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Quantifying speculative-bubble effects in major European soccer leagues

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ABSTRACT

We apply the theory of super-exponential rational bubbles to football transfer data. Refining previous qualitative approaches we model the aggregate transfer spend as a fraction of the TV income. Evidence of substantial bubble effects is found across the English, French, German and Italian leagues. This suggests long-term reductions in transfer spending relative to TV receipts. Our model predicts the existence of other signs of soccer bubbles beyond over-pricing. These include differences in the market for star players and the market for regular players and other signs of illiquidity.

1. Introduction

Soccer is big business, with vast transfer fees paid for players (Coates and Parshakov, 2022). However, professional soccer is also a financial basket case. This has been highlighted by a spate of recent points deductions in the English Premier League for breaches of the league's profit and sustainability rules. However, these problems are deep-seated, dating back to at least 2006–2011, with European soccer club indebtedness increasing substantially despite revenues drastically increasing at the same time (Plumley et al., 2021). The governing body UEFA has introduced Financial Fair Play regulations to address this. However, insolvency continues to affect European Leagues (Carin, 2019) amid suggestions compliance has been piecemeal (D'Angelo, 2018). This has been accompanied by fraudulent behaviour (Dimitropoulos, 2011), monies wasted in compensation paid to sacked managers (Fry et al., 2021) and inefficient transfer spending (Mourao, 2016).

These excesses make for a compelling analogy between speculative bubbles and football finance. However, previous work has been largely qualitative in nature. A recent exception is Pancotto et al. (2024). Richau et al. (2021) apply a qualitative model in Kindelberger and Aliber (2005) to football transfer markets. Some quantitative analysis of the aggregate transfer spend is also performed.

Theory thus has an important role to play in extending previous empirical work (see Section 4). Theory also has an important role to play in understanding such a complex environment. Balancing sporting and financial performance is challenging (Galariotis et al., 2018) and intrinsically speculative in nature. Speculation may also be needed to break into prevailing elites (Plumley et al., 2021) and as a pre-requisite for genuine innovation to occur (Gisler and Sornette, 2021).

Inspired by Richau et al. (2021) we develop a speculative bubble model for soccer transfer data. The importance of our contribution is threefold. Firstly, we model super-exponential bubbles in the aggregate transfer spend as fraction of the TV money. This places results in an appropriate theoretical context (Cheah and Fry, 2015) and puts data onto a more meaningful measurement scale. Secondly, we sound a timely note of caution regarding the sustainability of football finance. Transfer spending can be categorised as a speculative bubble. This implies future spending may have to be reduced in line with available TV monies. Thirdly, a theoretical exposition using super-exponential rational bubble models is interesting and important in its own right. Our model also predicts the existence of other forms of illiquidity in soccer markets beyond over-pricing.

The layout of this paper is as follows. The model is outlined in Section 2. An empirical application to major European soccer leagues is given in Section 3. Section 4 concludes and discusses the opportunities for further research.

2. The model

In this section we develop a model for speculative bubbles. The practical importance of our approach is fourfold. Firstly, the approach

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tallies with previous suggestions of football bubbles (Richau et al., 2021). Secondly, the approach is empirically innovative since it is applied to the aggregate transfer spend measured as a fraction of the season's TV income. Thirdly, speculative bubbles constitute a natural way of modelling and conceptualising negative future scenarios. Fourthly, the approach can also be adapted to model switches between periods of over and under valuation (Fry and Cheah, 2016).

Let P_t denote the price of an asset at time t and let $X(t) = \log(P(t))$. In our context $P(t)$ represents the aggregate transfer spend as a fraction of the TV money. Following Johansen et al. (2000) our starting point is the equation

$$P(t) = P_1(t)(1-\kappa)^{j(t)}, \tag{1}$$

where $P_1(t)$ satisfies

$$dP_1(t) = \left[\mu(t) + \sigma^2(t)/2\right] P_1(t)dt + \sigma(t)P_1(t)dW_t, \tag{2}$$

where W_t is a Wiener process and $j(t)$ is a jump process satisfying

$$j(t) = \begin{cases} 0 & \text{before the crash} \\ 1 & \text{afterwards.} \end{cases} \tag{3}$$

