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Articles

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The current issue is the first of the seventh volume of the *Athens Journal of Sports*, published by the Sport, Exercise, & Kinesiology Unit of the ATINER under the aegis of the Panhellenic Association of Sports Economists and Managers (PASEM).

Gregory T. Papanikos, President, ATINER.

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11-14 May 2020, Athens, Greece

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- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **13 April 2020**

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Dr. Maria Konstantaki, Academic Member, ATINER & Senior Lecturer, Buckinghamshire New University, UK.

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Numerical Simulation of Wind Drift of Arrows on the Olympic Venue for Tokyo 2020

By Julio Ortiz[*], Masato Ando[±] & Takeshi Miyazaki[‡]

In the present work, the dynamics of archery arrows are studied by means of a mathematical model to evaluate their response to different wind characteristics and initial conditions. Numerical computations are performed to quantify the effect that the background wind has on the dynamics of the arrows during their flights. Aerodynamic and physical characteristics of two commercial arrows are considered. The background wind information from the venue, where the Archery competition will be held in the Tokyo Olympic Games in 2020 was provided by JAMSTEC. In a simulated archery range of 70 m, the heavier arrow showed a lateral deviation from the center of the target of ~0.11 m, whereas the lighter arrow showed a final deviation in its trajectory of ~ 0.15 m. The ratio of the drag force to the gravitational force plays a key role in determining the deviation in the trajectory. By keeping the boundary layer laminar, a less deviated shot can be achieved. With increasing arrow's initial velocity, the deviation in the trajectory also reduces.

Keywords: *Background wind, Numerical computation, Olympic Games, Tokyo 2020, Trajectory and attitude of archery arrows.*

Introduction

In this paper, the effect of different types of background winds in the dynamics of archery arrows is studied by means of numerical simulations. Archery competition is a sports discipline in which the accuracy and precision are key factors in order to obtain a good final score. In the competitions using a recurve bow, the archers aim at a target with 1.22 m in diameter and located 70 m away. The target is divided into 10 smaller evenly spaced concentric circles, rings. The innermost of the rings has a diameter of 0.122 m and is assigned with the maximum of 10 points. The archers shoot a specified number of arrows and the one who sums more points wins the competition. Striking the innermost ring gives the opportunity to elevate the final score, which is complicated if the multiple elements affecting the shots are considered.

In recent years, the sports engineering became a flourishing research field for engineers due to the realization of the positive impact of using modern tools and techniques in the design and testing stages of sports equipment. The literature

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covers a wide range of examples for various sports and approaches (Allen and Goff 2018, Haake 2009), including sport projectiles (Goff 2013, Hubbard 1984).

The archery competition has been extensively studied. On the one hand, the internal ballistics of the arrows, i.e. when the arrow is propelled using the bow, has been analysed by Kooi and Sparenberg (1997), Kooi (1998) and Zaniewsky (2009). Kooi described in detail the flexural oscillation of the arrows during the release stage by assuming the arrows to be inextensible Euler-Bernoulli beams, whereas Zaniewsky analysed the vibrations in the bow-arrow system (Kooi and Sparenberg 1997, Kooi 1998, Zaniewsky 2009).

On the other hand, the external ballistics of an archery arrow refer to the stage immediately after the propulsion phase in which an arrow is subject to aerodynamic and gravitational forces. In a 70 m archery range, arrows shot with an initial velocity of around 57 ms^{-1} remain in free-flight less than 1.5 s. Arrows traveling downrange rotate and oscillate longitudinally around their center of mass. Such complex movements make difficult the analysis of their dynamics.

Several research groups have analysed the arrow's external ballistics. Barton et al. (2011, 2012) designed and mounted an electronic velocity sensing device to measure the launching and impact velocities of hunting arrows shot with a crossbow (Barton et al. 2011, 2012). Park et al. (2011) carried out water channel experiments and UV dye tests to understand the effect that the point's shape has on the arrow's boundary layer (Park et al. 2011). The water channel tests were performed with a maximum Reynolds number Re= 3.43×10^4 (using the arrow's diameter as the characteristic length) and varying the angle of attack from 0º to 3º. The transition point from a laminar to a turbulent boundary layer was verified to be sensitive to the point's geometry, Re and angle of attack.

Park (2011) carried out numerical computations to obtain the wind drift of several types of arrows when uniform side-winds blow (Park 2011). In a previous work of our group (Ortiz et al. 2019), the deviations in the trajectories of arrows subject to background wind with laminar and turbulent boundary layers were quantified. For a uniform side wind of 3 ms^{-1}, arrows with laminar boundary layers showed a reduction in the lateral drift by around 0.15 m, which is not negligible, compared with their turbulent counterpart. Furthermore, arrows with larger mass showed less deviated trajectories than the lighter ones.

It is relevant to note that during outdoor archery competitions, the background wind is an important factor that cannot be controlled by the archers and that must be taken into account when studying the dynamics of archery arrows. It is known that the wind currents might be one of the most important elements disturbing the shots (Park 2019). The wind influence on sports competitions has already been studied for other sports disciplines, like the ski jumping (Jung et al. 2018) and javelin throw (Hubbard and Rust 1984). Nevertheless, the existing studies related with archery competition only cover uniform-type wind velocities, which under real meteorological conditions might be unusual.

During actual outdoor competitions, it is likely that the winds' velocity along the archery range change spatially and temporary. Furthermore, the wind direction might vary abruptly, adding difficulty to the shots and provoking an unexpected arrows' behaviour. Such changing wind velocities have been considered previously to compute the trajectory of golf shots (Yaghoobian and Mittal 2018); nevertheless, there is no record of such analysis for the archery competition.

To carry out a more realistic simulation of an outdoors archery competition, the effect of non-uniform wind velocities is considered in the current study. The present work takes into account the wind characteristics where the archery competition will be held in the summer Tokyo Olympic Games in 2020. The wind information was computed using a Large Eddy Simulator (LES), developed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The main characteristic of the wind behaviour information provided by JAMSTEC is that the wind component velocities vary with time and position, allowing to test the response of commercial arrows under a realistic environment.

In this paper, we investigate the influence of the mass, initial velocity and initial angular velocity in the dynamics of the archery arrows. Also, the behaviour of the arrows under uniform and changing winds is compared. Finally, the influence of the delay in the transition of the arrow's boundary layer is studied.

This work is organized as follows; in the section "General Characteristics" are provided the descriptions of the arrows, mathematical model, background wind and initial conditions. In the section "Results" the findings from the numerical computations are shown. In the section "Discussions" are studied the cases for which a delay in the transition of the boundary layer exists. In the section "Conclusions" are made the last comments with a brief summary.

General Characteristics

Description of the Arrows

Archery arrows are composed of an elongated shaft, a point located at its front, a set of vanes and a nock at its rear part. In this study, the physical and aerodynamic characteristics of two commercial arrows, obtained in previous experiments of our group (Ortiz et al. 2019), are considered. Both studied arrows are manufactured from an aluminium alloy tube with an external carbon sheet as cover. We refer to them as the type-A and type-B arrows.

The physical characteristics mass (M), radius (r), length (l), moments of inertia around the arrow's axis (I_3) and perpendicular to it (I), are listed in Table 1. The aerodynamic characteristics are listed in Table 2. The parameters α and β are related with the lift and pitching moment, respectively. Also, the spin parameter (S_P) and the initial velocity of the arrows (V_0) are shown. Two different values of the drag coefficients for the laminar, C_D (lam), and turbulent, C_D (turb), regimes are taken into account in the simulations. The former is used when the ideal initial angular velocity is achieved (see the section "Initial conditions"). Whereas the latter is used when such ideal initial conditions cannot be achieved. The archery arrows are light and flexible, nevertheless the difference of ~0.005 kg in mass play an important role in their dynamics.

For comparison, we refer to other sports, where the dynamics of the projectiles play a key role, e.g., the javelin throw. Even though archery and javelin throw differ in many aspects, the javelins are subject to the same aerodynamic forces as the archery arrows and serve us to remark some important physical characteristics. Javelins are long spears with a mass of around 0.80 kg and a fineness ratio f = 80. The initial launching velocity for javelins is about 30 ms^{-1}. While studying the dynamics of flying javelins, Hubbard (1984) found that these projectiles develop large angles of attack during their flight (γ_{max} > 35°) leading to large lift forces necessary to increase the range that would make the thrower to get a high score in the competition (Hubbard 1984). Such values of γ also induce a large drag component that leads to less precise shots. In javelin throw, precision is not as relevant as in the archery competition.

Table 1. *Physical Characteristics of the Arrows*

Symbol	Name	Type-A	Type-B
r [m]	Radius	2.62×10^{-3}	2.40×10^{-3}
l [m]	Length	0.625	0.625
M [kg]	Mass	0.0142	0.0197
I [kgm^2]	Moment of inertia	6.98×10^{-4}	8.97×10^{-4}
I_3 [kgm^2]	Moment of inertia	2.81×10^{-7}	3.23×10^{-7}

Table 2. *Aerodynamic Characteristics of the Arrows*

Symbol	Name	Type-A	Type-B
α [1/rad]	Parameter alpha	40.2	45.1
β [1/rad]	Parameter beta	16.2	21.2
S_P	Spin parameter	0.029	0.034
C_D (lam)	Drag coefficient	1.50	1.63
C_D (turb)	Drag coefficient	2.69	3.23
V_0 [ms^{-1}]	Initial velocity	57.3	56.7

Source: Ortiz at al. (2019).

One important difference between the aerodynamics of arrows and javelins is the position of their corresponding center of pressure *c.p.* and center of gravity *c.g.* In javelins, *c.p.* is found very close to *c.g.,* at around 8×10^{-3} m [Hubbard, 1984]. Whereas in the case of the arrows, *c.g.* is located in the front part while *c.p.* in the tail, having a distance of around 0.40 m between them. The fact that *c.p.* and *c.g.* are very close represents an absence of pitching moment in the javelin's flight. Therefore, no counterbalance effect to the increasing angle of attack takes place. The growing magnitude of γ allows generating large values of lift and dragging forces. Contrary, the maximum value of the angle of attack computed by Miyazaki et al. (2017) in arrows in free flight, under still air conditions, is around γ_{max}=0.4° (Miyazaki et al. 2017). This small angle of attack is a product of the pitching moment-lift force balance effect. Such small γ generates smaller drag force and drift in an arrow than in a javelin, allowing precise shots.

Description of the Mathematical Model

In this study, the equations of a rigid body simulating an archery arrow are computed. Such model disregards the flexural oscillation of the real arrows in free flight, which simplifies the study of these projectiles. We define a fixed coordinate system *x*, *y* and *z* with the corresponding unit vectors ***i***, ***j*** and ***k***¸ as shown in Figure 1. Besides the gravitational force (g), exerted on the vertical direction (z), the movement of the arrow is influenced by the background wind, which is $\boldsymbol{U}=(u_x, u_y, u_z)$. In the defined coordinate system, *x* and *y* form a horizontal plane or the ground. The velocity of the arrow's center of mass is $\boldsymbol{V}=(V\sin\Theta\cos\Phi, V\sin\Theta\sin\Phi, V\cos\Theta)$. Two unit vectors, $\boldsymbol{t}=\boldsymbol{V}–\boldsymbol{U}/\mid\boldsymbol{V}–\boldsymbol{U}\mid$ and $\boldsymbol{n}=(\sin\theta\cos\phi, \sin\theta\sin\phi, \cos\theta)$ are considered. The former along the vector sum of the relative velocity of the arrow's center of mass and the wind, ***V***–***U***, whereas, the latter along the arrow's axis, as shown in Figure 1. Consider θ and Θ, as the angles formed between ***n*** and ***t*** with *z*, respectively, whereas ϕ and Φ are measured between the ground projection of ***n*** and ***t*** with *x*, respectively.

As the arrow translates in free-flight, a misalignment between ***n*** and ***t*** is expected due to the background wind influence. Such misalignment is characterized as the angle of attack $\gamma=\cos^{-1}[\boldsymbol{n}\cdot\boldsymbol{t}]$. The computation of the time evolution of γ is of interest due to from its value can be inferred the state of the boundary layer (Ortiz et al. 2019).

The aerodynamic loads drag ($\boldsymbol{F}_D$) and lift ($\boldsymbol{F}_L$) must be considered during the flight simulation. These forces are exerted contrarily and perpendicularly to ***V***– ***U***, respectively. The drag and lift forces are, respectively:

$$\boldsymbol{F}_\mathrm{D}=-\frac{1}{2}C_\mathrm{D}\rho\pi r^2|\boldsymbol{V}-\boldsymbol{U}|(\boldsymbol{V}-\boldsymbol{U})\,, \tag{1}$$

$$\boldsymbol{F}_\mathrm{L}=\frac{1}{2}\alpha\rho\pi r^2[|\boldsymbol{V}-\boldsymbol{U}|^2\boldsymbol{n}-\boldsymbol{n}\cdot(\boldsymbol{V}-\boldsymbol{U})(\boldsymbol{V}-\boldsymbol{U})], \tag{2}$$

where C_D is the drag coefficient and ρ is the air's density. The parameter α is related to the lift coefficient with $C_L=\alpha\gamma$ and is determined experimentally [Ortiz et al., 2019]. The arrow's radius is *r*.

