concludes the paper.

2. LITERATURE REVIEW

The pioneering studies of Scherr et al. (1993) and Brown and Hartzell (2001) initiated research on the relationship between sports and financial performance. Analysing the performance of the American basketball team Boston Celtics, in the National Basketball Association (NBA) championship, they demonstrate that game results significantly influence share prices, trading volume and volatility. Following these findings, academic research increasingly focused on the same relationship in the football sector (Renneboog & Vanbrabant, 2000; Stadtmann, 2004, 2006; Demir & Danis, 2011; Galoppo & Boido, 2020; Kalaitzakis et al., 2022). The various studies differ regarding sample composition (teams and league), time frame covered and econometric methodology.

Existing literature focuses on domestic and international matches in a single country or international matches in different countries. Since our research considers three Italian teams and the results of the Italian Serie A (Italy's premier football league) championship matches, we focus on similar studies for important teams in Europe in the literature analysis.

One of the first studies of the influence of football club performance on share prices was carried out by Renneboog and Vanbrabant (2000). Using event study methodology and the calculation of the cumulative abnormal returns (CAR) of 17 football teams listed on the London Stock Exchange (LSE) or on the alternative investment market (AIM) in the period 1995–1998, the researchers highlight the presence of abnormal returns in share prices when match results are announced. Victories lead to an increase in prices, and draws and defeats lead to a decrease. Where a match is lost, the abnormal return is greater than for a win, which they term the "loss effect".

According to the theory of efficient markets, stock prices should vary in relation to the release of new information, which includes betting odds on match results (Kalaitzakis et al., 2022). However, Palomino et al. (2009) do not find a statistically significant reaction to the publication of betting odds.

three UEFA Cups, two UEFA Super Cups, one UEFA Cup Winners' Cup, one UEFA Intertoto Cup, and nine Supercoppa Italiana titles. During the period under analysis, Juventus won the Serie A title in each of the years considered. The club also won four Coppa Italia titles and two Supercoppa Italiana titles during this time.

Dobson and Goddard (2009) extend the empirical evidence of Renneboog and Vanbrabant (2000) by considering the effect of surprise in addition to the results themselves of the matches. Through the study of 13 football clubs listed on LSE or AIM between 1997–1999 researches find that the change in share prices is greater after an unexpected victory than after an expected victory. On the other hand, Zuber et al. (2005), again analysing professional English Premier League clubs listed on the LSE between 1997 and 2000, find that team share prices are very insensitive to match results and surprise effects.

On the British market, Palomino et al. (2009) find that the market processes positive news of victory faster than negative news of defeat. In fact, in the event of a victory, the market only records positive abnormal results on the first trading day following the match. But it reacts to defeats by recording negative abnormal returns in the first three days. According to Bernile and Lyandres (2011), the market reacts slowly, with negative abnormal returns, in the event of a defeat due to excessive pre-match optimism on the part of fan-investors in relation to the performance of their favourite team. Disappointment in a defeat turns the hopes for a win into negative stock returns.

Ashton et al. (2011) examine the link between international soccer results and stock market returns. They find that generalized auto regressive conditional heteroscedasticity (GARCH) (1,1) regressions capture wins and losses more appropriately than ordinary least squares (OLS), and the magnitudes of the coefficients reflect the relative importance of games played.

Similar results have been found for clubs listed on other markets: Portugal by Duque and Ferreira (2005), Türkiye by Devecioğlu (2004), Aygören et al. (2008), Demir and Danis (2011), and Saraç and Zeren (2013) and Germany by Stadtmann (2006).

To our knowledge, there are only three existing studies on the Italian market relating to the relationship between stock performance and sporting performance of Juventus, Lazio, and Roma and only one study on Lazio and Roma.

Boido and Fasano (2007) measure the sporting performance of each of the three teams through match result (victory, defeat, draw) and the goal difference calculated as the difference between the number of goals scored by the team and the number of goals conceded during a match. The key variable examined is the "Post Match Delta Return", which represents the change in stock returns immediately after a match compared to the average return over the five trading days preceding the match. In 2005–2006, the period under analysis, Boido and Fasano (2007) show that the Post Match Delta Return after victories is higher than that found in the case of defeat.

Majewski (2014), using autoregressive models over a time period from 2001 to 2014, demonstrates that for Roma and Juventus, there is no evidence of a significant relationship between victories, or the probability of victory estimated by bookmakers and stock returns. In the econometric analysis, the variables significantly impacting stock returns were draws and defeats, both home and away. For Roma, home defeats have a significant negative effect on share returns, while, somewhat strangely, away defeats show an increase in share returns. These results are confirmed for Juventus, with the exception of away defeats, which show a significant negative relationship with returns. For Lazio, Majewski (2014) finds that the probability of victory, both home and away, has a positive relationship with stock returns, while the probabilities of defeat and draw show a negative relationship. In summary, match performance and market expectations have a significant, albeit variable, impact on the stock returns of the three football clubs listed on the stock exchange.

The third study by Boțoc et al. (2019), using GARCH econometric models, also finds that match results have a significant impact on the share prices of all three teams, but the nature and intensity of this impact vary according to the team and whether the match is played at home or away. Wins have a significant and positive impact on the stock prices of all three teams. This impact is of greater magnitude for Juventus and Lazio when the win is away from home and thus considered more difficult to achieve. On the other hand, defeats have a significant negative impact on the share prices of Juventus, Lazio and Roma. For all teams, defeats have a negative impact on share prices, which is more pronounced for Juventus and Roma when the defeat occurs at home. Draws show a neutral (Lazio and Roma) or negative (Juventus) impact on stock prices.

Finally, Demir and Rigoni (2014) focus on the two teams, Roma and Lazio, notorious rivals which share the same stadium. The authors include interaction variables in their analysis model in order to study the combined effect of the performance of the team and its arch-enemy, and unexpected performances of the arch-enemy (positive or negative), to evaluate the impact of surprise. Using the market model to calculate the normal returns of each club's shares and determining the abnormal returns, which is the difference between the actual return and the expected return, they find that the victories (defeats) of the preferred team generate positive (negative) reactions on the stock market. But the performance of the rival also influences these reactions. In particular, a defeat combined with an unexpected win for the arch-rival amplifies the negative market reaction. On the other hand, a defeat for the arch-rival can mitigate the negative effect of a defeat, which suggests that emotions arising from sporting rivalry significantly influence traders' investment decisions.

3. RESEARCH METHODOLOGY

In this study, we start from the hypothesis that the stock market is efficient and, therefore:

H1a: The variable determining price adjustment of a team's stock price is the surprise element of a match result and not the result itself.

H1b: The price adjustment is instantaneous and is incorporated into the opening price on the first day after the match.

This hypothesis normally has some implications:

H2a: The market price reaction is symmetrical: there is no difference in the impact between positive and negative surprise.

H2b: The market price reaction does not concern only large or small surprises.

H2c: The market price reaction is independent of where the match takes place ("home" or "away").

In our opinion, many anomalies in existing studies arise because the variable considered is the actual match result rather than its surprise element. It is, however, true that to estimate this element of surprise, it is also necessary to estimate expectations, and of course, a "true" market expectation is not available.

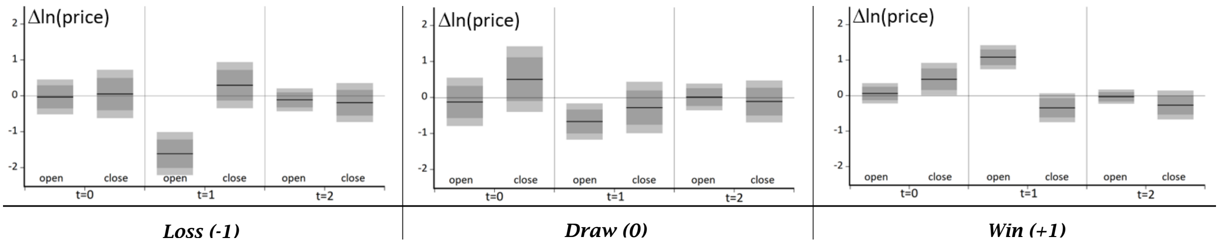
The econometric software we used is EViews 12. Pool estimators were used normally, but also systems of equations and sometimes single equations. The Wald test was used to test restrictions on coefficients. Restrictions tested are generally joint restrictions, since individual restrictions are more likely to be subject to rejection. (Type I error, or false positive, is the rejection of the null restriction of the Wald test when it is actually true).