Prior to the crash $P(t) = P_1(t)$ and it follows that $X(t)$ satisfies

$$dX_t = \mu(t)dt + \sigma(t)dW_t - \upsilon dj(t), \tag{4}$$

where $\upsilon = -log(1-\kappa) \geq 0$. If the crash has not occurred by time t we have that

$$E[j(t+\Delta) - j(t)] = \Delta h(t) + o(\Delta), \tag{5}$$

$$\text{Var}[j(t+\Delta) - j(t)] = \Delta h(t) + o(\Delta), \tag{6}$$

where $h(t)$ is the hazard rate. As in Cheah and Fry (2015) under the assumption of a constant rate of return

$$\mu(t) - \upsilon h(t) = \mu; \quad \mu(t) = \mu + \upsilon h(t). \tag{7}$$

Thus, the effect of the crash hazard rate $h(t)$ is to drive up prices during the bubble. Our model also predicts a related impact upon market volatility. As in Cheah and Fry (2015) under the assumption of a constant intrinsic rate of risk

$$\sigma^2(t) + \upsilon^2 h(t) = \sigma^2; \quad \sigma^2(t) = \sigma^2 - \upsilon^2 h(t). \tag{8}$$

Thus, allied to an increase in prices defined by Eq. (7), bubbles should be accompanied by a decrease in the volatility function. Choosing the form of $h(t)$ completes the model. Following Cheah and Fry (2015) we use

$$h(t) = \frac{\beta t^{\beta-1}}{\alpha^\beta + t^\beta}. \tag{9}$$

Economic size of the effect. An estimate of the economic size of the effect can be constructed as follows. If $\upsilon \neq 0$ we have that

$$X_t \sim N(X_0 + \mu t + \upsilon H(t), \sigma^2 t - \upsilon^2 H(t)),$$
$$H(t) = \int_0^t h(u)du = \ln\left(1 + \frac{t^\beta}{\alpha^\beta}\right). \tag{10}$$

From Eq. (10) define

$$\widetilde{P}(t) = \text{Median } P(t) = P_0 e^{\left(\mu + \frac{\sigma^2}{2}\right)t} \left(1 + \frac{t^\beta}{\alpha^\beta}\right)^{\upsilon}.$$

Define the fundamental value as

$$P_F(t) = [\widetilde{P}(t) | \upsilon = 0] = P_0 e^{\mu t}.$$

If $\upsilon \neq 0$ the over-pricing effect during bubbles can be estimated as the "average distance" between fundamental and observed prices:

$$\gamma = \text{Effect size} = 1 - \frac{1}{T}\int_0^T \frac{P_F(t)}{\widetilde{P}(t)} dt = 1 - \frac{1}{T}\int_0^T \left(1 + \frac{t^\beta}{\alpha^\beta}\right)^{-\upsilon} dt. \tag{11}$$

Long-term economic prospects. The long-term economic prognosis after the bubble bursts may be inferred from the long-term logarithmic growth rate μ:

$$\mu > 0 \Rightarrow \text{outlook positive}$$
$$\mu < 0 \Rightarrow \text{outlook negative.} \tag{12}$$

Eq. (12) thus gives a principled way of quantifying the long-term outlook for European football markets once short-term speculative-bubble effects subside. See Section 3.

Table 1
Football finance data used as part of this study. Figures are in millions of Euros unless stated.

Year	England		Italy		France		Germany	
	Transfer spend	TV deal (£m)	Transfer spend	TV deal	Transfer spend	TV deal	Transfer spend	TV deal
1999	374.4821	167.5						
2000	314.138	167.5					149.685	212
2001	485.002	167.5			233.46	329	115.965	383
2002	580.451	366.67			171.37	329	185.2	383
2003	335.583	366.67			73.38	329	120.89	383
2004	424.132	366.67			109.68	329	85.28925	440
2005	506.64	341.33			140.65	375	86.715	440
2006	503.828	341.33			179.26	550	108.61	440
2007	546.925	341.33			206.99	655	144.73	440
2008	941.213	390			262.15	668	272.21	440
2009	857.756	390			247.24	668	185.25	412
2010	593.6725	390	555.2	844	271.47	668	245.86	412
2011	701.3	594	478.48	935	153.92	668	213.44	412
2012	639.018	594	639.76	967	246.34	607	224.22	412
2013	775.025	594	576.73	967	259.9	607	291.105	412
2014	924.402	1006	605.68	967	408.58	607	307.9	628
2015	1233.7035	1006	552.3	967	176.52	607	370.525	628
2016	1471.95	1006	804.1	1151	365.34	726.5	475.896443	628
2017	1666.905	1712	901.83	1151	364.52	726.5	731.6175	628
2018	2182.72	1712	1077.6	1151	751.08	726.5	732.04	1160
2019	1654.56	1712	1374.56	1313	743.29	726.5	566.81	1160
2020	1811.431086	1258.33	1465.51	1313	844.62	726.5	970.535	1160
2021	1582.151	1258.33	995.75	1313	471.48	582	396.4	1160
2022	1706.6658	1258.33	842.08	927.5	480.76	582	511.298635	1079
2023	3086.56	1632	888.49	927.5	744.1	582	553.86	1079

Table 2
Spanish football finance data used as part of this study. Figures are in millions of Euros unless stated.