The angular momentum is $\boldsymbol{L}=I\boldsymbol{n}\times \mathrm{d}\boldsymbol{n}/\mathrm{d}t+I_3\omega_3\boldsymbol{n}$, where I and I_3 represent the moments of inertia around the axis perpendicular to ***n*** and around it, respectively. ω_3 is the axial angular velocity component. Therefore, the equations of motion are expressed as:

$$M\frac{d\boldsymbol{V}}{dt}=-Mg\boldsymbol{k}+\boldsymbol{F}_D+\boldsymbol{F}_L, \tag{3}$$

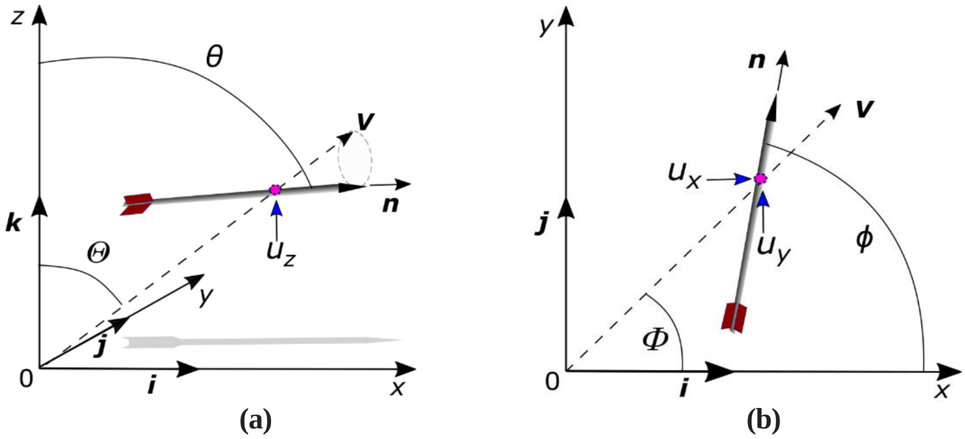
$$\frac{\mathrm{d}\boldsymbol{L}}{\mathrm{d}t}=I\boldsymbol{n}\times\frac{\mathrm{d}^2\boldsymbol{n}}{\mathrm{d}t^2}+I_3\left(\frac{\mathrm{d}\omega_3}{\mathrm{d}t}\boldsymbol{n}+\omega_3\frac{\mathrm{d}\boldsymbol{n}}{\mathrm{d}t}\right)$$
$$=\frac{1}{2}\beta\rho\pi r^2 l|\boldsymbol{V}-\boldsymbol{U}|\boldsymbol{n}\times(\boldsymbol{V}-\boldsymbol{U})+N_3\boldsymbol{n}\,, \tag{4}$$

where M is the arrow's mass, g is the gravitational acceleration and N_3 is the axial component of the torque. The parameter β is related with the pitching moment coefficient by $C_M=-\beta\gamma$ and it is determined experimentally (Ortiz et al. 2019). Since we do not have any information about N_3 and then the time evolution of the angular velocity is unknown, is necessary to approximate its value assuming that

$S_P = \omega_3 r/|\boldsymbol{V} - \boldsymbol{U}|$ is constant (Miyazaki et al. 2012, Miyazaki et al. 2017). Here, S_P is the spin parameter, which is obtained from wind tunnel experiments. This assumption is valid for small angles of attack, $|\gamma| < 3.0°$.

To solve such a system composed by Equations 3-4, it is necessary to compute $\mathrm{d}V/\mathrm{d}t$, $\mathrm{d}\Theta/\mathrm{d}t$, $\mathrm{d}\Phi/\mathrm{d}t$, $\mathrm{d}\omega_\theta/\mathrm{d}t$ and $\mathrm{d}\omega_\phi/\mathrm{d}t$, where $\mathrm{d}\theta/\mathrm{d}t = \omega_\theta$ and $\mathrm{d}\phi/\mathrm{d}t = \omega_\phi$. The system is solved by using a standard 4th order Runge-Kutta method with a time step $\Delta t = 5 \times 10^{-4}$ s.

Figure 1. *Illustration of an Arrow in Free-flight with the Relevant Variables considered in the Mathematical Model*



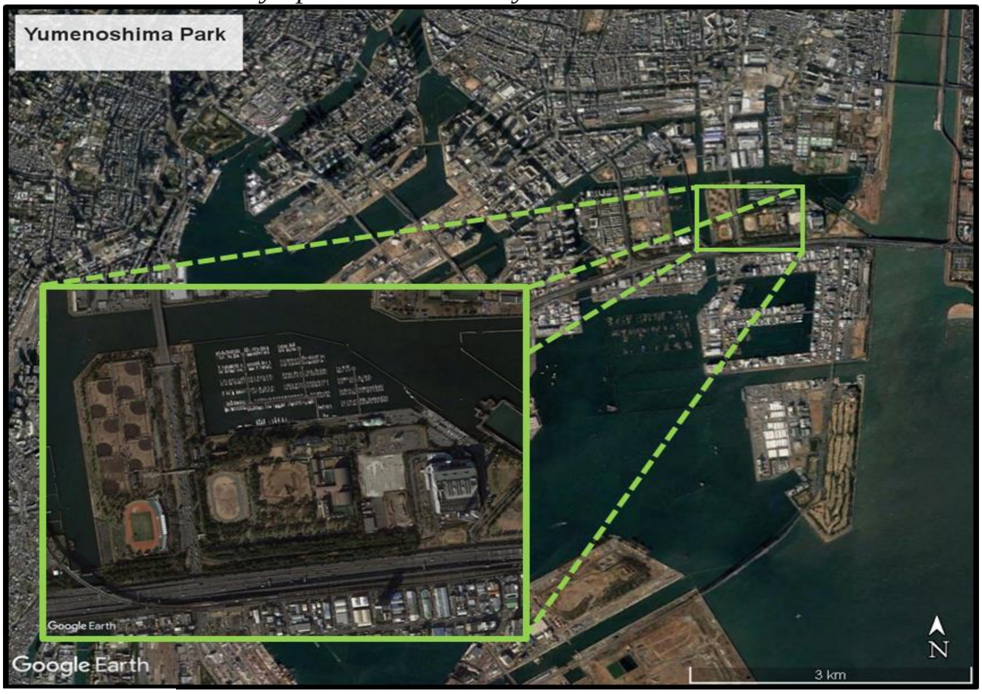
Source: Authors.

Description of the Simulated Archery Range

The venue for the archery competitions in the Tokyo Olympic Games 2020 will be held in the semi-closed bay of Tokyo in Yumenoshima Park (Figure 2). The area is located to the east of Tokyo Metropolitan area near to the sea and has a surface of ~95,000 m^2. At the moment of writing, the main venue location has been decided but the final design of the archery stadium(s) and facilities are not available for the public yet. Therefore, we project the existence of two possible main competition areas inside the sporting complex. We refer to them as the *final round area* (fields I, II and III), at the western part of the complex, and the *ranking round area* (fields IV, V and VI) (Figure 3). Each of the tracks are north oriented with a shooting direction South-North and are simulated to have a dimension of 70 m × 5 m. At 70 m from the shooting position, it is located a target that has 1.22 m in diameter. It is recognized that the presence of buildings and the local plant canopy affect seriously the wind patterns (Yaghoobian et al. 2018), which must be taken in consideration in future studies.

Due to the wind effect, the arrows are expected to show deviations in the trajectory, which can be measured at 70 m using their striking points with the target. Such deviations from the center of the target are δy and δz in the y and z directions, respectively. The radial deviation from the center of the target is $\delta r = (\delta y^2 + \delta z^2)^{½}$. Such deviations are measured and compared for the different types of winds and initial conditions.

Figure 2. *Yumenoshima Park in the Bay of Tokyo, where the Archery Competitions will be held in the Olympic Games in Tokyo 2020*



Source: Authors.

Figure 3. *Illustration of the Archery Ranges, the Fields I-III are considered as the Final Round Area, whereas the Fields IV-VI are the Ranking Round Area*

Source: Authors.

The data corresponding to the time depending wind information in the venue was obtained by means of the high-resolution numerical simulations' results and provided by JAMSTEC. To compute the wind components, they used the Multi-scale Simulator for the Geoenvironment (MSSG) model (Matsuda et al. 2018). The MSSG is an atmosphere-ocean coupled general circulation model that, at urban scales, may work as a large-eddy simulator (LES) with the capability to include local building shapes. The simulated wind data describes a typical clear day of August 2007 in the Tokyo bay with sea breeze. This information corresponds to a plane located at 2.5 m from the ground with a horizontal resolution of 5 m. The wind velocity components change with the position and time during 30 s with a time step of 0.1 s. In Figures 2 and 3, the original satellite images were obtained from Google Earth Pro and correspond to the current state of the field in October 2018.

Computation of the Background Wind at any Instant and Position

Because JAMSTEC provides three wind components on a plane at 2.5 m from the ground level with a horizontal resolution of 5 m, it is necessary to inter- and extrapolate the wind information at any arrow's position and time. The surface layer approach is used to obtain the wind (u_x u_y and u_z) that the arrow experiences along its free-flight. The vertically logarithmic wind profile can be described with$u_x = u_{x*}/k \ln\,(z/z_{\mathrm{rl}})$ and $u_y = u_{y*}/k \ln\,(z/z_{\mathrm{rl}})$. Here, k is the universal von Karman's constant and has an experimentally determined value of $k \approx 0.4$. The value of z is the position of the arrow's center of mass with respect to the ground and z_{rl} corresponds to the roughness length, whose typical value for a grassy field is z_{rl}=0.01 m. The friction velocities u_{x*} and u_{y*} are computed for each iteration with:

$$u_{x\,(2.5)} = \frac{u_{x*}}{k} \ln\left(\frac{2.5}{z_{\mathrm{rl}}}\right), \qquad (5)$$

$$u_{y\,(2.5)} = \frac{u_{y*}}{k} \ln\left(\frac{2.5}{z_{\mathrm{rl}}}\right), \qquad (6)$$

where $u_{x\,(2.5)}$ and $u_{y\,(2.5)}$ are the x and y components of the wind at 2.5 m from the ground level and provided by JAMSTEC. Therefore, the wind velocities in the x and y directions at any instant and location are obtained with:

$$u_x = \frac{u_{x\,(2.5)} \ln\left(\frac{z}{z_{\mathrm{rl}}}\right)}{\ln\left(\frac{2.5}{z_{\mathrm{rl}}}\right)}, \qquad (7)$$

$$u_y = \frac{u_{y\,(2.5)} \ln\left(\frac{z}{z_{\mathrm{rl}}}\right)}{\ln\left(\frac{2.5}{z_{\mathrm{rl}}}\right)}. \qquad (8)$$

If the condition of continuity is considered, $\nabla \cdot U = 0$, the vertical component of the wind, u_z, can be obtained by using:

$$u_z = 0.0884\, u_{z(2.5)} \left[z \ln\left(\frac{z}{z_{rl}}\right) - z + 0.01\right], \qquad (9)$$

where $u_{z\,(2.5)}$ is the known vertical wind velocity at 2.5 m. The solution of Equations (3-4) allows to know the position, x_i, y_i and z_i, of the arrow's center of mass at any instant, t_i, whereas by solving Equations 7-9, it is possible to obtain the wind components u_{xi}, u_{yi} and u_{zi} for such position. Nevertheless, the change in the arrow's center of mass location is computed in orders of mm (O (10^{-3})), whereas the spatial resolution of the wind information is 5 m. Therefore, the wind components at any arrow's position were spatially interpolated. Furthermore, the time interval for the wind data provided by JAMSTEC is 0.1 s, whereas the time step in the Runge-Kutta computation is 5×10^{-4} s, resulting necessary to perform a time interpolation of the wind components at each time step. For both the spatial and time interpolations, a cubic spline method was used.

Figure 4 shows the time evolution of the velocity for the three wind components along the total length of the fields II and V at a distance z =2.5 m from the ground during 30 s. The wind velocity ranges from -1 ms^{-1} to 3.5 ms^{-1}. In Figure 4a-b, the predominance of South-North (tail-winds, u_x>0) wind currents is appreciated in both fields due to the presence of the ocean at the south of the archery venue. In the field II at ~30 m, from the shooting position (Figure 4a) and t_0=0 s, the tail-winds show a maximum velocity of u_x~3.2 ms^{-1} and reduces gradually until u_x~0.25 ms^{-1}.