To construct our dataset, we first identify the full set of matches relevant to our analysis. Our sample includes all official Serie A matches played by Juventus, Lazio, and Roma over the 2013–2014 to 2018–2019 football seasons, for a total of 190 observations per club. This six-season horizon ensures consistency in league format and excludes distortions due to the COVID-19 pandemic. Stock prices (open and close) were retrieved from Investing.com for Juventus and from Yahoo Finance for Lazio and Roma, both of which draw from Borsa Italiana's official data feed. For each match, we aligned the last available pre-match closing price (day *t*) and the first market-opening price after the match (day *t* + 1).

In Italy, football matches played on day *t*, even on weekdays, are always played with the stock market closed. Market reaction is thus always postponed to the first day (*t* + 1) when the stock exchange is open.

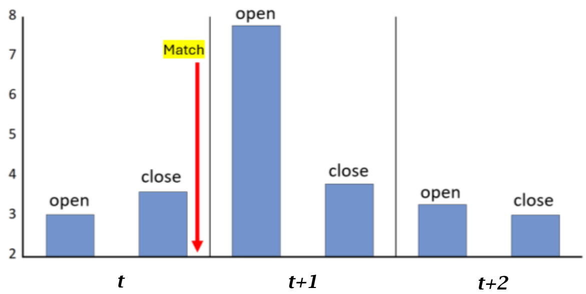
Figure 1 shows the average of the logarithmic variations (multiplied by 100) in the stock price of the three Italian teams (Juventus, Lazio, Roma) on the day of the football match (or on the previous day if the match was held on a public holiday) and on the following two days, divided into defeat, draw, and victory. The greatest variation occurs precisely at the stock market opening on day *t* + 1 (Figure 2).

Figure 1. *Δln* of share prices according to the result of the football match (average value of Juventus, Lazio and Roma)



Note: Grey zones indicate 95% and 99% of the logarithmic price variation; the black segment is their average value.
Source: Authors' elaboration.

Figure 2. Volatility of football stock prices (Juventus, Lazio and Roma) divided by the volatility of the Italian stock market index



Note: Volatility = variance of % variation in stock prices.
Source: Authors' elaboration.

In any case, market efficiency implies that only the surprise element of the result (i.e., the match result R_{it} minus its expected value $E[R_{it}]$, where *i* is the team) is relevant to the stock market reaction. In fact, expectation should already be included in the stock price formation before the match, and only the surprise aspect $\varepsilon_{it} = R_{it} - E[R_{it}]$, matters.

To calculate the expectations of *R*, we first consider the probabilities of the three possible events (victory, draw, defeat) of any of the three teams. The probabilities were obtained from online data provided by the international sporting odds comparison website BetBrain and also reported in various years (https://www.statistichesulcalcio.com). They are the decimal odds numbers showing the amount the bettor could win for every one euro wagered for any of the three possible bets on the outcome of a match (win, draw, defeat)

If *h* is the team of interest (Juventus, Lazio, Roma) and *k* the opposing team, we indicate the online data as follows:

- $S_{h,1}$ = odds in case of victory of *h*;
- $S_{h,0}$ = odds in case of a draw between *h* and *k*;
- $S_{h\text{-}1}$ = odds in case of victory of *k*, i.e., defeat of *h*;

We assume that the value of $S_{h,x}$ (*x* = 1, 0, -1) multiplied by its probability $p_{h,x}$ corresponds to one euro minus the amount π_h kept by the bookmaker as profit, which is kept constant for the sake of simplicity:

$$S_{h,x}p_{h,x} = (1 - \pi_h) \qquad (1)$$

The above equality implies:

$$p_{h,x} = \frac{(1 - \pi_h)}{S_{h,x}} \qquad (2)$$

and therefore, per *x* = 1, 0, -1:

$$p_{h,1} = \frac{(1 - \pi_h)}{S_{h,1}} \qquad (2.1)$$

$$p_{h,0} = \frac{(1 - \pi_h)}{S_{h,0}} \qquad (2.2)$$

$$p_{h,-1} = \frac{(1-\pi_h)}{S_{h,-1}} \tag{2.3}$$

But the sum of the three probabilities must be 1, consequently.

$$1 = p_{h,1} + p_{h,0} + p_{h,-1} = \frac{(1-\pi_h)}{\left(\frac{1}{S_{h,1}} + \frac{1}{S_{h,0}} + \frac{1}{S_{h,-1}}\right)} \tag{3}$$

from which:

$$(1-\pi_h) = \frac{1}{\left(\frac{1}{S_{h,1}} + \frac{1}{S_{h,0}} + \frac{1}{S_{h,-1}}\right)} \tag{4}$$

which, substituted in the previous equalities allows us to measure the various probabilities:

$$p_{h,x} = \frac{1}{\left[\left(\frac{1}{S_{h,1}} + \frac{1}{S_{h,0}} + \frac{1}{S_{h,-1}}\right) \times S_{h,x}\right]} \tag{5}$$

where $x = 1, 0, -1$.

The result R_h of a match is a random variable of +1 if team h wins, 0 in the case of a draw, and -1 if in the case of defeat. Its expected value is, therefore:

$$E[R_h] = 1 \times p_{h,1} + 0 \times p_{h,0} - 1 \times p_{h,-1} = p_{h,1} - p_{h,-1} \tag{6}$$

Table 1 reports the statistics of $1 - \pi_h$, where $h = J$ (Juventus), L (Lazio) and R (Roma).

Table 1. Statistics of our measure of $1 - \pi_h$ and the unit profit π_h

Statistic	***1-π$_J$***	***π$_J$ (%)***	***1-π$_L$***	***π$_L$ (%)***	***1-π$_R$***	***π$_R$ (%)***
Mean	0.950	0.050	0.950	0.050	0.950	0.050
Median	0.952	0.048	0.952	0.048	0.952	0.048
Maximum	0.963	0.037	0.963	0.037	0.962	0.038
Minimum	0.933	0.067	0.933	0.067	0.928	0.072
Std. dev.	0.006	0.006	0.006	0.006	0.006	0.006
Observations	190	190	190	190	190	190

Note: J = Juventus, L = Lazio, R = Roma. Sample 1 = 190 observations).
Source: Authors' elaboration.

In practice, the mean value of k is the same for any club (its mean is 5%) and is fairly stable. We assume that as a sporting odds comparison website operating worldwide, BetBrain uses a complicated model with a large information set to fix odds. In this study, for the purpose of comparison with actual results, we estimate future match results using a simpler model based on a small number of variables (these variables can be easily obtained from https://www.transfermarkt.it https://www.statistichesulcalcio.com). We assume that the result of a match depends mainly on the following:

1) The difference between the value at the start of the championship of the players of the team *i* to the opposing team *k*: $\ln\frac{Value_i}{Value_k}$;

2) The number of points in the league standings before the match of the team in question compared to those of the opposing team divided by the number of matches already played ($Points_i - Points_k$);

3) Whether the team in question plays at home or away ($Where_i$).

The above variables also explain, at least in part, the expectations on the outcome $R_{i,t}$ obtained from the betting odds of BetBrain (Table 2, Model 1). At the same time, they should allow us to estimate a naïve equation predicting the match results $R_{i,t}$ (Table 2, Models 2 and 3). For greater clarity, we will call $E[R_{i,t}|BetOdds]$ expected match results obtained from BetBrain data and $E[R_{i,t}|NaiveOLS]$ or $E[R_{i,t}|NaiveORD]$ the expected results derived from our naïve model, depending on the estimator used (OLS or ordered probit).

