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Complex dynamics in the distribution of players' scoring performance in Rugby Union world cups

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HIGHLIGHTS

- Players' scoring performance was investigated over 7 rugby world cups (1987–2011).
- A special attention was given to the switch between amateurism and professionalism.
- The simplified canonical law describes well the distribution of points scored.
- Professionalism led to a decrease in the relative performance of best scorers.
- Professionalism led to a progressive homogenization among all scorers performance.

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ABSTRACT

The evolution of the scoring performance of Rugby Union players is investigated over the seven rugby world cups (RWC) that took place from 1987 to 2011, and a specific attention is given to how they may have been impacted by the switch from amateurism to professionalism that occurred in 1995. The distribution of the points scored by individual players, P_s, ranked in order of performance were well described by the simplified canonical law $P_s \propto (r+\phi)^{-\alpha}$, where r is the rank, and ϕ and α are the parameters of the distribution. The parameter α did not significantly change from 1987 to 2007 ($\alpha = 0.92 \pm 0.03$), indicating a negligible effect of professionalism on players' scoring performance. In contrast, the parameter ϕ significantly increased from $\phi = 1.32$ for 1987 RWC, $\phi = 2.30$ for 1999 to 2003 RWC and $\phi = 5.60$ for 2007 RWC, suggesting a progressive decrease in the relative performance of the best players. Finally, the sharp decreases observed in both $\alpha(\alpha = 0.38)$ and $\phi(\phi = 0.70)$ in the 2011 RWC indicate a more even distribution of the performance of individuals among scorers, compared to the more heterogeneous distributions observed from 1987 to 2007, and suggest a sharp increase in the level of competition leading to an increase in the average quality of players and a decrease in the relative skills of the top players. Note that neither α nor ϕ significantly correlate with traditional performance indicators such as the number of points scored by the best players, the number of games played by the best players, the number of points scored by the team of the best players or the total number of points scored over each RWC. This indicates that the dynamics of the scoring

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performance of Rugby Union players is influenced by hidden processes hitherto inaccessible through standard performance metrics; this suggests that players' scoring performance is connected to ubiquitous phenomena such as anomalous diffusion.

1. Introduction: the game of rugby

Rugby Union, one of the two codes of rugby football, was declared as an open game, free of the previous restriction of amateurism, on 26 August 1995 by the International Rugby Football Board, which later became the International Rugby Board (IRB). The Rugby World Cup, first held in 1987 in New Zealand, takes place every four years, and is one of the major international rugby competitions with the Six Nation Championship in Europe (disputed by England, France, Ireland, Italy, Scotland and Wales), and the Rugby Championship in the Southern Hemisphere (disputed by Argentina, Australia, New Zealand and South Africa). Note that the Six Nations Championship and the Rugby Championship are the successors of the Five Nations Championship and the Tri Nations, which have respectively been contested between England, France, Ireland, Scotland and Wales from 1940 to 1999, and between Australia, New Zealand and South Africa from 1996 to 2011. Readers unfamiliar with the game may refer to http://en.wikipedia.org/wiki/Rugby_union and http://www.irb.com for details on the origin, rules and governing bodies.

To date, several aspects of the game have been thoroughly investigated, including game statistics [1–4], players skills [5,6], player characteristic and game patterns [7–9], the effects of rule changes on game patterns [10–13] and on the incidence of injury [14], and different aspects of performance analysis [15] such as the physical demands of performance [16–19], the tactical aspects of performance [20–23], and the technical analysis of performance [24].

However, despite a few reviews on the social and financial consequences of Rugby Union professionalism in Australia, New Zealand and South Africa [25–29], considerations of the consequences of the shift between amateurism and professionalism in Rugby Union have been limited to studies of the incidence of injuries [29–31] and playing patterns [3,32]. Due to an expanding consumer culture (and despite early warnings that if the code was to pay its players and administrators it would transform from play into work and destroy its amateur ethos and character building quality [33]), the traditional cultural and social barriers that were thought to divide business from sport vanished [34]. Commercialization overwhelmed the game in 1995 when Murdoch's global TV network entered into the multimillion agreement with the national governing bodies of Australia, New Zealand and South Africa. As a consequence, Rugby Union is not only a sport anymore, but became a business that craves for media attention, corporate support and audience interest, and subsequently increased the demand for televised rugby competitions and the derived demand for rugby player [25]. Rugby Union transformed into a highly professionalized and business-like activity, with players earning massive salaries and receiving a lot of media attention such as New Zealander Jonah Lomu and Englishman Jonny Wilkinson, who were the first Rugby Union players to reach a status of global superstars.

No attention has been given, however, to the individual scoring performance of players over the years, and how they might have been impacted by professionalism. In this context, this paper shows that the distribution of rugby players individual scoring performance in seven successive world cups is well adjusted by the Zipf–Mandelbrot scaling law [35,36]. It also investigates how players relative performance may have been impacted by professionalism, and discusses their origin and significance through an analogy with the economic and ecological systems, the system of ideal gases, and idealized theoretical systems where individuals are rewarded not according to their absolute performance, but according to their performance relative to others, and coined 'celebrity markets' [37].

2. Complex systems and the simplified canonical law

Many natural complex systems such as rainfalls [38,39], earthquakes [40,41], solar flares [42], population growth [43], species lifetimes [44] and abundance [45], population dynamics [46], forest fires [47], rainforest dynamics [48] and epidemics [49]. This has also been observed in social and economic systems such as city size [50–52] and growth [53,54], company size [55] and income [56], the sales of music recordings [57], scientific citations [58,59], internet surfing [60,61], the frequency of occurrence of personal names in most cultures [62], car traffic [63] and war distribution [64,65] that all are characterized by rare large fluctuations interspersed among long period of relative stasis. For instance, at the evolutionary scale, adaptive radiations occur in short bursts of evolutionary activity, referred to as punctuated equilibrium [66,67], and extinction events in the fossil records appear episodic with relatively long periods of stability alternating with short-lived extinction events [68]. Biomass and species are also rarely dispersed uniformly, but instead characterized by intermittent distributions, with rare dense patches interspersed among a wide range of low density patches [69]. Similarly, a long text generally contains many words that are employed in few contexts and a small number that occurs widely [70,71]. These systems typically self-organize to produce scale-free distributions [72,73]. More recently heavy-tailed distributions were also found in the statistical distribution of achievement in sport and science [74,75].

Scale-free distributions were recognized more than a century ago by the economist Vilfredo Pareto (1848–1923) who showed that the wealth w in any society followed the power-law form $P(W) \propto w^{-\gamma}$ [76], or equivalently $P(W > w) \propto$