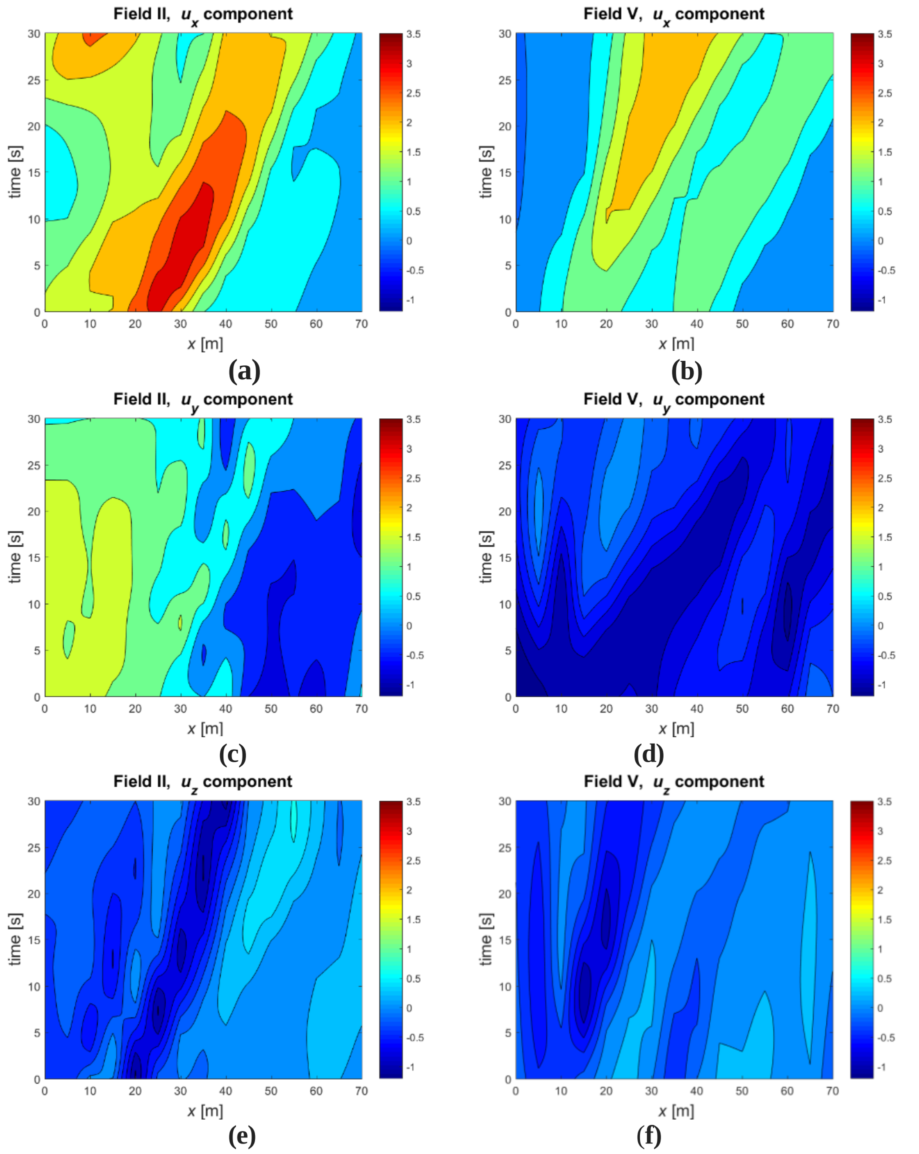
Regarding to the side-wind component in the field II (Figure 4c), there exists predominance of positive side-winds (u_y>0) whereas in the field V the side-wind velocity remains negative (u_y<0) during most of the time (Figure 4c). The vertical wind component in Figure 4e-f is negative along both tracks, $u_z < 0$. As appreciated from the Figure 4, the wind conditions change with the position and the time. Such kind of behaviour might be expected in archery ranges located outdoors. The archer's lack of knowledge of the wind behaviour may lead to an unexpected arrow's trajectory, affecting the final score.

Initial Conditions

The initial position of the arrow corresponds to the fixed place at which the archer holds it before performing the shot, thus the position of the center of mass is x_0=0, y_0=0 and z_0=1.5 m. The center of the target is located 70 m away in the positive x direction and z_{tar}=1.3 m from the ground.

We consider Φ_0= 0 and the value of Θ_0 is adjusted so that under still wind conditions, the arrow hits the center of the target. Θ_0 depends on the characteristics of the arrow, initial velocity V_0 and initial angular velocities $\omega_{\theta 0}$ and $\omega_{\phi 0}$., initial velocity V_0 and initial angular velocities $\omega_{\theta 0}$ and $\omega_{\phi 0}$. The initial velocities for both types of arrows are listed in Table 2. The magnitude of the initial angular velocities plays an important role to reduce the angle of attack and the drag exerted on the arrow, as shown by Ortiz et al. (2019). Therefore, two different initial angular velocities are considered in a separated way.

Figure 4. *Time Evolution of the Wind Components u_x (**a**,**b**), u_y (**c**,**d**) and u_z (**e**,**f**) for the Fields II and V*



Source: Authors.

In the former, the angular velocities are assumed to be zero or $(\mathrm{d}\boldsymbol{n}/\mathrm{d}t)_0=0$, implying that:

$$\omega_{\phi 0}= \omega_{\theta 0}=0, \tag{10}$$

$$\phi_0=0, \tag{11}$$

$$\theta_0=\Theta_0. \tag{12}$$

The second category is the so-called ideal initial angular velocity, defined as $(d\boldsymbol{n}/dt)_0=(d\boldsymbol{t}/dt)_0$. When the ideal initial angular velocity is achieved, the arrow almost aligns with $\boldsymbol{V}$-$\boldsymbol{U}$ and γ remains small enough to preserve the boundary layer laminar (Miyazaki et al. 2017). For these kinds of computations, the laminar value of C_D is used. When the zero initial angular velocity is considered, the turbulent value of C_D is introduced.

Results

In this section, the results obtained from the numerical computations are presented. In the first subsection the effects of uniform side-, head- and tail-winds in the trajectory are compared. Additionally, the influence of increasing the initial velocity of the arrows under side-winds is described.

Further, the role that the arrows' mass play in their behaviour under velocity-changing wind fields is studied in detail. Finally, the trajectories of arrows for which the boundary layer transition, from laminar to turbulent regimes, takes place during the flight are compared.

Behaviour of the Arrow Subject to a Uniform Background Wind

As a first approach, it is considered the influence of uniform winds. In these cases, the arrows are subject to the same wind velocity regardless their position. The three studied cases are the side-, head- and tail-winds. The side-wind (u_y) is exerted along the y-axis, whereas in the tail- ($u_x>0$) and head-winds ($u_x<0$), the air flow is in and against the x-direction, respectively. A wind velocity of 3 ms^{-1} is considered for all the uniform cases.

For the lighter type-A arrow, the time evolution of the angle of attack, γ, is shown in Figure 5 for the cases with zero initial angular velocity in the main area. The cases with ideal initial angular velocity are represented in the inserted panel in the inferior part of the figure, whereas the panel in the right superior part depicts the target and the points at which the arrows strike on it.

Miyazaki et al. (2017) proposed that the state of the boundary layer might be inferred from the angle of attack, γ (Miyazaki et al. 2017). For small angles of attack, $\gamma<0.4°$, the boundary layer can be considered laminar, whereas for $\gamma>0.6°$ the boundary layer appeared to be turbulent in most of the extension of a type-A arrow. Therefore, the concept of a threshold value of the angle of attack, γ_{thr}, can be introduced. If such γ_{thr} value is exceeded, the transition from laminar to turbulent boundary layer would take place.

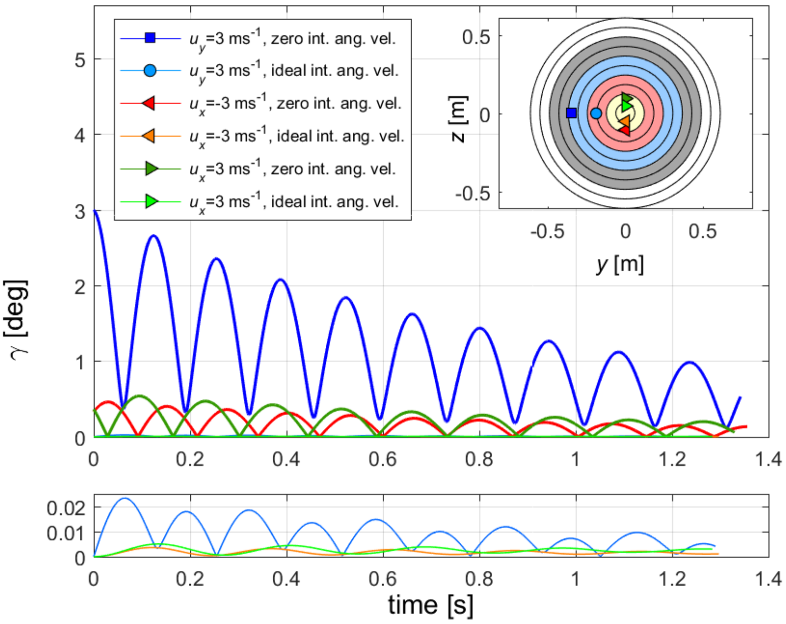
For the side-wind with zero initial angular velocity (—), an initial angle of attack of $\gamma=3°$ might be large enough to provoke a turbulent boundary layer along the whole trajectory of the arrow, resulting in a final deviation from the center of the target of around $\delta r=0.35$ m (■).

Due to the purely side-wind effect, the arrow shows only a lateral deviation or wind drift. For the cases of tail- (—) and head-winds (—) with zero initial angular velocity, the final deviations from the center of the target are around $\delta r=0.10$ m

(▶) and δr=0.11 m (◀), respectively, which implies that the side-wind affects in a more important way the trajectory of arrows in free-flight.

Consider the cases for which the ideal initial angular velocity is set in the computations, inserted panel in the inferior part of Figure 5, now the arrow almost aligns with the wind component and an angle attack close to zero is developed. The value of γ remains small enough to keep a laminar boundary layer and the deviation from the center of the target reduces to around δr=0.19 m (●) for the side-wind. By keeping the arrow aligned with the wind flow and therefore the boundary layer laminar, it is possible to reduce the lateral deviation in the trajectory. Nevertheless, shooting the arrow with the ideal initial conditions might be challenging for the archers. Recently, Miyazaki et al. (2017) reported their experience in trying to adjust and control the arrows' initial angular velocity with little success (Miyazaki et al. 2017).

Figure 5. *Main Area: Time Evolution of the Angle of Attack Considering Side-, Head- and Tail-Winds with a Velocity of 3ms^{-1} for the Cases with Zero Initial Angular Velocity and Type-A Arrow. Inferior Panel: Cases with Ideal Initial Angular Velocity. Inserted Panel in the Right: Striking Points in the Target for All the Cases*



Source: Authors.

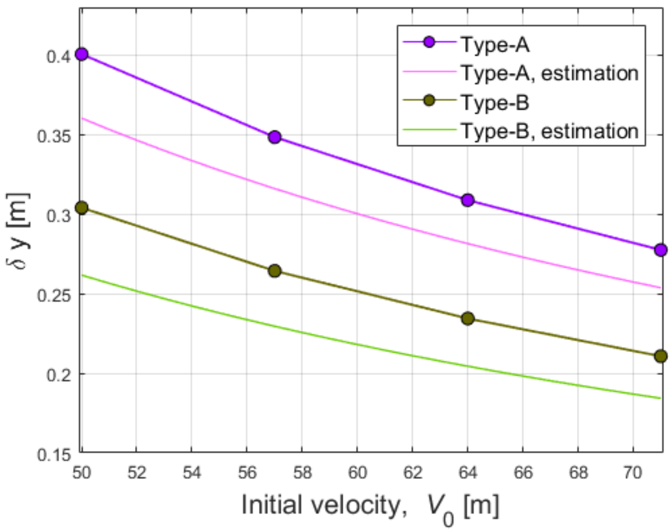
In Figure 6, it is shown that by increasing the arrow's initial velocity, V_0, it is possible to reduce the lateral deviation in the trajectory. Zero initial angular velocity and a uniform side-wind of 3 ms^{-1} was considered in the computations (— and —). If the typical velocity (V_0=57 ms^{-1}) for arrows shot with recurve bows is increased ~25%, a reduction in the lateral deviation of ~0.05 m and ~0.07 m can be expected for the heavier arrow and the lighter one, respectively. Arrows shot with compound bows generally have larger initial velocities, V_0>80 ms^{-1}, resulting in less deviated trajectories than those shot with recurve bows (Park 2011).

Considering that the lateral deviation in the trajectory or wind drift is mainly provoked by the lateral component of the drag, a rough estimation of the wind drift can be approximated by

$$\delta y \sim \frac{F_D}{2M} \frac{u_y}{\sqrt{V_0^2+u_y^2}} \left(\frac{L}{V_0}\right)^2 \sim \frac{C_D \rho \pi r^2}{4M} \frac{u_y}{V_0} L^2, \tag{13}$$

where F_D is the drag force and L is the length of the archery range. In Figure 6 the results from the estimation (— and —) are plotted along with the results from the numerical computations for both types of arrows. The difference from the estimation and the numerical results arises from the assumption that in Equation (13) the velocity V_0 remains constant along the whole arrow's trajectory, whereas in an actual shot, the arrow's velocity was confirmed to reduce ~15% and ~12% for the type-A and type-B, respectively.

Figure 6. *Dependence of the Lateral Deviation in the Trajectory on the Initial Arrow's Velocity. Not Ideal Initial Angular Velocity and a Side-wind of 3ms^{-1} were considered*



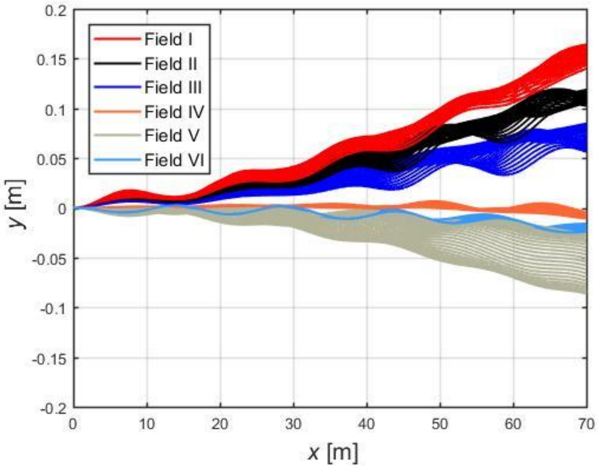
Source: Authors.