Year	Spain transfer spend	Spain TV deal
2018	530.99	1374.10
2019	1051.25	1420.00
2020	1539.39	1417.70
2021	428.24	1444.70
2022	390.55	1426.93
2023	564.34	1374.10

3. Data and empirical application

The data collected are shown in Tables 1–2 and reflect the relatively recent institution of collective TV deals in the Spanish and Italian leagues. Following Richau et al. (2021) data on aggregate transfer spend is taken from `transfermarkt.com`. Transfer-spending data for England is then converted to pounds sterling using historical annual exchange-rate data. We then calculate $P(t)$ as the aggregate transfer spend as a fraction of the season's TV money. Plots of $P(t)$ are shown in Fig. 1. Summary statistics for the log-returns are shown in Table 3.

Tables 4–5 present tests for the presence of speculative bubbles in the $P(t)$ series. Table 4 gives the results of a non-standard maximum-likelihood ratio test (Self and Liang, 1987) that tests the null hypothesis $\upsilon = 0$ against the one-sided alternative $\upsilon > 0$. Based on Eq. (11) Table 5 tests the null hypothesis $\gamma = 0$ against the one-sided alternative $\gamma > 0$. Results in Tables 4–5 suggest evidence for bubbles in England, Italy, France and Germany. Results in Table 5 indicate the economic size of the effect is substantial.