Table 2. Estimation of $E[R_{i,t}|BetOdds]$ and $E[R_{i,t}]$ from our model

		$E[R_{i,t}\|BetOdds]$		$R_{i,t}$		$R_{i,t}$	
Model		***(1)***		***(2)***		***(3)***	
Estimator		***OLS***		***OLS***		***Ordered probit***	
Variable		***Coef.***	***SE***	***Coef.***	***SE***	***Coef.***	***SE***
J-const	J	-0.065	(0.042)	0.146	(0.133)	-	-
L-const	L	-0.130***	(0.027)	-0.193**	(0.085)	-	-
R-const	R	-0.133***	(0.032)	-0.075	(0.101)	-	-
ln(value$_J$/value$_K$)	J	0.169***	(0.028)	-0.045	(0.088)	-0.136	(0.176)
ln(value$_L$/value$_K$)	L	0.169***	(0.027)	0.249***	(0.086)	0.309**	(0.158)
ln(value$_R$/value$_K$)	R	0.208***	(0.028)	0.217**	(0.088)	0.338**	(0.161)
point$_J$-point$_K$	J	0.108***	(0.030)	0.312***	(0.094)	0.705***	(0.201)
point$_L$-point$_K$	L	0.153***	(0.033)	0.451***	(0.103)	0.960***	(0.235)
point$_R$-point$_K$	R	0.086***	(0.030)	0.229***	(0.095)	0.437**	(0.188)
where$_J$	J	0.229***	(0.034)	0.387***	(0.106)	0.863***	(0.222)
where$_L$	L	0.275***	(0.034)	0.143	(0.107)	0.273	(0.195)
where$_R$	R	0.258***	(0.034)	0.187*	(0.107)	0.323*	(0.189)
Adj. R^2		0.585		0.261		–	
Durbin-Watson (DW) test		1.004		2.015		–	

*Note: Method: pooled least squares; sample (adjusted) 2 = 190; included observations: 185 after adjustments; cross-sections included: 3; total pool (unbalanced) observations: 504; *, **, ***: significant at 10%, 5%, 1% probability; coefficient SE in brackets; F: F-statistic test, χ^2: chi-square test; Italian Football Club: J (Juventus), L (Lazio), R (Roma); ordered probit: maximum likelihood (ML) (Newton-Raphson/Marquardt steps); number of ordered indicator values: 3; coefficient covariance computed using observed Hessian (one estimation for each stock).*
Source: Authors' elaboration.

Our explanatory variables are linked to the expectation $E[R_{i,t}|BetOdds]$ deriving from BetBrain since all coefficients are significant at 1% probability. Moreover, most coefficients are highly significant in our naïve estimate of $R_{i,t}$. Given that the dependent variable can take only three integer values: -1, 0, or +1, we used both OLS and the more efficient ordered probit estimator.

Table 3 shows the correlation between the errors (surprise element) of the three estimators. The first one, $E[R_{i,t}|BetOdds]$, is based on BetBrain odds and the other two are derived from an OLS estimate of our model, $E[R_{i,t}|NaiveOLS]$ and an ordered estimate $E[R_{i,t}|NaiveORD]$. The correlations are always robust, even though the sources are different.

Table 3. Correlation matrix of the surprise terms for the three estimators

Variables			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	$R_{J,t} - E[R_{J,t}|BetOdds]$	J	1.000	0.898	0.890	-	-	-	-	-	-
(2)	$R_{J,t} - E[R_{J,t}|NaiveOLS]$	L	0.898	1.000	0.991	-	-	-	-	-	-
(3)	$R_{J,t} - E[R_{J,t}|NaiveORD]$	R	0.890	0.991	1.000	-	-	-	-	-	-
(4)	$R_{L,t} - E[R_{L,t}|BetOdds]$	J	-	-	-	1.000	0.905	0.897	-	-	-
(5)	$R_{L,t} - E[R_{L,t}|NaiveOLS]$	L	-	-	-	0.905	1.000	0.991	-	-	-
(6)	$R_{L,t} - E[R_{L,t}|NaiveORD]$	R	-	-	-	0.897	0.991	1.000	-	-	-
(7)	$R_{R,t} - E[R_{R,t}|BetOdds]$	J	-	-	-	-	-	-	1.000	0.940	0.944
(8)	$R_{R,t} - E[R_{R,t}|NaiveOLS]$	L	-	-	-	-	-	-	0.940	1.000	0.998
(9)	$R_{R,t} - E[R_{R,t}|NaiveORD]$	R	-	-	-	-	-	-	0.944	0.998	1.000

Source: Authors' elaboration.

4. RESULTS AND DISCUSSION

4.1. Surprise and stock price reaction

Having computed the various expectations $E[R_h]$ of the match results for the three teams, we have all the elements needed to estimate the relevance of the surprise factor on stock price variations.

The model used here is:

$$\Delta\ln(P_{i,t+1}) = \alpha_i + \beta_i(R_{i,t} - E[R_{i,t}]) + \gamma_i \Delta\ln(P_{IND,t+1}) \quad (7)$$

We consider three alternative definitions of stock price change:

$$\ln\left(\frac{PC_{i,t+1}}{PC_{i,t}}\right) \; t+1 \text{ close price / } t \text{ close price} \quad (8)$$

$$\ln\left(\frac{PO_{i,t+1}}{PC_{i,t}}\right) \; t+1 \text{ open price / } t \text{ close price} \quad (9)$$

$$\ln\left(\frac{PC_{i,t+1}}{PO_{i,t+1}}\right) \; t+1 \text{ close price / } t+1 \text{ open price} \quad (10)$$

All price changes are multiplied by 100 to avoid excessively small estimate parameters, where:

- $P_{i,t+1}$ is the stock price of team i on the first day of stock market opening after the match at time *t;*
- $P_{i,t}$ is the last available stock price before the match, measured on day *t;*
- h is the team (J = Juventus, L = Lazio, R = Roma);
- $PC_{i,h,t+1}$ is the close stock price of team h on day $t+1$;
- $PO_{i,h,t+1}$ is the open stock price of team h;
- $PC_{IND,t+1}$ is the close stock market index;
- $PO_{IND,t+1}$ is the open stock market index;
- $R_{i,h,t} - E[R_{i,h,t}]$ is the surprise factor of the match result of team h ($R_{i,h,t}$) minus its expectation $E[R_{i,h,t}]$.

Table 4 reports the main statistics of the variables used in this paper. All three football clubs are listed on Borsa Italiana throughout the sample period (over the 2013–2014 to 2018–2019 football seasons). All prices are denominated in euros and recorded in Central European Time, consistent with the official trading calendar of Borsa Italiana. We verified that no stock splits, reverse splits, or comparable corporate actions occurred for any of the three clubs during the sample period. Therefore, we rely on unadjusted daily open and close prices, which are appropriate for our log-difference specifications.

Daily prices for Juventus were collected from Investing.com, while daily prices for Roma and Lazio were retrieved from Yahoo Finance. Both platforms draw on the official exchange data feed.

Table 4. Descriptive statistics

Variable	*Mean*	*Med.*	*Max.*	*Min.*	*SD*	*Skew.*	*Kurt.*	*Obs.*
Juventus								
$\ln PC_{J,t+1}/PC_{J,t}$	0.327	0.270	11.074	-7.296	2.256	0.579	6.111	180
$\ln PO_{J,t+1}/PC_{J,t}$	0.335	0.340	4.419	-4.130	1.309	0.054	4.054	181
$\ln PC_{J,t+1}/PO_{J,t+1}$	-0.004	-0.139	8.260	-7.291	2.066	0.298	5.935	180
$\ln PC_{IND,t+1}/PC_{IND,t}$	-0.221	-0.109	4.664	-6.143	1.384	-0.283	5.275	179
$\ln PO_{IND,t+1}/PC_{IND,t}$	0.005	0.070	2.284	-3.525	0.795	-0.745	6.554	179
$\ln PC_{IND,t+1}/PO_{IND,t+1}$	-0.229	-0.075	2.380	-6.002	1.168	-0.890	5.880	181
$R_{J,t}$	0.642	1.000	1.000	-1.000	0.665	-1.611	4.140	190
$R_{J,t} - E[R_{J,t}\|BetOdds]$	0.195	0.341	1.752	-1.653	0.669	-0.887	3.846	190
Lazio								
$\ln PC_{L,t+1}/PC_{L,t}$	-0.392	-0.375	11.096	-10.749	3.151	0.073	4.911	181
$\ln PO_{L,t+1}/PC_{L,t}$	0.091	0.142	9.473	-13.758	2.990	-0.259	6.448	181
$\ln PC_{L,t+1}/PO_{L,t+1}$	-0.484	-0.298	7.341	-11.945	2.973	-0.453	4.534	181
$\ln PC_{IND,t+1}/PC_{IND,t}$	-0.099	-0.063	4.664	-6.143	1.421	-0.090	5.712	179
$\ln PO_{IND,t+1}/PC_{IND,t}$	0.006	0.048	2.284	-3.653	0.829	-0.969	7.790	179
$\ln PC_{IND,t+1}/PO_{IND,t+1}$	-0.109	-0.003	2.872	-6.002	1.208	-0.782	5.947	181
$R_{L,t}$	0.205	0.500	1.000	-1.000	0.870	-0.409	1.451	190
$R_{L,t} - E[R_{L,t}\|BetOdds]$	0.026	0.275	1.687	-1.752	0.783	-0.268	1.905	190
Roma								
$\ln PC_{R,t+1}/PC_{R,t}$	-0.443	-0.489	9.337	-10.622	2.811	0.414	5.355	181
$\ln PO_{R,t+1}/PC_{R,t}$	0.269	0.000	11.292	-5.249	2.202	1.012	6.872	181
$\ln PC_{R,t+1}/PO_{R,t+1}$	-0.713	-0.667	9.012	-6.669	2.237	0.544	5.207	181
$\ln PC_{IND,t+1}/PC_{IND,t}$	-0.258	-0.109	3.458	-6.143	1.341	-0.519	5.062	179
$\ln PO_{IND,t+1}/PC_{IND,t}$	-0.030	0.044	2.068	-3.525	0.762	-0.920	7.002	179
$\ln PC_{IND,t+1}/PO_{IND,t+1}$	-0.230	-0.057	2.890	-6.002	1.182	-0.888	5.884	181
$R_{R,t}$	0.416	1.000	1.000	-1.000	0.763	-0.859	2.238	190
$R_{R,t} - E[R_{R,t}\|BetOdds]$	0.146	0.362	1.755	-1.603	0.742	-0.577	2.629	190

Source: Authors' elaboration.