Influence of the Mass in a Changing Wind Field

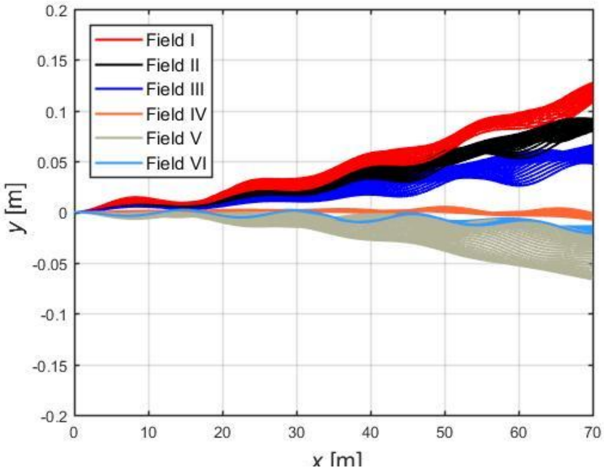
Figure 7 shows an upper view of the computed trajectories for the type-A (Figure 7a) and type-B (Figure 7b) arrows with zero initial angular velocity. With multiple colours are represented the trajectories corresponding to the 6 different archery ranges. Multiple lines are plotted for different starting times with a delay of 1s between them. By changing the starting time of the shot, it is possible to make sure that the arrows are subject to different wind fields during free-flight. Regardless of the location and wind behaviour, the arrows with larger mass show less deviated trajectories (Figure 7b) than the lighter ones (Figure 7a). The lateral deviation in the trajectory decreases with increasing arrow's mass.

The averaged δy for each of the fields also change significantly, showing the different wind behaviour for each of the locations. In the final round area (fields I, II and III), positive side-winds are exerted on the arrows, resulting in positive values of δy. Whereas for the ranking round area (fields IV, V and VI) the negative deviations were found as a result of the negative side-winds (u_y<0). The average and standard deviation of δy also varies from field to field. The averaged values of δy resulted in 0.15 m, 0.11 m and 0.07 m for the fields I, II and III respectively for the lighter arrow (Figure 7a). Appreciably larger values of the standard deviation in δy are present for the field V (—) compared with those of the field VI (—).

Figure 7. *Computed Trajectories in All the Fields using Different Starting Times. Not Ideal Initial Angular Velocity was considered in All the Cases for **(a)** Type-A and **(b)** Type-B Arrows*



(a)

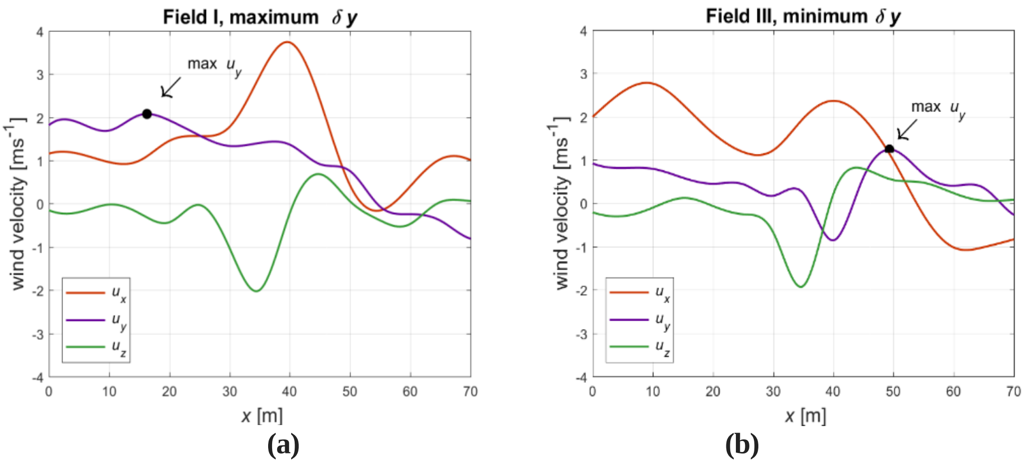


(b)
Source: Authors.

From the multiple shots with the type-A arrow and zero initial angular velocity were selected two cases in the final round area corresponding to the maximum and minimum δy, found in the fields I (—) and III (—), respectively. A difference in the lateral deviation of ~ 0.10 m between such cases is not negligible and may affect in an important way the final score in the competition.

The wind velocity components, u_x, u_y and u_z, experienced by the arrows in those two cases is plotted in Figure 8. As the arrows fly in the archery range, the wind strength changes with position. In the case of maximum δy in the field I (Figure 8a), the maximum value of the side-wind u_y is 2.07 ms^{-1}. This side-wind velocity is exerted on the arrow for just a fraction of a second, in contrast to the cases of uniform side-wind, where the arrow experienced the same wind velocity along all the trajectory. For the case with minimum δy in the field III (Figure 8b), the maximum side-wind velocity experienced by the arrow is 1.23 ms^{-1}, from which the smaller δy arises. The influence of the side-wind is emphasized because it appears to be more dangerous for the shots than the head- and tail-winds, as shown in the inserted panel in Figure 5.

Figure 8. *Variation of the Wind Velocity with the Position Experienced by the Type-A Arrows showing Maximum and Minimum Values of δy in Fields I **(a)** and III **(b)***

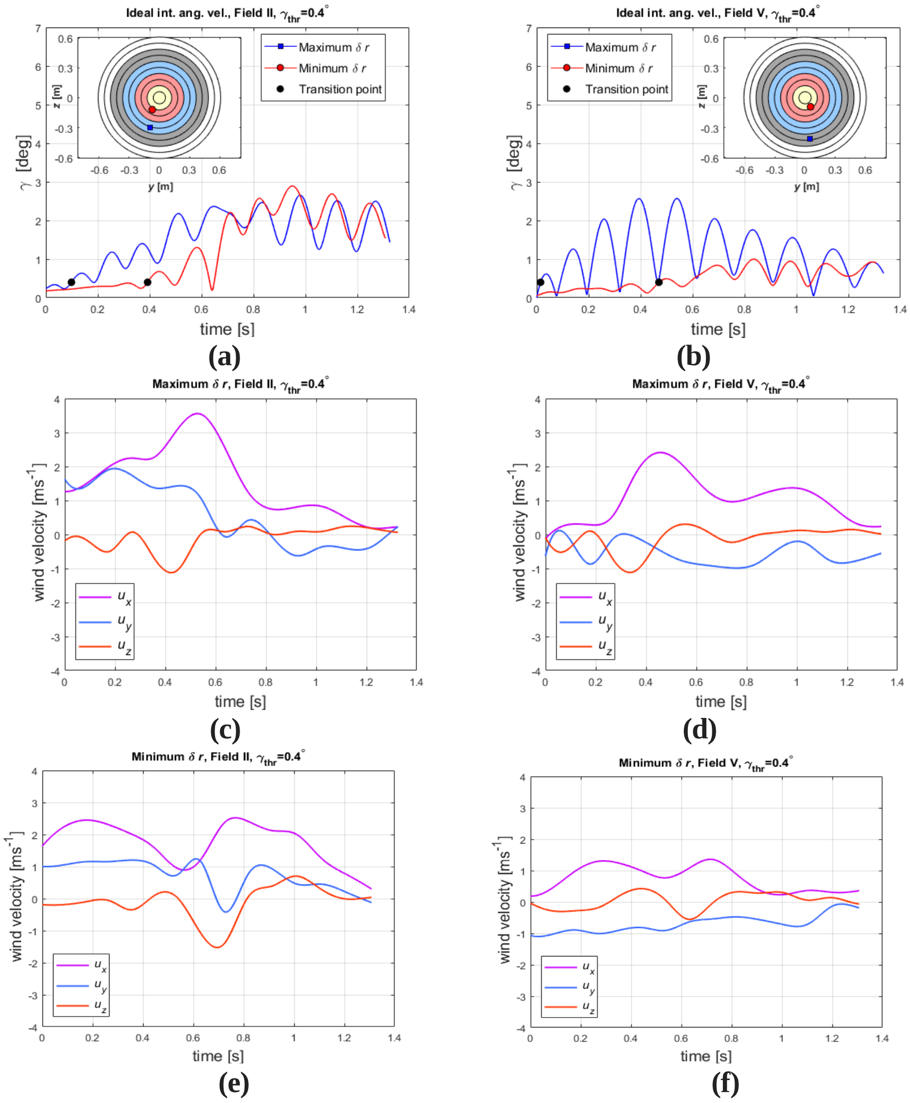


Source: Authors.

Vertical Drop of Arrows Shot with the Ideal Initial Angular Velocity

Figure 9 shows the time evolution of the angle of attack, γ, for a type-A arrow with the ideal initial angular velocities in the fields II and V with γ_{thr}=0.4°. This implies that the boundary layer is initially laminar and becomes turbulent once γ_{thr} is exceeded. There were performed computations for multiple starting times with a time difference of 1 s between them. The shots are shown with maximum (— and ■) and minimum (— and ●) values of δr for each field. It is indicated with ● when the transition to turbulent boundary layer takes place. For the field II in Figure 9a with maximum δr (■), the transition to turbulent boundary occurs at ~0.1 s from the shot, leading to a final radial deviation from the center of the target of δr=0.31 m. For the case of minimum radial deviation (●), δr=0.14 m, with a retarded transition to turbulent boundary layer, an improvement of more than 0.15 m could be achieved.

Figure 9. *Results for the Computations with Maximum and Minimum Values of δr considering a Threshold Angle of Attack γ_{thr}=0.4° for the Fields I and V using a Type-A Arrow and Ideal Initial Angular Velocities* ***(a)*** *and* ***(b)*** *Show the Time Evolution of the Angle of Attack, γ. Inserted Panels: Impact Points on the Targets. Time Evolution of the Wind Components (u_x, u_y and u_z) Experienced by the Arrow along its Trajectory* ***(c, d, e*** *and* ***f)***



Source: Authors.

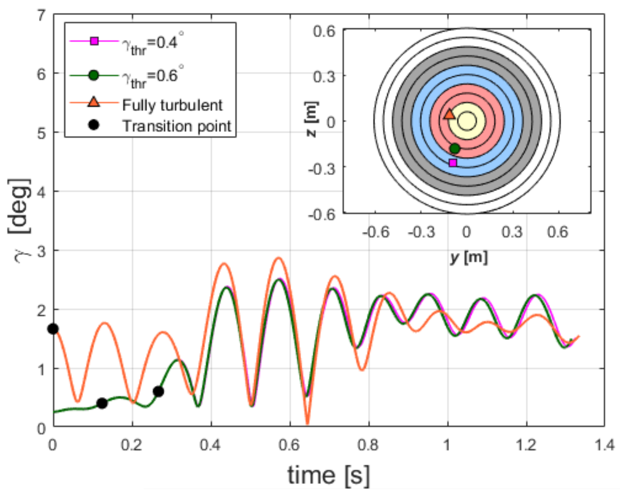
In Figure 9b for the field V, it is shown that delaying ~0.44 s the transition to turbulent boundary layer may result in a significant reduction in the radial deviation from the center of the target. The obtained values are δr=0.41 m and δr=0.11 m for the earlier and the retarded transitions, respectively. Moreover, for the case with minimum δr, the value of the angle of attack remains small, γ<1°, during all the flight (—), thus generating small drag and a less deviated trajectory.

In Figure 9c-f, the wind components experienced by the arrows with maximum and minimum values of δr are shown. An earlier transition to turbulent boundary layer provokes that the arrows stay longer in the air, because of the larger drag force, thus contributing to the vertical drop in the trajectories. Further, in contrast to the cases with purely side-, head- and tail-winds, the non-zero vertical wind component u_z (—) also induces deviation in the *z* direction.

Discussion

It has been proposed that the transition to turbulent boundary layer may take place when the maximum angle of attack is located in the range $0.4° < \gamma_{max} < 0.6°$ for $Re=1.75\times10^4$ (Miyazaki 2017). As *Re* increases, the threshold angle at which the transition takes place decreases. Within the mentioned range, it is expected that exists a threshold angle, γ_{thr}, at which the transition occurs. In this section, the influence of the value of such γ_{thr} is explored. Therefore, there were performed simulations considering transition to turbulent boundary layer with two different threshold values, γ_{thr}=0.4° and γ_{thr}=0.6°, and compared with the case of a fully turbulent boundary layer.

Figure 10. *Results for the Computations for a Type-A Arrow in the Field II using Two Different Threshold Values of the Angle of Attack (γ_{thr}=0.4° and γ_{thr}=0.6° with Ideal Initial Angular Velocity) and Fully Turbulent Boundary Layer*



Source: Authors.

Figure 10 shows the time evolution of the angle of attack and in the inserted panel the target with the impact points on it. The ideal initial angular velocity was set for the cases with laminar-turbulent transition. On the other hand, a zero initial angular velocity was fixed in the fully turbulent computations. The characteristics of the type-A arrow were considered and the archery range where the shots were computed is the field II. For the case when γ_{thr}= 0.4° was set (— and ■), a turbulent boundary layer is developed at ~0.12 s and results in a final deviation from the center of the target of δr=0.29 m.