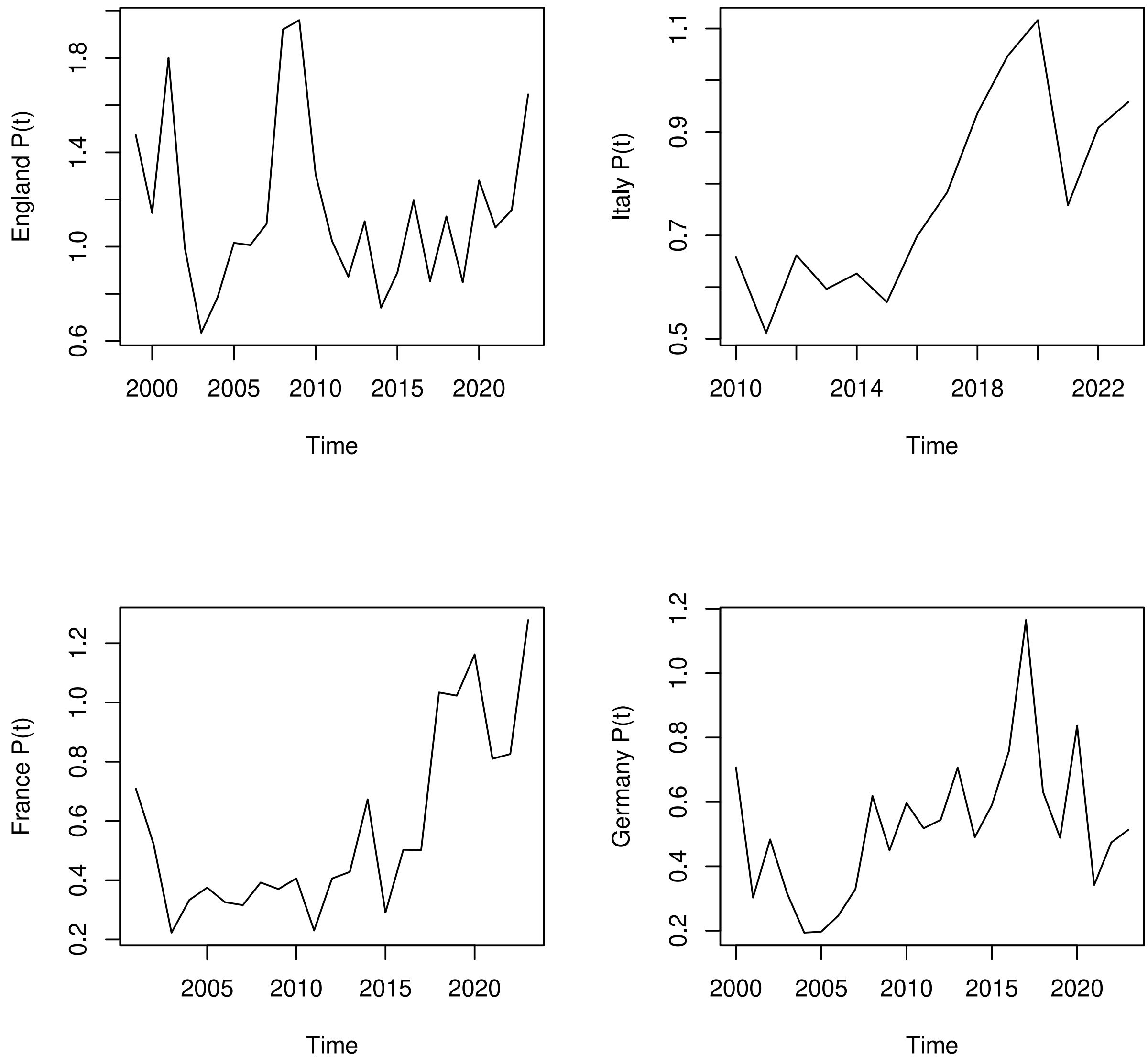

Fig. 1. Plot of constructed $P(t)$ series for English, Italian, French and German football leagues.

Table 3
Summary statistics of log-returns data.

Series	Mean	Max	Min	St. Dev	Kurtosis	Skewness	Jarque Bera
England	0.005	0.561	−0.594	0.326	1.835	−0.113	1.408
Spain	0.012	0.650	−1.298	0.779	2.684	−1.113	1.053
Italy	0.029	0.257	−0.386	0.189	2.941	−0.942	1.923
France	0.027	0.723	−0.848	0.424	2.764	−0.505	0.985
Germany	−0.014	0.632	−0.895	0.438	2.231	−0.527	1.631

Table 4
Likelihood ratio tests for the presence of a speculative bubble within aggregate transfer-spend data measured as a fraction of the TV income.

Country	Random walk model	Bubble model	Likelihood ratio	p-value
England	−6.676	−3.874	5.602	0.024
Spain	−5.286	−3.287	3.999	0.057
Italy	3.765	6.646	5.760	0.022
France	−11.811	−9.588	4.447	0.045
Germany	−13.128	−8.613	9.031	0.004

Table 5
Coefficient of over-pricing test for the presence of a speculative bubble within aggregate transfer-spend data.

Country	$\hat{\gamma}$	E.S.E $\hat{\gamma}$	t-value	p-value
England	0.751	0.019	39.027	0.000
Spain	0.221	0.105	2.091	0.142
Italy	0.446	0.079	5.646	0.000
France	0.820	0.033	24.912	0.000
Germany	0.765	0.022	34.707	0.000

Table 6
Test for negative long-term logarithmic growth rate.

Country	$\hat{\mu}$	E.S.E $\hat{\mu}$	t-value	p-value
England	−0.234	0.071	−3.300	0.002
Spain	0.012	0.156	0.035	0.513
Italy	−0.124	0.056	−2.220	0.027
France	−0.364	0.070	−5.214	0.000
Germany	−0.301	0.093	−3.236	0.002

Table 6 tests the null hypothesis the logarithmic growth rate $\mu \geq 0$ against the one-sided alternative $\mu < 0$. Results give evidence for negative long-term logarithmic growth rates in England, Italy, France and Germany. Thus, reductions in transfer spending as a fraction of the TV monies received may be anticipated over the longer-term.

4. Conclusions and further work

We apply the theory of super-exponential rational bubbles to football transfer data. Refining previous qualitative approaches we model the aggregate transfer spend as a fraction of the TV income serves as the price of a representative asset. We sound a timely note of caution regarding the financial sustainability of European soccer and lay out an appropriate theoretical basis for future work (see below).

Following Richau et al. (2021) we analyse data from the English, French, German, Italian and Spanish leagues. Two different statistical tests give confirmatory evidence of bubbles in England, France, Germany and Italy. Moreover, the size of the bubble is substantial. No evidence of a bubble was found in Spain though this may be linked to limited data availability due to the relatively recent nature of Spain's collective TV deal. Bubbles in England, France, Germany and Italy are accompanied by negative long-term logarithmic growth rates. This suggests that transfer spend will ultimately have to be reduced in line with TV receipts.

There are several interesting avenues for future research. Related theory (Sornette and Ouillon, 2012) suggests differences in the market for regular players and the market for star players. Bubbles may be associated with an increased number of transactions (Kindelberger and Aliber, 2005). This implies bubbles may be associated with an increase in the number of transfers (including free transfers) though early findings are inconclusive (Richau et al., 2021). Theory (Johansen et al., 2000) and empirical work (Fry, 2008) predict power-law singularities of the form $\sim |t_c - t|^\alpha$ in liquidity, trading volume and market impact prior to crashes. The prediction would therefore be of other signs of football bubbles beyond over-pricing. Other social factors, e.g. excessive media attention, may also indicate the presence of soccer bubbles.

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Data availability

Data will be made available on request.

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