The estimated equation

$$\Delta\ln(P_{h,t+1}) = \alpha_h + \beta_h(R_{h,t} - E[R_{h,t}]) + \gamma_h \Delta\ln(P_{IND,t+1}) \tag{11}$$

for Juventus, Lazio and Roma are reported in Table 5, where the expectation of $E[R_{h,t}]$ is measured by $E[R_{R,t}|BetOdds]$. We assume that the surprise factor $R_{h,t} - E[R_{h,t}]$ causes a variation in the sign of the stock price, but if the market is efficient, the variation should end as soon as the stock market opens. The change in the stock index should also positively impact the price of shares.

Table 5 shows that our assumptions are sound. The surprise factor is significant with a probability of 1% for all three stocks in the case of price variations between the closing on t and the opening on $t + 1$ (Model 2), but not after the opening (Model 3). In the case of Lazio, there is actually still a price adjustment during day $t + 1$: the coefficient -0.537 is significant at 5% of probability, though not at 1%. However, the joint test that all the coefficients of the three teams are zero cannot be rejected at 1% probability.

Table 5. Stock price changes and surprise $R_{i,t} - E[R_{i,t}]$ based on betting odds

	Model	(1)		(2)		(3)	
Explanatory variables	Coef.	$ln(PC_{i,t+1}/PC_{i,t})$		$ln(PO_{i,t+1}/PC_{i,t})$		$ln(PC_{i,t+1}/PO_{i,t+1})$	
		Coef.	SE	Coef.	SE	Coef.	SE
const$_i$	α_J	0.315*	0.191	0.114	0.146	0.172	0.185
	α_L	-0.352*	0.182	0.044	0.141	-0.384**	0.176
	α_R	-0.481**	0.189	0.040	0.144	-0.554***	0.182
$R_{i,t} - E[R_{i,t}]$	β_J	0.914***	0.267	1.047***	0.207	-0.113	0.258
	β_L	1.479***	0.233	2.010***	0.183	-0.537**	0.228
	β_R	1.442***	0.244	1.547***	0.189	-0.109	0.236
$\ln(PC_{IND,i,t+1}/PC_{IND,i,t})$	γ_{1J}	0.755***	0.132	-	-	-	-
	γ_{1L}	0.366***	0.128	-	-	-	-
	γ_{1R}	0.774***	0.136	-	-	-	-
$\ln(PO_{IND,i,t+1}/PC_{IND,i,t})$	γ_{2J}	-	-	0.323*	0.178	-	-
	γ_{2L}	-	-	0.614***	0.172	-	-
	γ_{2R}	-	-	0.325*	0.185	-	-
$\ln(PC_{IND,i,t+1}/PO_{IND,i,t+1})$	γ_{3J}	-	-	-	-	0.619***	0.150
	γ_{3L}	-	-	-	-	0.503***	0.147
	γ_{3R}	-	-	-	-	0.687***	0.149
Adj. R^2		0.235		0.311		0.100	
DW		2.087		2.183		1.960	
Redundant	Pr(F)	0.0065		0.9221		0.0146	
Fixed effects	Pr(χ^2)	0.0060		0.9208		0.0136	
Wald test: $\beta_J = \beta_L = \beta_R$	Pr(F)	0.2214		0.0024		-	
	Pr(χ^2)	0.2205		0.0023		-	
Wald test: $\beta_J = \beta_L = \beta_R = 0$	Pr(F)	-		-		0.1150	
	Pr(χ^2)	-		-		0.1136	
Wald test: $\gamma_J = \gamma_L = \gamma_R$	Pr(F)	0.0445		0.4017		0.6725	
	Pr(χ^2)	0.0437		0.4011		0.6723	

*Note: Method: pooled least squares; sample 1 = 190 observations; included observations: 180; cross-sections included: 3; total pool (unbalanced) observations: 537; *, **, ***: significant at 10%, 5%, 1% probability; coefficient SE in brackets; F: F-statistic test, χ^2: chi-square test; Italian Football Club: J (Juventus), L (Lazio), R (Roma).*
Source: Authors' elaboration.

Our findings contribute to and refine the evidence documented in earlier studies on how financial markets respond to football match outcomes. Consistent with Renneboog and Vanbrabant (2000) and Palomino et al. (2009), we confirm that unexpected sporting results — rather than raw outcomes — drive stock price adjustments. As these studies emphasise, investors incorporate only the "surprise" component of match performance into prices, a mechanism clearly reflected in the behaviour of opening prices on the first trading day following a match. In line with Ashton et al. (2011) and Edmans et al. (2007), our results also point to sentiment-driven reactions, particularly when surprises are large. However, we detect stronger and more consistent adjustments for Juventus, which echoes Benkraiem et al. (2009), who argue that larger or more visible clubs generate greater investor attention and stronger price reactions.

Furthermore, when the Wald test verifies that the coefficients of $R_{i,t} - E[R_{i,t}]$ in Models 2 and 1 of Table 5 are the same (Table 6), the null restriction of the Wald test is accepted at 46% of probability, and after the opening stock price, since coefficients are the same, surprise no longer has a systematic effect on price. In any case, the surprise factor exerts a stronger effect on the stock price for Lazio and Roma than for Juventus, which is one of the oldest and most famous Italian football clubs.

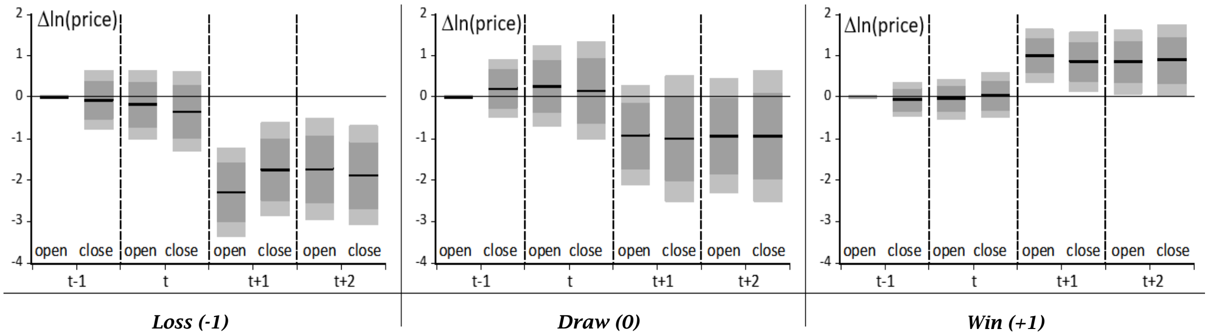
Table 6. Wald test of the null restriction on the coefficients of $R_{i,t} - E[R_{i,t}]$ in Models 1 and 2 of Table 5

Test statistic	Value	df	Probability
Chi^2	2.547	3	0.4668

Note: Method: system of equations; Wald test; J = Juventus, L = Lazio, R = Roma. The tested restrictions are $\beta_{J(2)} = \beta_{J(1)}$, $\beta_{L(2)} = \beta_{L(1)}$, $\beta_{R(2)} = \beta_{R(1)}$.
Source: Authors' elaboration.