On the other hand, when the threshold value was increased to γ_{thr}= 0.6° (— and ●), the transition to turbulent boundary layer (●) took place at ~0.27 s after the shot was performed. For the latter case, the final deviation from the center of the target resulted in δr=0.20 m. Even though for both shots the boundary layer remains turbulent for most of the trajectory, a delay of ~0.15 s in the transition resulted enough to reduce ~0.09 m the radial deviation from the center of the target. Such reduction of the deviation in the trajectory might not be negligible to sum points in the final score. By keeping the boundary layer laminar the drag is reduced and therefore the deviation in the trajectory.

Consider now the case when the archer assumes zero initial angular velocity, i.e., not ideal initial conditions or turbulent boundary layer along the whole trajectory. In this case, the initial angle of attack presents a large enough value to generate a turbulent boundary layer from the beginning, γ>1.6°, nevertheless the radial deviation from the center of the target is δr=0.12 m. Even larger drag force might be exerted due to the magnitude of γ, the final deviation resulted smaller than the cases with transition during the flight. The outcome appears to depend not only in the initial conditions, but also on the background wind characteristics. Even the archer was able to shoot the arrow with the ideal initial conditions, an unexpected wind behaviour along the flight resulted in large trajectory deviations.

Conclusions

In this paper, we investigated the influence of background winds on archery arrows using a mathematical model. The archery competitions are performed outdoors. Therefore, the background wind must be taken into because it represents one of the most important elements disturbing the shots.

We assumed the arrows to behave as rigid bodies. By computing their attitude, it was possible to obtain the time evolution of the angle of attack, from which the state of the boundary layer was inferred.

In our simulations, we introduced the background wind information that corresponds to the ground where the archery competitions will be held in the Olympic Games of Tokyo in 2020. Such wind information provided by JAMSTEC was the result of high-resolution large eddy simulations.

It was found that uniform side-wind disturbs more seriously the trajectory of arrows than the uniquely head- and tail-winds. Nevertheless, in an actual wind field the direction and wind velocity change with the location and time, resulting in unexpected arrows' behaviour.

Under a theoretical uniform side-wind, it appears feasible to keep the boundary layer laminar along the complete trajectory by aligning the arrows' attitude with the wind flow. By doing so, it is possible to reduce the wind drift.

The arrows' initial velocity and mass play a determinant role in the final deviation from the center of the target. With increasing initial velocity and mass, the arrows showed less deviated trajectories, regardless of the wind behaviour.

It was found that by delaying the transition from laminar to turbulent boundary layer, deviations in the trajectory were reduced under certain circumstances. The control of such transition has to be seriously considered. Furthermore, an unexpected behaviour of the wind during the arrows' flight may result in large deviations in their trajectory, even if the ideal initial conditions are achieved. Under non-uniform velocity wind fields, trying to keep the arrow's boundary layer laminar may be more harmful than beneficial.

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Classification of All-Rounders in the Game of ODI Cricket: Machine Learning Approach

By Indika Wickramasinghe[*]

Player classification in the game of cricket is very important, as it helps the coach and the captain of the team to identify each player's role in the team and assign responsibilities accordingly. The objective of this study is to classify all-rounders into one of the four categories in one day international (ODI) Cricket format and to accurately predict new all-rounders'. This study was conducted using a collection of 177 players and ten player-related performance indicators. The prediction was conducted using three machine learning classifiers, namely Naive Bayes (NB), k-nearest neighbours (kNN), and Random Forest (RF). According to the experimental outcomes, RF indicates significantly better prediction accuracy of 99.4%, than its counter parts.

Keywords: *Team sport, machine learning, cricket, ODI, player classification*

Introduction

Cricket is considered as a bat and ball team game. The game has basically three formats, namely, the test cricket, one-day-international cricket (ODI), and T20. Test cricket, the longest format is regarded by experts of the game as the ultimate test of playing skills. An ODI cricket game is played for 300 legal deliveries (balls) per side, and the shortest format, T20 is played for 120 legal deliveries (balls) per side. A typical cricket team comprises of 11 players and the team batting first is identified by the outcome of tossing a coin. In the game of cricket, there are three major disciplines: batting, bowling, and the fielding. When selecting 11 players for a team, it is necessary to balancing the team by selecting players to represent each of the above three departments.

A player who excels in bowling the cricket ball is considered as a bowler, while a player with higher potential of hitting the cricket ball is considered as a batsman. An all-rounder is a regular performer with bat and the ball. According to Bailey (1989), an all-rounder is a player who is able to grasp a position in his team for either his batting or his bowling ability. Though fielding is an integral part in the game, batting and bowling skills are given higher priorities than fielding. A genuine all-rounder is a special all-rounder who is equally capable of batting and bowling, most importantly this player can bat as a quality batsman and bowl as s quality bowler. Majority of all-rounders in the game of cricket dominate either batting or bowling skills, therefore they are named as batting all-rounders or as bowling all-rounders.

Identification of all-rounders is very vital for the success of a team. Classifying an all-rounder as genuine, batting, or a bowling is even beneficial for cricket

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selection panels, coaches, and players. A review at the literature provides evidences of such studies. Using Indian Premier League (IPL) data, Saikia and Bhattacharjee (2011) classified all-rounders into four groups, namely performer, batting all-rounder, bowling all-rounder, and under-performer. According to their results, the Naïve Bayes algorithm has given a classification accuracy of 66.7%. In an attempt to rank all-rounders in test cricket, Tan and Ramachandran (2010) utilized both batting and bowling statistics to devise a mathematical formula. In another study, Stevenson and Brewer (2019) derived a Bayesian parametric model to predict how international cricketers' abilities change between innings in a game. Furthermore, Christie (2012) researched physical requirements of fast bowlers and stated the necessity of physiological demands to evaluate bowlers' performances. Saikia et al. (2016) developed a performance measurement using a combination of batting and bowling statistics to quantify all-rounder's performance. Wickramasinghe (2014) introduced an algorithm to predict batsman's performance using a hierarchical linear model. This multi-level model used player-level and team-level performance indicators to predict the player's performance.

Selecting a team against a given opposition team is not an easy task, as various aspects including the strengths and the weaknesses of both teams are required to consider. Bandulasiri et al. (2016) identified a typical ODI game as a mixture of batting, bowling, and decision-making. Presence of a quality all-rounder in a team is an asset to a team, as it brings huge flexibility in the composition of the team. A good all-rounder makes the captain's job easy as the player can play a dual role, whenever the captain requires (Van Staden 2008). Though the impact of all-rounders towards the success of a team is enormous, there are no underline criteria to identify them.

The existence of prior research work in identifying all-rounders in the game of cricket is handful. According to the knowledge of the author, there is no existing study regarding classification of all-rounders in ODI format. Our objective of this study is to device a method to categorize all-rounders in the ODI format of cricket. We use several machine learning techniques to classify an all-rounder as a genuine all-rounder, batting all-rounder, bowling all-rounder, and as an average all-rounder.

This study brings novelty for the cricket literature in many ways. According to the author's point of view, this is one of the first studies conducted to classify all-rounders in ODI version of the game using machine learning techniques. Furthermore, the selected player-related performance indicators and the used machine learning techniques are unique for this study. Findings of this study can benefit the entire cricket community and cricket industry as always prediction in sports brings an economical value to the industry (Gakis et al. 2016).

The rest of the manuscript is organized as follows. Next section will discuss about the data selection procedure and descriptive statistics about the collected data. In the methodology section, three machine learning techniques are discussed. Then, in the following section findings of this study are illustrated. Finally, the discussion and conclusion section will discuss further about the conducted study and concludes the manuscript.

Data Collection and Player - Selection Criteria

Data for this study was collected using a publically available website, under the following criteria. Players, who have played more than 50 ODI games with an aggregate score of over 500 runs, were selected. Furthermore, it was essential for each player to have at least a half-century under their name, and collected more than 25 ODI wickets. Under the above criteria, a total of 177 players were selected and ten player related performance indicators (features) were recorded. Table 1 summarises these ten features and their descriptive statistics.

Table 1. *Descriptive Statistics of Dataset*

Variable	Description	Mean	SD
Matches:	The number of games each player has played	146.64	83.12
Runs:	Number of accumulated runs a player has scored in his career	2,972.79	2,859.03
HS:	Highest score a player has scored in his career	101.25	36.97
BatAv:	Batting average of a player	26.04	9.12
NumCen:	Number of times a player has scored 100 runs or more in a game	2.96	6.00
NumWkts:	Number of accumulated wickets a player has taken in this career	115.79	86.05
BesstB:	Best bowling figures as a bowler	4.51	0.98
BowAv:	Bowling average of the bowler	35.04	6.64
NFiveWkts:	Number of times a bowler has taken 5 or more wickets in a game	0.99	1.58
NCatches:	Number of catches a player has caught in his career	47.32	30.83

Saikia and Bhattacharjee (2011) classified all-rounders based on median value of both batting average and bowling averages. In this collected data, the distributions of both batting and bowling follow Gaussian distributions. Therefore, in this study we use the mean values of both batting and bowling averages to classify all-rounders according to the scheme summarised in Table 2. Figure 1 illustrates the joint distribution of batting and bowling averages, and the four categories of players.

Based on the Table 2 and Figure 1, we classify each all-rounder into one of the four categories: genuine all-rounder *(G),* batting all-rounder *(B),* bowling all-rounder *(Bw),* and average all-rounder *(A).*

Figure 1. *Distribution of Batting Averages and Bowling Averages*

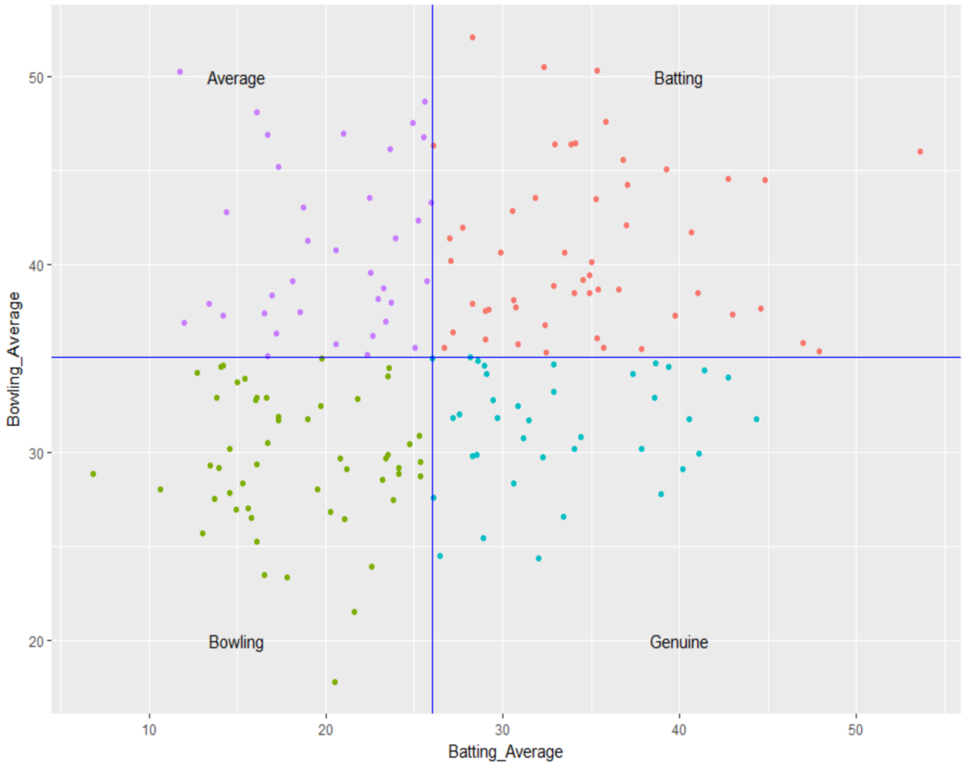


Table 2. *Classification Criteria of All-Rounders*

Category of the all-rounder (Type)	Criteria	
	Batting Average	Bowling Average
Genuine (G)	> 26.04	< 35.04
Batting (B)	> 26.04	> 35.04
Bowling (Bw)	< 26.04	> 35.04
Average (A)	< 26.04	> 35.04

The class variable of the data set is named as *Type*, which represents each of the four classifications.

Methodology

In this study, we use three machine learning techniques, NB, kNN, and RF to classify all-rounders into one of the four groups. Regression analysis is one of the alternative conventional statistical procedures for an analysis like this. The number of data appoints used in regression analysis is higher, proportional to the number of involved features (Allision 1999, Bai and Pan 2009). Furthermore, some of the machine learning algorithms such as NB is considered as a better performer with smaller datasets (Hand 1992, Kuncheva 2006). Under the previously stated constraints, we opt to use these three machine learning approaches to analyse these data.

Naïve Bayes (NB)

The NB classifier is considered as one of the simplest and accurate data classifying algorithms. The base of this classifier is the well-known Bayes theorem, used in probability theory. The simplicity, the accuracy, and the robustness of NB have made NB a popular classifying technique with various applications (Arar and Ayan 2017). As the literature indicates, NB is one of the top performing classifiers used in data mining (Wu et al. 2008).

Let $X = (x_1, x_2, ..., x_n)$ be a *n*-dimensional random vector (features) from domain D_X and $Y = (y_1, y_2, ..., y_m)$ be a *m*-dimensional vector (classes) from domain D_Y. In this study, $n = 10$ is the number of factors and $x_1, x_2, ..., x_{10}$, the first column of the Table 1. Similarly, here $m = 4$ and $Y = (y_1, y_2, y_3, y_4)$; $y_1 = Genuine\ all-rounder$, $y_2 = Batting\ all-rounder$, $y_3 = Bowling\ all-rounder$, $y_4 = Average\ all-rounder$. Our aim is to estimate the value of Y by maximizing $P(Y = y \mid X = x)$. NB assumes that features are independent of each other for a given class. Therefore,

$$
\begin{aligned}
&P(X_1 = x_1, X_2 = x_2, ..., X_n = x_n \mid Y = y)\\
&= P(X_1 = x_1 \mid Y = y).P(X_2 = x_2 \mid Y = y)....P(X_n = x_n \mid Y = y)\\
&= \prod_{i=1}^{n} P(X_i = x_i \mid Y = y)
\end{aligned}
$$
.

According to the Bayes theorem, we have $P(y \mid X) = \frac{P(X \mid y)P(y)}{P(X)}$.

Then we can write $P(y \mid X)$ as follows.

$$
\begin{aligned}
P(y \mid X) &= \frac{P(X = x, Y = y)}{P(X = x)}\\
&= \frac{P(Y = y)P(X = x \mid Y = y)}{P(X = x)}\\
&= \frac{P(Y = y)\prod_{i=1}^{n} P(X_i = x_i \mid Y = y)}{\prod_{i=1}^{n} P(X_i = x_i)}\\
&\propto P(Y = y)\prod_{i=1}^{n} P(X_i = x_i \mid Y = y)
\end{aligned}
$$

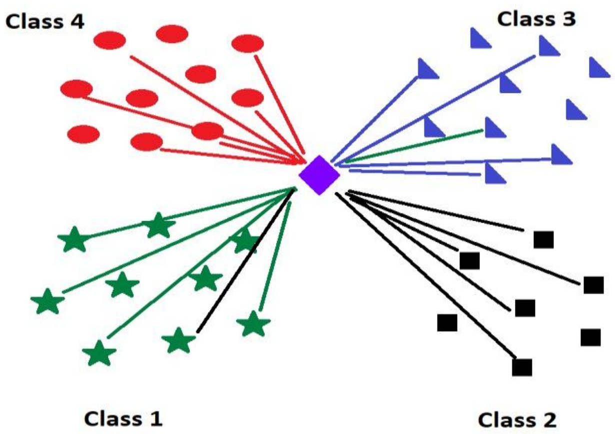
Therefore, our aim is to find y, that maximize the above expression. In another words, we need to find y, which is

$$\arg\max_y P(Y - y)P(Y = y)\prod_{i=1}^{n} P(X_i = x_i \mid Y = y)$$

k-Nearest Neighbour's Algorithm (kNN)

The kNN can be considered as one of the simplest machine learning classifiers, which is based on distance matric (Figure 2). Applications of kNN can be found in text categorization (Elnahrawy 2002), ranking models (Xiubo et al. 2008), and object recognition (Bajramovic et al. 2006). If a novel data point is given, kNN attempts to identify the correct category of the novel point, using the characteristics of the neighbouring data points. The main trait of the data points is going to be the distance from novel data point to each of the other data points. When considering the distance metric, Euclidian is the most commonly used one though other metrics such as Manhattan Distance, Mahalanobis Distance and Chebychev Distances are also used in practice. Table 3 shows some other popular distance matrices used in data classification.

Figure 2. *kNN Classifier*



Let $\{x_i, y_i\}; i = 1, 2, ..., n$ be the training sample in which x_i represents the feature value and $y_i \in \{c_1, c_2, ..., c_M\}$ represents the M categories (class value). Furthermore, let X be a novel data point. The kNN algorithm can be summarised as follows.

- Calculating the distance from this novel point *X* to all other points in the dataset.
- Sort the distances from each point to the novel point and select the *k* (usually an odd number to prevent tie situations) smallest distances, i.e., nearest *k* neighbours $y_{i1}, y_{i2}, ..., y_{ik}$.
- Then for each of the above *k* nearest neighbours, it records the corresponding class (labels) $c_j; j = 1, 2, .., M$ and calculate the following conditional probability.

$$P\left(c_x = c_j \mid X = x\right) = \frac{1}{k}\sum_{i=1}^{k} I_{c_i}(x);$$

where $I_{c_i}(x) = \begin{cases} 1; x \in c_i \\ 0; x \notin c_i \end{cases}$

- The class c_j that has the highest probability is assigned to the novel data point, as the category of the data point.

Table 3. *Popular Distance Metrics*

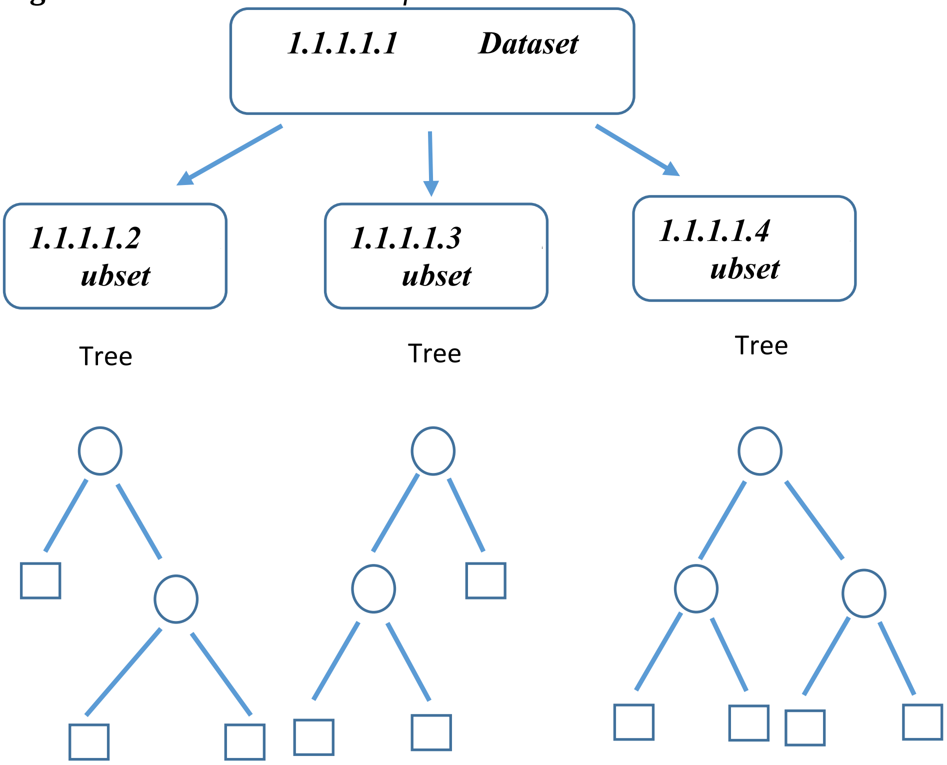
Name	Distance Matric
Euclidean	$\sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$
Manhattan	$\sum_{i=1}^{n} \lvert x_i - y_i \rvert$
Chebyshev	$\max\left(\lvert x_i - y_i \rvert\right)$
Minkowski	$\sqrt[p]{\sum_{i=1}^{n}(x_i - y_i)^p}$

Random Forest (RF)

RF algorithm extends the idea of decision trees by aggregating higher number of decision trees to reduce the variance of the novel decision tree (Couronné 2018). Each tree is built upon a collection of random variables (features) and a collection of such random trees is called a Random Forest. Dues to the higher classification accuracy, RF is considered as one of the most successful classification algorithms in modern-times (Breiman 2001, Biau and Scornet 2016) (Figure 3). Furthermore, the performance of this classification algorithm is significant for unbalanced and missing data (Shah et al. 2014), compared to its counterparts. RF has been studied by many researchers both in theoretically and experimentally since its introduction in 2001 (Bernard et al. 2007, Breiman 2001, Geurts 2006, Rodriguez 2006). Further studies have been conducted to improve the classify-cation accuracy of RF by clever selection of the associated parameters of RF (Bernard et al. 2007).

A handful of applications of machine learning algorithms in the context of cricket can be seen in the literature. Using kNN and NB classifiers, Kumar and Roy (2018) forecasted final score of an ODI score after the completion of the fifth over of the game. NB and RF were two of the machine learning techniques Passi and Pandey (2018) used in their study to predict the individual player’s performance in the game of cricket. Using English T20 county cricket data from 2009 to 2014, Kampakis and Thomas (2015) developed a machine learning model to predict the outcome of the T20 cricket game.

Figure 3. *Random Forest Classifier*



Findings

All the experimental outcomes were tested under the k-fold cross-validation, which is used to generalize the findings of the study to any given independent sample as discussed in the literature (Burman 1989, Kohavi 1995). We executed all of the three machine learning classifiers with the collected data and according to the experimental outcomes, NB classifier reached a maximum of 60.7% prediction accuracy. Furthermore, the maximum prediction accuracy using Knn was 55.08%. In order to see how the prediction accuracy changes with the selection of distance matric with kNN algorithm, we measured the prediction of accuracies with respect to the various distance matrices. Table 4 summarises the percentage of prediction accuracy for each of the selected distance metric and the value *k* used in kNN.

With RF, an initial accuracy rate of 93.34% was recorded, which is the highest among the three classifiers we used. Further investigation was conducted to optimize the prediction accuracy, by varying the associated parameters of RF.

Table 4. *Distance Metric, K value, and Percentage of Prediction Accuracy*

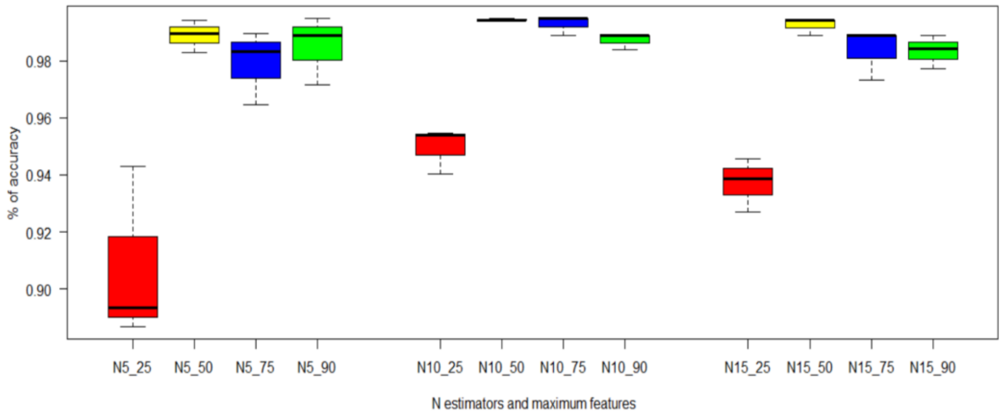
Distance Metric	K	Percentage of Accuracy
Euclidian	3	47.55%
	5	49.36%
	7	46.77%
Manhattan	3	49.81%
	5	51.98%
	7	54.83%
Chebyshev	3	49.88%
	5	52.38%
	7	55.08%
Minkowski, p=3	3	43.38%
	5	50.99%
	7	50.12%

Important Parameters used in RF

Among the various parameters used with RF, the following important parameters were changed to see a better prediction rate.

n_estimators: This represents the number of trees in the RF.
max_features: This represents the maximum number of features when the RF selects the split point.
min_samples_leaf: This represents how many minimum number of data points in the end node.

Figure 4. *Change of Prediction Accuracy with Different Parameters*



Values of n_estimators, max_features, and min_samples_leaf were varied from $\{5,10,15\}$, $\{0.25, 0.50, 0.75, 0.90\}$, and $\{1,2,3\}$. The obtained corresponding values of the percentages of prediction accuracies are displayed by the Figure 4.