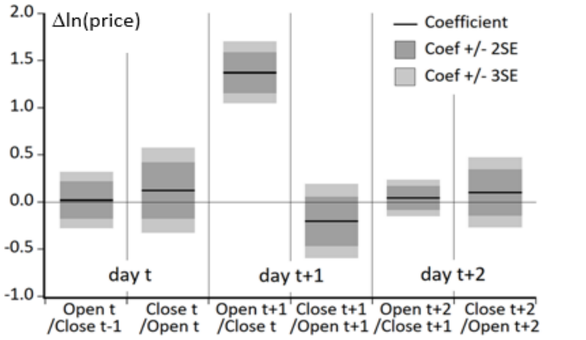
By estimating the same equation for days t and $t + 1$, it is possible to represent the dynamics of the influence of the surprise on price changes. Figure 3 presents the CAR of *Δln* stock price average reaction of Juventus, Lazio and Roma to their surprise factors, and Figure 4 presents the most important measure of the effect. Figures 3 and 4 also show that the adjustment is strongly significant when considering the open price on day $t + 1$.

Figure 3. CAR of Δln stock price reaction to surprise



Note: Mean value of J, L, R; grey bands represent 2 and 3 times SE confidence interval; black line is the average value.
Source: Authors' elaboration.

Figure 4. Effect of surprise factor on stock price variations



Note: Method: local impulse; mean value of J, L, R; grey bands represent 2 and 3 times SE confidence interval; black line is the average value.
Source: Authors' elaboration.

Again, as noted above, the efficient markets hypothesis requires that it is the surprise factor $R_{i,t} - E[R_{i,t}]$, rather than the expected value $E[R_{i,t}]$, that influences the stock price on $t + 1$. To test this assumption, we introduce the expectation $E[R_{i,t}]$ as an additional regressor in Eq. (11) of Table 5:

$$\Delta \ln(P_{h,t+1}) = \alpha_h + \beta_i(R_{i,t} - E[R_{i,t}]) + \gamma_i \Delta \ln(P_{IND,t+1}) + \delta_i E[R_{i,t}] \quad (12)$$

The estimates, limited to the coefficients of interest, are reported in Table 7 along with the Wald test of the two null restrictions: $\delta_J = \delta_L = \delta_R = 0$ and $\beta_J = \delta_J$, $\beta_L = \delta_L$, $\beta_R = \delta_R$. If accepted, the first null restriction would suggest that only the surprise aspect matters; the second restriction would suggest that only the actual result matters.

The joint restriction that the coefficients of $E[R_{i,t}]$ are zero cannot be rejected, and, at the same time, the second restriction is rejected: this confirms that only the surprise factor affects future price variations.

By substituting $E[R_{i,t}|NaiveORD]$ to $E[R_{i,t}|BetOdds]$ into the equation:

$$\Delta \ln(P_{h,t+1}) = \alpha_h + \beta_h(R_{h,t} - E[R_{h,t}]) + \gamma_h \Delta \ln(P_{IND,t+1}) \quad (13)$$

it is possible to derive an alternative estimate of the impact of surprise on stock prices (Table 8). All results reported in Table 5 are confirmed as consistent with those of the two estimates in Table 8.

Here too, all the coefficients of surprise are significant in estimating the variation between the closing price on day *t* and the opening price on $t + 1$, and in all models of Table 8, parameters are similar to the analogous models of Table 5. Conversely, the corresponding Adj. R^2s are lower in Table 8 for all football teams: the market expectations should, therefore, be more similar to those obtainable from the betting odds than $[R_{i,t}|NaiveORD]$. Furthermore, when both surprise measures were included in the same equation, $E[R_{i,t}|NaiveORD]$ was found to be redundant.

A further advantage is that $E[R_{i,t}|BetOdds]$ only uses the information available on day *t*, while the variable $[R_{i,t}|NaiveORD]$ is calculated using a regression based on all the information available in the years considered.

Table 7. The relevance of surprise vs. expectations

Explanatory variables	***Coef.***	$ln(PO_{i,t+1}/PC_{i,t})$	
		Coef.	***SE***
$R_{i,t} - E[R_{i,t}]$	β_J	1.138***	0.213
	β_L	1.989***	0.184
	β_R	1.575***	0.193
$E[R_{i,t}]$	δ_J	0.762*	0.456
	δ_L	0.429	0.431
	δ_R	0.304	0.424
Wald test: $\delta_J = \delta_L = \delta_R = 0$	*Pr(F)*	0.2324	
	Pr(χ²)	0.2311	
Wald test: $\beta_J = \delta_J$, $\beta_L = \delta_L$, $\beta_R = \delta_R$	*Pr(F)*	0.0002	
	Pr(χ²)	0.0002	

*Note: Only relevant coefficients are reported for the sake of simplicity. Method: pooled least squares; sample (adjusted) 2 = 190; included observations: 180 after adjustments; cross-sections included: 3; total pool (unbalanced) observations: 537; *, **, ***: significant at 10%, 5%, 1% probability; coefficient SE in brackets; F: F-statistic test, χ^2: chi-square test; Italian Football Club: J (Juventus), L (Lazio), R (Roma).*
Source: Authors' elaboration.

Table 8. Stock price changes and surprise $R_{i,t} - E[R_{i,t}]$ based on the ordered estimation of the naïve model in Table 2

	Model	(1)		(2)		(3)	
Explanatory variables	Coef.	$ln(PC_{i,t+1}/PC_{i,t})$		$ln(PO_{i,t+1}/PC_{i,t})$		$ln(PC_{i,t+1}/PO_{i,t+1})$	
		Coef.	SE	Coef.	SE	Coef.	SE
$const_i$	α_J	0.514**	0.200	0.314	0.155	0.174	0.194
	α_L	-0.273	0.195	0.060	0.155	-0.342*	0.190
	α_R	-0.306	0.202	0.280*	0.156	-0.608***	0.196
$R_{i,t} - E[R_{i,t}\|NaiveORD]$	β_J	0.915***	0.318	1.195***	0.252	-0.269	0.308
	β_L	1.463***	0.265	1.850***	0.212	-0.416	0.259
	β_R	1.508***	0.279	1.768***	0.221	-0.294	0.270
$\ln(PC_{IND,i,t+1}/PC_{IND,i,t})$	γ_{1J}	0.725***	0.148	-	-	-	-
	γ_{1L}	0.432***	0.144	-	-	-	-
	γ_{1R}	0.681***	0.155	-	-	-	-
$\ln(PO_{IND,i,t+1}/PC_{IND,i,t})$	γ_{2J}	-	-	0.255	0.203	-	-
	γ_{2L}	-	-	0.755***	0.209	-	-
	γ_{2R}	-	-	0.140	0.233	-	-
$\ln(PC_{IND,i,t+1}/PO_{IND,i,t+1}$	γ_{3J}	-	-	-	-	0.597***	0.161
	γ_{3L}	-	-	-	-	0.517***	0.159
	γ_{3R}	-	-	-	-	0.634***	0.163
Adj. R^2		0.202		0.278		0.090	
DW		2.094		2.127		1.789	
Redundant	Pr(F)	0.0047		0.4549		0.0161	
Fixed effects	Pr(χ²)	0.0043		0.4480		0.0148	
Wald test: $\beta_J = \beta_L = \beta_R$	Pr(F)	0.3076		0.1102		-	
	Pr(χ²)	0.3067		0.1091		-	

*Note: Method: pooled least squares; sample (adjusted) 2 = 190; included observations: 175 after adjustments; cross-sections included: 3; total pool (unbalanced) observations: 472; *, **, ***: significant at 10%, 5%, 1% probability; coefficient SE in brackets; Italian Football Club: J (Juventus), L (Lazio), R (Roma).*
Source: Authors' elaboration.