After searching for better parameterization, we investigated the associated errors with the RF Regression model. Both Mean Absolute Error (MAE) and Mean Squared Error (MSE) were recorded for the model with previously identified parameters. Figures 6 and 7 display the variation of both MAE and MSE for each values of parameters. As the experimental outcomes indicated, RF reached a maximum prediction accuracy of 99.4% with the selection of *n_estimators*=10, *max_features*=0.50, *min_samples_leaf*=2, and n_*estimators*=10, *max_ features* =0.75, *min_samples_leaf=1.*

Figure 5. *Prediction Accuracy, max_features and* ***min_samples_leaf*** *for n_ estimators=10*

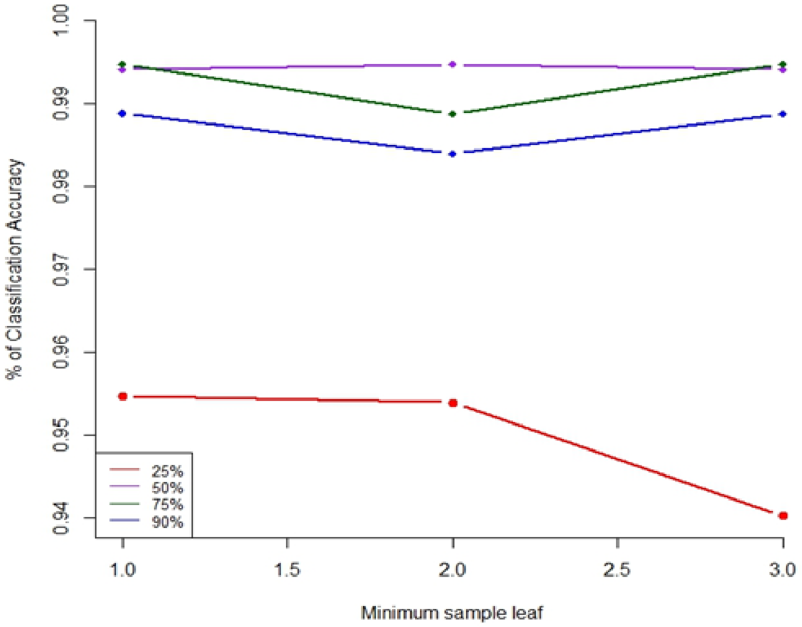


Figure 6. *Parameters of Random Forest vs. Mean Absolute Error*

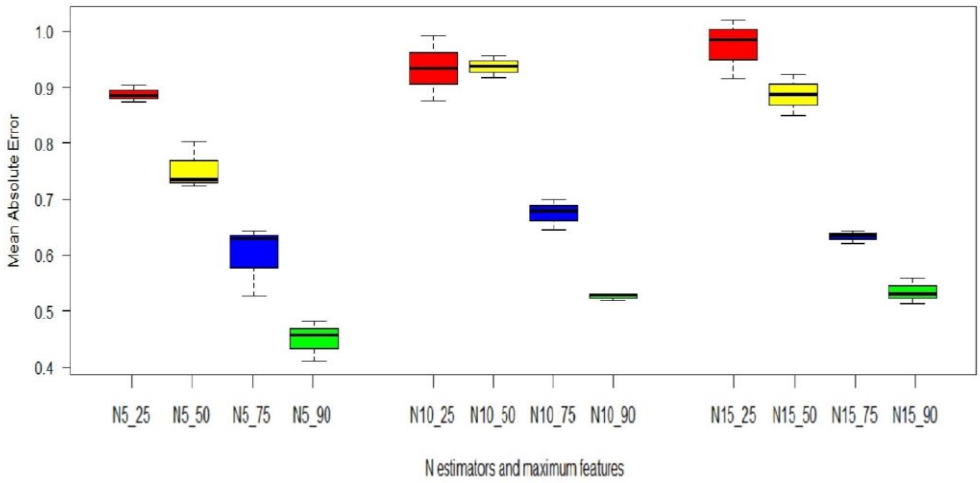
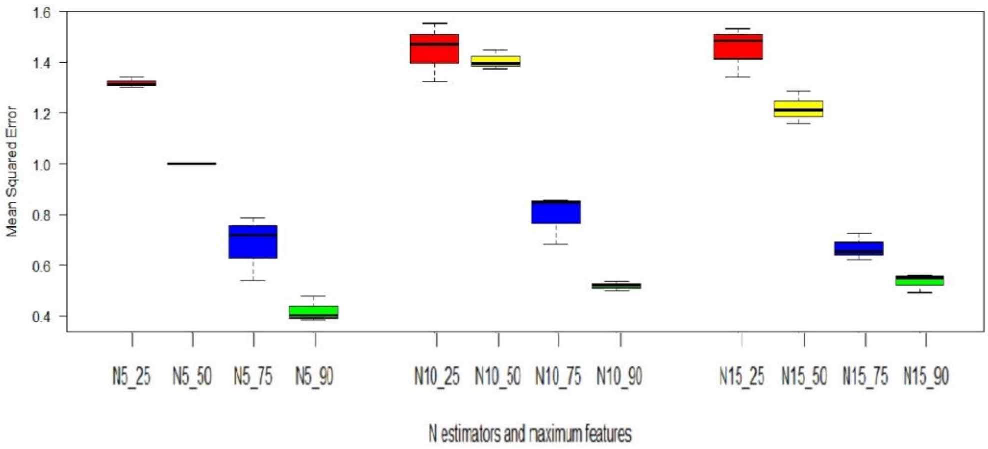


Figure 7. *Parameters of Random Forest vs. Mean Square Error*



Discussion and Conclusion

In this manuscript, we discussed how to categorize all-rounders in the game of ODI cricket. Using a collection of 177 players from all the ODI playing countries, ten player-related predictors, together with three machine learning techniques, we investigated how to categorize all-rounders into one of the four categories. In this study, we utilized three machine learning techniques, namely Random Forest (RF), k-nearest neighbours (kNN), and Naïve Bayes (NB) to predict the appropriate category each of the all-rounder should belong.

After initial execution of the above three algorithms, the prediction accuracies for kNN, NB, and RF were 50.08%, 59.00%, and 93.34% respectively. Further improvement of the prediction accuracy was able to achieve with the proper selection of the parameters. By changing the distance metric with kNN and the *k* value, we were able to improve the prediction accuracy up to 55.08%. Similarly, NB was improved up to 60.7%. According to Figures 4-7, it is clear that RF has improved to the highest prediction accuracy of 99.4%, with the selection of appropriate values for the parameters. This can be reached with two different parameter settings. i.e., when *n_estimators is* 10, *max_features* is 0.50, *min_samples_leaf* is 2, and *n_estimators* is 10, *max_features* is 0.75, *min_samples_leaf* is 1. In addition to the prediction accuracy, an investigation was conducted to find out the relative errors involved with these processes. According to the findings, these errors became minimum when *n_estimators* is 10, *max_features* is 0.75 and *min_samples_leaf* is 1 respectively and the values were 0.68 and 0.86 respectively.

In summary, our experimental results indicated that RF algorithm outperformed both kNN and NB by huge margins. The findings of this study benefit the officials of the game of cricket and the players in many ways. Player selection committees, coaches of teams, and even the players can utilize these outcomes to identify appropriate all-rounders. It would be important to include additional performance indicators, including statistics about the opposition teams that the players play against for future studies.

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Universality and Singularities of Sports Shows Production

By Patrice Bouvet[*]

After recalling that the production of a sports event, like any production, follows a wave-like pattern, the three phases of said production will be distinguished: preparation/reflection, actualization, finalization. The point of this distinction lies in that: respectively competitive balance, "competitive exceptionality", and competitive stakes. The former takes into account the difference between the percentages of the completed skills and the permanence of such skills which set apart the professional from the amateur players. The latter is defined as the sum of the monetizable stakes and the direct economic stakes. Hence, as the producers of sports events mainly market four types of rights, we may suggest a new analysis of the monetization of sports events.

Keywords: monetization, production, results, sports economics, sports events.

Introduction

The multiplication of scientific articles[1] and media debates on these issues attests to this: the economics of sport is a growing discipline. Logically, since it is now largely "monetized", professional sport most often attracts the attention of researchers and commentators. However, in the end, what do professional athletes produce? The answer is now well known: a live performance with certain particularities.

The term "production" is frequently used in economics but also in everyday vocabulary. Nevertheless, its definition often remains vague. Thus, for example, "production" refers indistinctly to the action that gives rise to the goods and services and the result of that action (the finished product). In the past, various answers have been given to the question of what to produce. For mercantilists, production essentially means mining precious metals. For physiocrats, only agriculture is productive. Later, Smith (1776) was the first to refute this view and to show the productive nature of manufactured works. Gradually the notion of production has broadened. Today in economic dictionaries (Echaudemaison 1996, p.351) it is defined as: "the act of manufacturing goods or making available to others, services that satisfy individual or collective goods, generally solvent".

According to this definition, production would be the domain of engineers, technicians and workers responsible for manufacturing and developing goods and services. Yet, as we have just recalled, economists have long since taken hold of the concept. Why? Because in reality humans are incapable of creating or

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[1]On this point see, particularly the articles published in the *Journal of Sports Economics* and the *International Journal of Sport Finance*.

destroying the slightest particle of matter. Whatever the goods or services, through a series of operations that are all reduced to simple "displacements", man borrows from the environment in which he lives the materials. The question of the relationship of these trips to time is therefore fundamental. This is the case in the production of sports shows as it is for all other productions. The latter seems more complex to study since it requires the cooperation of many producers: organizers, players or clubs and broadcasters, themselves in contact with other actors; fans and advertisers mainly. In addition, several "sports times" can be distinguished: the match, which will be the subject of our study here, a series of matches (round trip for example), a particular competition, a "season" or several seasons. Despite these specificities, some authors (Scully 1974, Gustafson et al. 1999, Borland 2006) have used factor theory to estimate a team's output. From this perspective, the match, the output, is the product of the combination of work (players, staff) and capital (stadium, other equipment), inputs. This type of analysis makes it possible to estimate the marginal productivity of players and compare team performance. In addition to certain difficulties, particularly to take into account the interactions between players, by definition this method does not focus on the entire production process (role of other actors) and ignores the temporal dimension of any production. This is one of the reasons that led us to consider this reflection.

In what follows, we will therefore endeavour to present the universal character of the production of sports shows, especially in its relation to time, then to highlight its many singularities. To this end, after having shown that economic production[2] is a "wave phenomenon" (I), we will focus on the peculiarities of the production of sports shows (II), characteristics which greatly determine its possibilities of valorisation (III).

Economic Production: A "Wave Phenomenon"

Prerequisites for Production

Making a computer, developing a cooking recipe, building a dam, organizing a sports show... and in general everything that is produced by man is produced after a "reflection-preparation" phase, usually long and complicated depending on the nature of the good or service produced. Therefore in the previous examples, it is respectively necessary to design and choose the different components, to procure and assemble the different ingredients, to choose the site and make the plans, to determine the place and define the rules of the match, even if this phase of "reflection-preparation" may be elementary and of short duration no production deviates from this rule. This first observation is obvious. It is nevertheless important because it makes it possible clearly distinguishing this preparatory phase from the actual implementation phase from the production phase, which is not creative. Indeed, apart from the imaginary (thought and art), human is not a creator. In accordance with the Lavoisier principle, the actions successively

[2]What we oppose to material production.

implemented to produce "transform" matter or energy. Frequently, this transformation[3] takes place in different phases: to produce more efficiently, people acquire "tools" that enable them to obtain productivity gains. These tools can be very different, they correspond to the material capital which, associated with work and nature, apparently constitute the "factors of production".

They consist of technical instruments used to produce other goods. On their own, these two first factors of production cannot, however, give rise to any production. Only their use by humans can lead to economic production. Despite this observation, economic production is defined as a function of these three factors for which it is possible to construct a mathematical relationship between the quantities produced (outputs) and the various factors (inputs) combined to obtain it. Since it is obligatorily in time, the previous observation leads to the question of the time/production ratio. This question is old! It requires, in our opinion, an analysis different to that which is the most traditionally proposed. Production is an action (or a displacement). Therefore, it can apparently be defined as a space traversed by a unit of time, i.e., as a speed. We then write:

$$\text{Production} = \text{Product/unit of time}$$

This equation is not acceptable. Indeed:

- if the production is null, the product is also null and vice versa;
- if the positive production is multiplied by a positive number, the product is multiplied by the same number and vice versa.

These two proposals are not verified for the speed of an object moving in a given space. If the movement is null, it is not sure that the speed is also null, it is enough that the time of the movement is null. Similarly, multiplying the speed does not give any results if it is not applied in a time. Production should not be considered as a speed. In other words, as usually defined, production has a dimension in time since it is the product of a speed by its application time. However, if the instantaneous speed is calculated at the limit, by the path travelled in an infinitely small time, the reasoning is circular since the space travelled is predefined. Economic variables do not move over time in a similar way to themselves.

If we define production according to its supposed factors, it is impossible to locate the productive activity in time. Conversely, if we decide to study production in terms of time, it is no longer possible to relate it to its supposed factors. To analyse economic production, it is essential to study its finalisation (instantaneous) and its progress (in continuous or continuum time) separately.

[3]For some productions, nature even takes care of it.

The Production

To study the relationship of events to time in the basic sciences, and in particular the physical sciences, it is customary to contrast continuous time (the "passing time") with discontinuous time. The first allows us to study the phenomena that always exist during the period studied. After dividing the continuous time into discrete intervals, the second one allows to analyse the phenomena that appear at the end of "jumps". They are called this because initially, corresponding to the first interval, nothing happens, then, in a single movement; the phenomenon appears and persists in the following intervals. To the extent that apparently economic actions, and therefore production, "consume time" since they start at a time t_0 and end at a time t_n, logically economists have based their analyses on these two "forms" of time and most often on discontinuous time.

What is the proposed analysis? First, it is a question of identifying periods in the continuous time that facilitate the analysis: the month, the year, the period of financing, of depreciation... Then, this division makes it possible to take account of the fact that to produce it is necessary to undertake a series of actions in t_0 which finally ends at a time t_n located at a finite distance of t_0. Therefore, production extends from t_0 to t_n while being constantly null in this interval. It becomes positive only in t_n. Thus, perceived production cannot be assimilated to the time elapsing between t_0 and t_n since the action defined in this period remains null until it becomes positive.

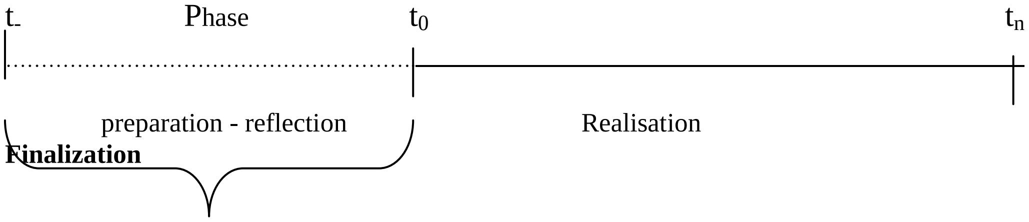
First null and then instantly positive, production appears to be a non-continuous phenomenon that can therefore be analysed in discontinuous time. To be convinced, let us take up the examples proposed above. A computer without a screen is not a computer, an uncut rib of beef is difficult to eat, the first stones of a dam are not a dam, an interrupted sporting event must be replayed. In a word, a semi-product, a product divided by the number two is no more a product than a 1/3, 1/4 or 1/6th of a product. This observation is hardly debatable. However, another interesting question concerns the result, the fruit of this production. Is there a "trace" of the product in continuous time? In other words, can the production of one object serve as a "basis" in the production of another object? For example: once a first computer has been completed, can it be used materially in the production of another computer? Even if for some productions an experimental effect is possible, it is obvious that it will only be useful for a new production. Certainly, the first computer will be a source of increased utility for its owner but the physical production of the second computer will start from scratch. Thus, economic production appears as a specific action that:

- takes place in continuous time, between t_0 and t_n, and,
- ends at a moment t, the moment of its finalization.