Table 9. Stock price changes and surprise $R_{i,t} - E[R_{i,t}]$ when estimations are corrected for their "measuring error" bias

Model		$ln(PC_{i,t+1}/PC_{i,t})$			$ln(PO_{i,t+1}/PC_{i,t})$			$ln(PC_{i,t+1}/PO_{i,t+1})$		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Coef.	OLS	IV (a)	IV (b)	OLS	IV (a)	IV (b)	OLS	IV (a)	IV (b)
$R_{J,t} - E[R_{J,t}]$	β_J	0.914***	0.933***	0.915***	1.047***	1.083***	1.218***	-0.116	-0.050	-0.294
		(0.267)	(0.273)	(0.273)	(0.207)	(0.211)	(0.241)	(0.256)	(0.491)	(0.330)
$R_{L,t} - E[R_{L,t}]$	β_L	1.479***	1.477***	1.326***	2.010***	1.976***	2.004***	-0.533**	-1.699*	-0.821
		(0.233)	(0.235)	(0.235)	(0.183)	(0.183)	(0.208)	(0.228)	(1.029)	(0.636)
$R_{R,t} - E[R_{R,t}]$	β_R	1.442***	1.523***	1.439***	1.547***	1.616***	1.745***	-0.095	-0.060	-0.317
		(0.244)	(0.247)	(0.247)	(0.189)	(0.191)	(0.228)	(0.235)	(0.455)	(0.297)

*Note: Method: pooled IV/two-stage least squares; cross-sections included: 3; total pool (unbalanced) observations: 473; instrument specification for $E[R_{i,t}]$) in IV: a) = Durbin estimator (rank of $E[R_{i,t}]$), b) = $E[R_{i,t}|NaiveORD]$; *, **, ***: significant at 10%, 5%, 1% probability; Italian Football Club: J (Juventus), L (Lazio), R (Roma).*
Source: Authors' elaboration.

One remaining problem is that the actual expectations of shareholders are not known. It is, therefore, not possible to measure actual market surprise with any accuracy, and consequently, all estimates suffer from bias deriving from a "measuring error", or what is often termed "error in variables". In order to roughly estimate the size of this bias, we employed an instrumental variable (IV) estimator instead of OLS by introducing appropriate instrument expectations. In the case of expectation measured by $E[R_{J,t}|BetOdds]$, for example, its rank (Durbin's method) can be taken as an instrument, as can also our alternative measure of expectations, i.e., $E[R_{i,t}|NaiveORD]$. IV estimated parameters are reported in Table 9, along with the previous OLS estimates for comparison. Estimated parameters are similar to the previous ones, although for $ln(PO_{i,t+1}/PC_{i,t})$, coefficients are somewhat higher. This implies that, although we do not have the actual values of market expectations, our measures based on the BetBrain odds are a good approximation.

4.2. Price irregularities and explanations

At the beginning of Section 3, we suggested hypothesis *H2a, H2b, and H2c* of an efficient market.

4.2.1. Market price reaction to surprise is symmetric

To verify *H2a*, we use Eq. (7), where $E[R_{i,t}]$ is identified with $E[R_{i,t}|BetOdds]$.

First of all, we introduce a new generic logic symbol (*x®y*), where *®* is a generic relation between *x* and *y* (e.g., >, or =, or another symbol), where (*x®y*) ≡ 1 if (*x®y*) is true, otherwise (*x®y*) ≡ 0.

After defining $\varepsilon_{i,t} = R_{i,t} - E[R_{i,t}]$ it is possible to verify whether the coefficients of positive and negative surprises are the same, using the following equation:

$$\Delta \ln\left(P_{i,t+1}\right) = \alpha'_i \times \left(\varepsilon_{i,t} > 0\right) + \alpha''_i \times \left(\varepsilon_{i,t} < 0\right) + \beta'_i\left(R_{i,t} - E\left[R_{i,t}\right]\right) \times \left(\varepsilon_{i,t} > 0\right) + \beta''_i\left(R_{i,t} - E\left[R_{i,t}\right]\right) \times \left(\varepsilon_{i,t} < 0\right) + \gamma_i \Delta \ln\left(P_{IND,t+1}\right) \quad (14)$$

The null restriction is $\alpha'_i = \alpha''_i$, $\beta'_i = \beta''_i$ (for i = J, L, R) to be verified by the Wald test (Table 10).

Table 10. Wald test for the joint and single restrictions $\alpha'_i = \alpha''_i$, $\beta'_i = \beta''_i$

Restrictions	***Wald test:***	$ln(PC_{i,t+1}/PC_{i,t})$	$ln(PO_{i,t+1}/PC_{i,t})$	$ln(PC_{i,t+1}/PO_{i,t+1})$
	Test statistic	***Probability***	***Probability***	***Probability***
$\alpha'_h = \alpha''_h$, $\beta'_h = \beta''_h$	F-statistic	0.7878	0.0027***	0.1841
	Chi-square	0.7881	0.0024***	0.1817
$\alpha'_h = \alpha''_h$	F-statistic	0.6066	0.0035***	0.1741
	Chi-square	0.6063	0.0032***	0.1727
$\beta'_h = \beta''_h$	F-statistic	0.7234	0.1404	0.3540
	Chi-square	0.7233	0.1390	0.3530

*Note: *, **, ***: significant at 10%, 5%, 1% probability.*
Source: Authors' elaboration.

Table 10 shows that for $ln(PO_{i,t+1}/PC_{i,t})$, the joint restriction is rejected. The reason is that equality between constants is rejected, although equality between surprise coefficients is not rejected at 10% probability.

The joint restriction cannot be rejected for $ln(PC_{i,t+1}/PC_{i,t})$, suggesting that this anomaly of different constants disappears during the day.

Similar results are obtained in the following case, where the market price reaction is similar for large and small surprises.

4.2.2. Market price reaction is similar for large and small surprises

Let us define a large surprise as one whose absolute value is greater than the 0.80 quantile. The test reported in Table 11 to check whether surprises are small or large is as follows (where $Q_{0.8}$ represents the 80th percentile):

$$\Delta \ln\left(P_{i,t+1}\right) = \alpha'_i \times (abs(\varepsilon_t) \le Q_{0.8}) + \alpha''_i \times (abs(\varepsilon_t) > Q_{0.8}) + \beta'_i\left(R_{i,t} - E\left[R_{i,t}\right]\right) \times (abs(\varepsilon_t) \le Q_{0.8}) + \beta''_i\left(R_{i,t} - E\left[R_{i,t}\right]\right) \times (abs(\varepsilon_t) > Q_{0.8}) + \gamma_i \Delta \ln\left(P_{IND,t+1}\right) \quad (15)$$

and test if $\alpha'_i = \alpha''_i$, $\beta'_i = \beta''_i$ to confirm the restriction.

Table 11. Wald test for the joint restriction $\alpha'_i = \alpha''_i$, $\beta'_i = \beta''_i$

Test	***Dependent variable***		
Wald test	$ln(PC_{i,t+1}/PC_{i,t})$	$ln(PO_{i,t+1}/PC_{i,t})$	$ln(PC_{i,t+1}/PO_{i,t+1})$
Test statistic	Probability	Probability	Probability
F-statistic	0.3096	0.0298**	0.7333
Chi^2	0.3077	0.0283**	0.7335

*Note: *, **, ***: significant at 10%, 5%, 1% probability.*
Source: Authors' elaboration.

Again, the test is rejected for $ln(PO_{i,t+1}/PC_{i,t})$ but accepted for $ln(PC_{i,t+1}/PC_{i,t})$: the adjustment takes place during the day.

4.2.3. Market price reaction to the surprise is independent of whether the match is played at home or away

The test is as follows, where *home* is a 1/0 dummy variable for matches played at home, and *away* is a 1/0 dummy variable for matches played away:

$$\Delta \ln\left(P_{i,t+1}\right) = \alpha'_i \times home_{i,t} + \alpha''_i \times away_{i,t} + \beta'_i\left(R_{i,t} - E\left[R_{i,t}\right]\right) \times home_{i,t} + \beta''_i\left(R_{i,t} - E\left[R_{i,t}\right]\right) \times away_{i,t} + \gamma_i \Delta \ln\left(P_{IND,t+1}\right) \quad (16)$$

And $\alpha'_i = \alpha''_i$, $\beta'_i = \beta''_i$ is the appropriate Wald test. Results are reported in Table 12.

Table 12. Wald test for the joint restriction $\alpha'_i = \alpha''_i$, $\beta'_i = \beta''_i$

Test	***Dependent variable***		
Wald test	$ln(PC_{i,t+1}/PC_{i,t})$	$ln(PO_{i,t+1}/PC_{i,t})$	$ln(PC_{i,t+1}/PO_{i,t+1})$
Test statistic	Probability	Probability	Probability
F-statistic	0.4765	0.3979	0.6274
Chi^2	0.4755	0.3965	0.6272

*Note: *, **, ***: significant at 10%, 5%, 1% probability.*
Source: Authors' elaboration.

The restriction that the surprise effects on price are identical is valid.

4.2.4. Cross-effects of the surprise factor

Demir and Rigoni (2014) find that the victories (defeats) of the Lazio and Roma teams generate positive (negative) reactions in their own stock market prices, but those reactions are also influenced by the performance of the other team. Consistently with this assumption, we modified our usual relation (Eq. (13)) for h = *J, L, R*, into:

$$\Delta \ln\left(P_{h,t+1}\right) = \alpha_h + \beta_{h,J}\left(R_{J,t} - E\left[R_{J,t}\right]\right) + \beta_{h,L}\left(R_{L,t} - E\left[R_{L,t}\right]\right) + \beta_{h,R}\left(R_{R,t} - E\left[R_{R,t}\right]\right) + \gamma_h \Delta \ln\left(P_{IND,t+1}\right) \quad (17)$$

Results are reported in Table 13, with an estimation from Table 5 for purposes of comparison.

The open price variation $ln(PO_{i,t+1}/PC_{i,t})$ is the most sensitive to the surprise factor of other team results. In its estimate, all coefficients are negative. Three coefficients, β_{LJ}, β_{RJ} and β_{JJ}, are significant at 10%, 5%, 1% respectively, but, strangely, they are not symmetric. It is unclear why β_{LJ} and β_{RJ} are significant but not β_{JL} and β_{JR}. Moreover, its adjusted R^2 (0.325) is slightly above the value obtained in Table 5 (0.311). In conclusion, the improvement obtained by including these variables is small, and the interpretation is less clear.

Table 13. Estimates including surprise effects of other teams: Comparison with the baseline estimates in Table 5

Football club	*Coef.*	*Variable*	$ln(PC_{i,t+1}/PC_{i,t})$	$ln(PO_{i,t+1}/PC_{i,t})$	$ln(PC_{i,t+1}/PO_{i,t+1})$	$ln(PO_{i,t+1}/PC_{i,t})$ *from Table 5*
J	β_{JJ}	$R_{J,t} - E[R_{J,t}]$	0.939***	1.061***	-0.098	1.047***
	β_{JL}	$R_{L,t} - E[R_{L,t}]$	0.218	-0.052	0.318	-
	β_{JR}	$R_{R,t} - E[R_{R,t}]$	0.035	-0.218	0.260	-
L	β_{LJ}	$R_{J,t} - E[R_{J,t}]$	-0.425	-0.342*	-0.110	-
	β_{LL}	$R_{L,t} - E[R_{L,t}]$	1.328***	1.897***	-0.580**	2.010***
	β_{LR}	$R_{R,t} - E[R_{R,t}]$	-0.744***	-0.524**	-0.257	-
R	β_{RJ}	$R_{J,t} - E[R_{J,t}]$	-0.250	-0.419**	0.177	-
	β_{RL}	$R_{L,t} - E[R_{L,t}]$	0.159	-0.224	0.443*	-
	β_{RR}	$R_{R,t} - E[R_{R,t}]$	1.487***	1.545***	-0.039	1.547***
Adj. R²			0.248	0.325	0.102	0.311
DW			2.024	2.190	1.938	2.183
Wald test						
$\beta_{JL} = \beta_{JR} = \beta_{LJ} = \beta_{LR} = \beta_{RJ} = \beta_{RL} = 0$		*Pr(F)*	0.0232**	0.0082***	0.2300	-
		Pr(χ²)	0.0219**	0.0075***	0.2277	-

*Note: Method: pooled least squares; sample (adjusted) 1 = 180; included observations: 180 after adjustments; cross-sections included: 3; total pool (unbalanced) observations: 536; *, **, ***: significant at 10%, 5%, 1% probability; Italian Football Club: J (Juventus), L (Lazio), R (Roma).*
Source: Authors' elaboration.

5. ROBUSTNESS TESTS

5.1. The effect of alternative coefficients of stock index variations

In all regressions of price changes estimated in this paper, the change in the stock market index P_{IND} is considered an explanatory variable, and its coefficient is estimated together with the other parameters. It is thus appropriate to check the sensitivity of the coefficients of interest (surprise) to different measurements of the link between variation in football stock prices and the stock index. This value can be obtained in different ways apart from its direct estimate γ_h in Eq. (13).

Theoretically, the value assigned to γ_h should have only a marginal influence on the more important coefficients of surprise, since the stock market index should not be influenced by the surprises themselves, and those variables should be uncorrelated. However, we opt to analyse the use of some alternative *a-priori* values for the coefficient linking club stock price variations to contemporaneous stock index variations. These coefficients, known in the literature as *beta*, make it possible to check how much they influence the parameters of the surprise factor $R_{h,t} - E[R_{h,t}]$.

The values selected for a priori *beta* are reported in Table 14: (1): beta = 0; (2): beta = 1; (3): a publicly available measure of the beta of each team we found online; (4): betas of the daily values we estimated for each team in the period 2014–2019.

Results confirm that surprise coefficients are fairly stable when the coefficient of the stock price index changes (Table 15).

Table 14. *A-priori* values of *beta*

Beta	*Football club*	$ln(PC_{IND,t+1}/PC_{i,t})$	$ln(PO_{IND,t+1}/PC_{i,t})$	$ln(PC_{IND,t+1}/PO_{i,t+1})$
(1)	All teams	0	0	0
(2)	All teams	1	1	1
(3)	Juventus (*)	0.81	0.81	0.81
	Lazio (**)	0.98	0.98	0.98
	Roma (***)	1.10	1.10	1.10
(4)	Juventus	0.4953	0.2964	0.4940
	Lazio	0.3556	0.3590	0.4802
	Roma	0.4042	0.2537	0.4442

*Source for * https://www.infrontanalytics.com/fe-IT/30282EI/Juventus-Football-Club-S-p-A-/beta;*
*Source for ** https://www.infrontanalytics.com/fe-it/IT0003621783/S-S-Lazio-S-p-A-/beta;*
*Source for *** https://www.infrontanalytics.com/fe-it/IT0001008876/A-S-Roma-S-p-A-/beta.*

Table 15. Surprise coefficients and different values of *beta*

Coef.	Variable	Free beta (Table 5)	Beta imposed a priori (Table 14) (1)	(2)	(3)	(4)
		$ln(PC_{i,t+1}/PC_{i,t})$				
β_J	$R_{J,t}-E[R_{J,t}]$	0.914***	0.956***	0.900***	0.911***	0.928***
β_L	$R_{L,t}-E[R_{L,t}]$	1.479***	1.449***	1.531***	1.529***	1.478***
β_R	$R_{R,t}-E[R_{R,t}]$	1.442***	1.480***	1.432***	1.427***	1.460***
		$ln(PO_{i,t+1}/PC_{i,t})$				
β_J	$R_{J,t}-E[R_{J,t}]$	1.047***	1.061***	1.020***	1.027***	1.049***
β_L	$R_{L,t}-E[R_{L,t}]$	2.010***	2.107***	1.948***	1.951***	2.050***
β_R	$R_{R,t}-E[R_{R,t}]$	1.547***	1.539***	1.563***	1.565***	1.545***
		$ln(PC_{i,t+1}/PO_{i,t+1})$				
β_J	$R_{J,t}-E[R_{J,t}]$	-0.113	-0.103	-0.127	-0.121	-0.112
β_L	$R_{L,t}-E[R_{L,t}]$	-0.537**	-0.658***	-0.409*	-0.414*	-0.538**
β_R	$R_{R,t}-E[R_{R,t}]$	-0.109	-0.059	-0.117	-0.124	-0.079

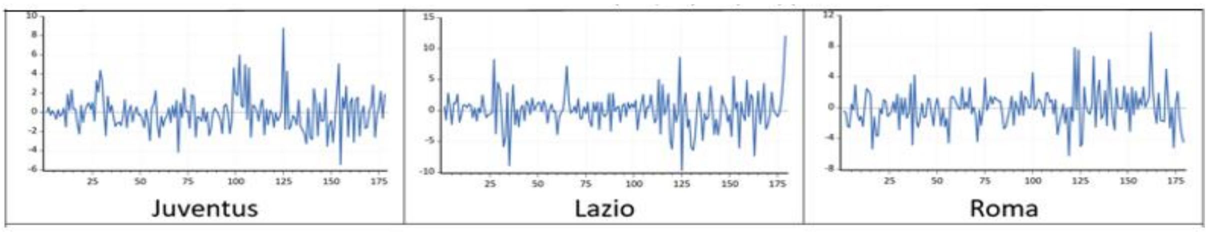
*Note: Method: pooled least squares; sample (adjusted) 1 = 190; included observations: 182; cross-sections included: 3; total pool (unbalanced) observations: 542; *, **, ***: significant at 10%, 5%, 1% probability; Italian Football Club: J (Juventus), L (Lazio), R (Roma). (1): beta = 0; (2): beta = 1; (3): a publicly available measure of the beta of each team we found online; (4): betas of the daily values we estimated for each team in the period 2014–2019.*
Source: Authors' elaboration.

5.2. Ordinary least squares, GARCH and quantile regression estimators

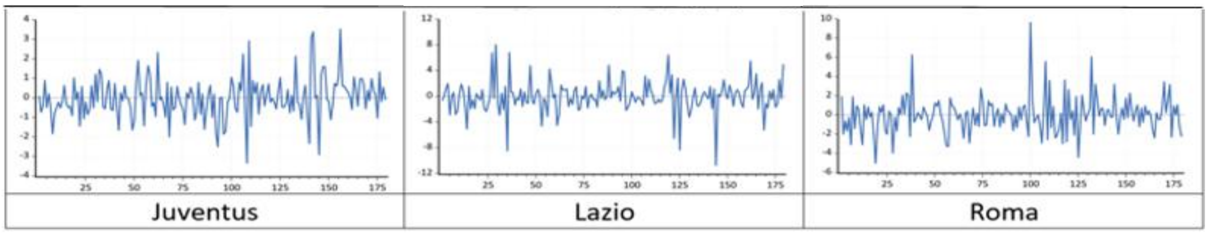
Ashton et al. (2011) find that their results are sensitive to which estimator is used, i.e., GARCH or OLS. GARCH, in fact, yielded certain significant results which OLS did not. In our study, residuals are not too distant from those required by an OLS assumption (residual normality and constant variance), as shown in Figures 5 and 6. There appears to be no problem with our estimates. However, as a further robustness check, estimates obtained by OLS, GARCH and quantile regression (QREG) (quantile regression, relatively insensitive to possible outliers) were compared.

Figure 5. Residuals of the OLS estimator of Table 5

Panel A: $\boldsymbol{ln(PC_{i,t+1}) - ln\,(PC_{i,t})}$

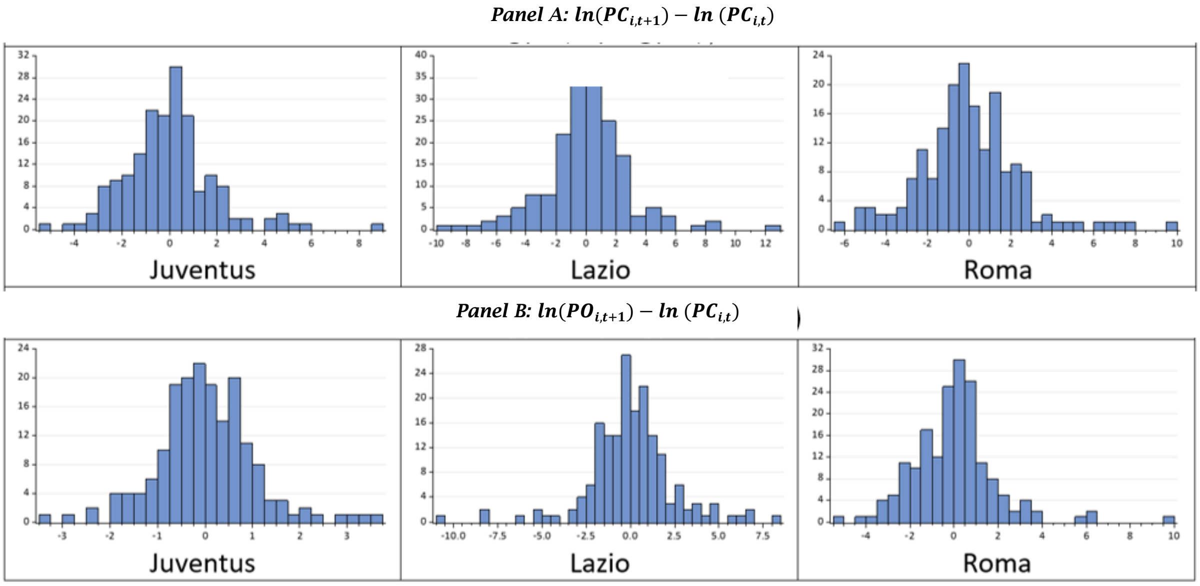


Panel B: $\boldsymbol{ln(PO_{i,t+1}) - ln\,(PC_{i,t})}$



Source: Authors' elaboration.

Figure 6. Residuals of OLS estimator — Histograms



Source: Authors' elaboration.

The corresponding estimated coefficients of the surprise factor $R_{i,t} - E[R_{i,t}]$ are reported in Table 16 for the regressions of $ln(PC_{i,t+1}) - \ln\ (PC_{i,t})$ and $ln(PO_{i,t+1}) - \ln\ (PC_{i,t})$. Coefficients from GARCH and QREG estimators do not appear to be very different and the remarks above on the basis of OLS remain valid.

Table 16. Coefficient of the surprise factor using different estimators

	$ln(PC_{i,t+1}) - ln\ (PC_{i,t})$		
Coef.	***OLS***	***GARCH(1,1)***	***QREG***
$R_{J,t} - E[R_{J,t}]$	0.914*** (0.267)	0.899*** (0.212)	0.880*** (0.219)
$R_{L,t} - E[R_{L,t}]$	1.479*** (0.233)	1.427*** (0.294)	1.226*** (0.270)
$R_{R,t} - E[R_{R,t}]$	1.442*** (0.244)	1.558*** (0.216)	1.352*** (0.293)
	$ln(PO_{i,t+1}) - ln\ (PC_{i,t})$		
Coeff.	***OLS***	***GARCH(1,1)***	***QREG***
$R_{J,t} - E[R_{J,t}]$	1.047*** (0.210)	0.982*** (0.113)	1.047*** (0.121)
$R_{L,t} - E[R_{L,t}]$	2.010*** (0.183)	1.917*** (0.248)	1.654*** (0.223)
$R_{R,t} - E[R_{R,t}]$	1.547*** (0.189)	1.575*** (0.195)	1.311*** (0.204)

*Note: GARCH estimated by ARCH maximum likelihood (Broyden-Fletcher-Goldfarb-Shanno (BFGS)/Marquardt), diagonal vector-half covariance. QREG estimated by median quantile regression with Huber-Sandwich standard errors; Epanechnikov kernel for sparsity estimation and Hall-Sheather bandwidth selection. *, **, ***: significant at 10%, 5%, 1% probability; Italian Football Club: J (Juventus), L (Lazio), R (Roma).*
Source: Authors' elaboration.

6. CONCLUSION

This study examines the relationship between football match outcomes and stock market reactions for the three Italian clubs listed on the stock exchange over the 2013–2014 to 2018–2019 football seasons. Measuring expectations of match outcomes with the use of bookmaker betting odds and a specially constructed econometric model, we find that the surprise factor of match results, rather than the results themselves, affects market prices, exactly as predicted by the theory of efficient markets. We also show that the bias arising from using approximate measures of the true market surprise regarding match results is small. These results underline the importance of correctly modelling expectations when analysing the link between sporting events and financial markets. Studies relying solely on raw match outcomes risk misinterpreting investor reactions, since the market responds only to genuinely unanticipated information. By isolating the unexpected component of performance, our framework offers a more accurate representation of how news is incorporated into prices. This approach also provides a clearer setting for evaluating semi-strong market efficiency, as it allows the reaction to be traced precisely to information that was not known *ex-ante*.

Even if the stocks considered are known to have a small amount of trade volume, the reaction of market prices to the surprise is rapid and is largely incorporated into the opening price on the first trading day after the match. We find that some irregularities observed in the opening prices are eliminated during the first day.

Employing more sophisticated estimators than OLS improves parameter efficiency, but does not influence the results. Similarly, alternative representations of the relationship between individual stock prices and market index changes are irrelevant to the findings. Our robustness checks, including IV, GARCH and QREG estimators, confirm that these results are stable across alternative specifications.

Some critical aspects of share price dynamics not covered in this analysis deserve further study. Future research could investigate the evolution over time of the link between surprise and price, explore the relevance of particularly important match dates for clubs, examine football club stock-price volatility at a higher frequency, or extend the analysis to other leagues and countries. Despite these limitations, the paper provides strong evidence that only the unexpected component of match outcomes affects returns and that stock markets incorporate this information quickly. These findings offer a deeper understanding of the mechanisms through which non-financial events influence financial markets and open several promising avenues for subsequent research on market efficiency and behavioural reactions in sports-related contexts.

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