The Finalization of the Production

According to the above, schematically, any production process can be represented as follows (Figure 1):

Figure 1. *Stages of Production*



To fully understand this diagram, let us take the example of the manufacture of a computer. Using the available components and the assembly plan drawn up in the preparation-reflection phase, the workers assemble the various components from t_0 to t_n. During this time, all the actions carried out by the workers lead to the desired result. Each gesture is particular to the production of the computer, as we have already noticed, and is a continuous action over time. However, until the computer is finished, finalized, it does not exist. Literally, it only appears at the precise moment of its completion. So how can these two findings be taken into account simultaneously? In one way only: by considering that economic production is an undulating phenomenon. A wave that is a coming and going. However, only an instantaneous comeback gives an account of the dual reality of production:

- the production ranges from t_0 to t_n, so it must go through this time,
- the production is only located at the point t_n, so it must be in t_n even during the journey from t_0 to t_n,
- the only solution - but it is entirely satisfactory - is in the recognition of the wave nature of production: at the point t_n, production is a wave, a movement in time, observed from t_n to t_0 and identically from t_0 to t_n (Schmitt 1984, p.58).

Let us take again the example of the production of a computer. It is a tangible asset. The material necessary for its manufacture is therefore preserved: nothing has been created and nothing is lost in the production process[4]. Naturally the computer is more useful to the man once it finished. The computer was first conceived, thought out, by the engineers in charge of its design, then manufactured by the workers in order to provide a useful tool for its users during its period of use. Producing therefore necessarily means thinking and working for useful purposes, or, to use Schmitt's definition, (1984, p.445): "to flow a matter (or energy) into a preconceived utility form".

The demonstration that production is a wave phenomenon is abstract. However, it does not allow any exceptions. Whatever it is, the production is first null in the realization phase and then becomes positive at the point of its finalization. Thus, not only it appears at the end of the realization phase but disappears at the precise moment when it becomes positive. The analysis of economic production must take these two aspects into account, so its study cannot take place in discontinuous (or continuous) time but in "quantum time" (Schmitt

[4]It is the same with energy.

1984, p.439). Production "quantifies time" (Schmitt 1984, p.440). Thus, any product is a quantum of time measured by the quantized time. This confirms the observation that only human work is truly productive: only human action to understand how additional utility can be obtained is productive. This is also the case in the production of a sports show.

To make the transition to our next part, let us now focus more specifically on the case of the production of a sports show. After the reflection-preparation phase required for its organization, a sports show, a football match for example, starts at "kick-off" (t_0) and ends (t_n) about 90 minutes later. Each technical gesture made by the players can be considered as quantum of action, i.e., as a finite number of instant indivisible actions[5]. In addition, since each quantum is instantaneous, so is the sum of quanta. Nevertheless, the match takes place in continuous time. If the kick-off is not given it does not exist. If the match is interrupted it is not the announced show. Once again, apparently there is a contradiction: how can the same action be both instantaneous and extended in time? The only solution is that the production (of the sports show here) is the action that quantifies the continuous time. Indeed, once the final whistle is pronounced the match does not extend. As the match stops at the final whistle, the production of the sports show is ultimately positive neither during the duration of the match (see above) nor once it is over. Unlike material goods that seem to have a longer life expectancy, several decades for a dam, for example, a sporting event has no positive inertia over time, its value disappearing at the point when the result of the match is known and endorsed. In fact, this is a general result. Indeed, if a computer for example, has a lifetime or a value of use (a utility) of several years, its exchange value is defined by the corresponding quantum of time that is not material.

There are nevertheless several differences between the production of a material good and the production of sports shows[6]. In addition to the necessary cooperation of several actors on which we will return, unlike other productions, the sports shows take place in a predetermined period of time by the sports rules (football), or conditioned by the achievement of the expected result (tennis), but for which the interest and therefore the value lies in the knowledge of the final result. Moreover (Bouvet, 2011, p.12):

- the conditions of production are perfectly codified: producers must respect precise rules,
- most of the particular conditions of production are known,
- the quantum if actions conferring its value on production are partially identified.

Thus, a sports show can ultimately be precisely defined as the technical gestures that contribute to the quality of the show, which is useful for spectators

[5]If they were not instant, they would have an extension in the continuous time and would therefore be divisible.

[6]If one, nevertheless wishes to equate sports shows with an "economic good", three characteristics must be noted: it is a rival good for which there is no obligation of use but possibilities of congestion.

and viewers (production), produced collaboratively in a pre-determined context (preparation-reflection), in the goal of obtaining a result whose value disappears at the end of the match (finalization).

The Features of the Production of Sports Shows

Organization of Production and Competitive Balance

Like any production, the production of sports shows begins with a reflection-preparation phase in which producers imagine how they can best meet the needs of potential consumers. In sports economics, the emphasis is most often placed on two of the organizational characteristics of this production. First, the joint nature of production (Gayant 2016, p.15): unlike other live shows, the production of a sports show requires the presence of several competitors, simultaneously or successively. Moreover, even if the revenues related to media coverage are now the most important, mediatized sports shows are derived products (Andreff 2012, p.115) from direct sports shows that take place in stadiums. For televised sports shows, in the reflection-preparation phase, three main actors are therefore required to cooperate to produce: competition organisers, players and their agents and broadcasters.

The organizers' reflection focuses on the calendar, design and implementation of the competitions and therefore of the matches. The definition of the calendar is a difficult exercise to try to reconcile as intelligently as possible the constraints of the stakeholders. Thus, a sports calendar must be fair, minimize the risk of injury, take account of weather hazards, audience opportunities, and the calendar of international competitions. The design of competitions is in most sports a legacy from the past. Thus, depending on the sport and country, competitions can be organised in the form of championships, cups, pools, etc., including play-offs or not. Nowadays, the choice of competition design is very largely determined by the organisers' desire to maximise their direct (access rights plus TV rights) and indirect profits (sponsorship revenues and derived products). The implementation of competitions is ensured by the sports authorities themselves (national and international federations, leagues) or by companies specialised in the organisation of sporting events. It is then up to them to define the marketing strategy, draw up budgets, communicate, ensure the security of the event, find sponsors, take care of the logistics, etc.

Top athletes, who are the real productive force of sports shows, before matches, prepare technically, physically and mentally to be as efficient as possible. In this phase, the choice of coaches often proves to be a decisive element of success.

Broadcasters, depending on their strategy, position themselves to acquire the rights to sporting events likely to generate the best audiences. Then they broadcast the competitions.

This brief overview of the multitude of elements involved in the production of a television sports show might suggest that it is not always possible to bring them together. Between organizers and players, organizers and broadcasters and even sometimes between players and broadcasters, conflicts sometimes appear. Nevertheless, all of them most often meet around a common objective: to arouse a permanent interest among the final consumers, the viewers and spectators. Several factors can contribute to this interest. Since the pioneering work of Rottenberg (1956), actors and analysts have come together on one of them: uncertainty is one of the common denominators of this interest. And, to preserve this uncertainty, the players or teams that meet, must be of a comparable level. In other words, we must ensure that a certain competitive balance is maintained.

Competitive balance is one of the key concepts of the sports economy, and indeed one of the only ones that is truly specific. Even if it can only be measured *ex-post*, it must necessarily be considered *ex-ante*, during the preparation-reflection phase of production. There are many definitions of competitive balance (Kringstad and Gerrard 2007) and multiple ways to measure it (Groot 2008). At our scale, the production of a sports event, the most commonly used indicator (Andreff 2012, p.165) is:

$$\text{Competitive Balance (CB)} = L_{ij} = t_i/(t_i + t_j)$$

Where:

- L_{ij} an indicator of the level of the teams[7].
- t_i is the quantity of talent of the club i, approximated by the percentage of past victories of the club,
- t_j is the quantity of talent of the club j, approximated in the same way.

Six main criticisms are addressed relative to this issue. In Europe, can the question of competitive balance be considered independently of the financial health of clubs (Andreff 2009)? In promotion/relegation models, are these opportunities not the most important determinant of its existence (Noll 2002)? Are differences in local potential not an important source of competitive imbalance (Helleu and Durand 2005)? Isn't the reputation of the teams even more decisive in the eyes of fans (Czarnitzki and Stadtmann 2002)? When the team that clearly dominates the competition is supported by many fans, can't the satisfaction they feel compensate for the weakness of the competitive balance (Szymanski 2001)? More fundamentally, why is it so rarely empirically validated (Andreff 2009)? Obviously, interest in sports events also depends on other factors. It is this observation that has led other authors (Kingstard and Gerrard 2004, Scelles and Durand 2010) to introduce into the literature the concept of competitive intensity, defined as: "the degree of competition within the league (or tournament) with respect to its price structure" (Kingstard and Gerrard 2004). This concept already makes it possible, and will undoubtedly make it possible even more so, depending on its future developments, to go beyond certain limits of competitive balance. Nevertheless, it does not refer to a particular match, and has the disadvantage of

[7]The ranking compared between the two teams at the point of the match and the bets placed with the bookmakers as to the outcome of the match are also a possible indicator.

not taking into account the events, the quanta of action, necessary for the realization of the production which are carried out by the players and participate in the quality and the "exceptionality" of the show.

Quality of the Show and "Competitive Exceptionality"

In most cases, the authors who were interested in the notion of quality of sports performances did so in an attempt to assess the influence of this variable on the behaviour of viewers and spectators, particularly with regard to stadium attendance (Garcia and Rodriguez 2000). To estimate this variable, they distinguish between:

- the supposed or expected quality of the teams at the beginning of the season. To do this, they study the clubs' budgets, the players' salaries (considered as indicators of their productivity), the number of international selections of players composing the teams, etc.
- the current level of the team, approximated by the number of home wins in the last three games, the number of goals scored in the last games, the ranking, etc.

By doing so, the expected quality of the match is estimated *ex-ante* based on *ex-post* variables. In this case, quality is therefore essentially approximated by the means used to obtain it and the performances recently achieved. The implicit assumption associated with this reasoning is that teams that develop sports facilities and/or achieve good results produce a quality show. Is this systematically the case? No. Sometimes prestigious teams that base their success on defensive strategies offer a poor quality of show. The tactical choices of coaches can lead teams to neutralize each other. Paralysed by the stakes, some players or teams do not always succeed in expressing their talent. But one of the elements that underlie the interest of viewers and spectators is precisely the quality of the gestures made by professional athletes. This is even one of the main differences with many other sectors of activity: the elementary acts of production that take place in the continuum are of interest to others (sports fans) than those who realize them (players). The indirect consequences of this particularity are well known: starification, importance of remuneration, commercial use, financial drifts etc.

At this stage of the reasoning, a question arises: why are these actions of interest to others? The answer is no longer any doubt. If millions of people are interested in the elementary acts of production carried out by high-level athletes it is because they recognize them as exceptional. In other words, it is because the champions can perform unique and exceptional "technical gestures" and in any case, out of reach of amateur practitioners, they arouse admiration. Thus, the "quality of the show" is largely based on the nature of the technical gestures, the precision of actions, and the inventiveness of top athletes. In order to appreciate the quality of a match, rather than to estimate it by past performances, we therefore think, in addition to the competitive balance indicator, that it is interesting to propose an indicator of "competitive exceptionality".

Beyond the performances that can be achieved by top athletes[8], it is the percentage of successful technical gestures and the permanence of these actions during the match that allow opposing the professional players to amateurs. Such an indicator can therefore take the following form:

$$CE_{xp} = \sum_{J=1}^{x} \sum_{a=1}^{n} [(PSA_{pro} - \overline{PSA_{ama}}) + (DSA_{End} - DSA_{Beginning})]$$

where:

- CE_{xp}: the competitive exceptionality indicator,
- J: The number of players making teams. Equal to 2 for individual sports,
- PSA_{pro}: the percentage of successful selected actions, i.e. successful technical gestures (passes, shots, stops ...) by the professional players,
- PSA_{ama}: the average percentage of comparable actions that amateur players achieved,
- DSA_{End}: the difference between the percentages (means) of the successful actions at the end of the game by the professional players and the amateur players,
- $DSA_{Beginning}$: the difference between the percentages (means) of the successful actions at the beginning of the game by the professional players and the amateur players.

Using the statistics collected by the companies OPTA or PROZONE, for example for a football match, CE_{xp} could be obtained by the following 7 steps:

1) by calculating, for each of the players participating in the match and for each action selected, the difference between the percentage of success for the professional player studied and the average percentage of success for an amateur player,
2) by summing the differences obtained = A,
3) by calculating the difference between the percentages (means) of the successful actions at the end of the game by the professional players and the amateur players = B,
4) by calculating, the difference between the percentages (means) of the successful actions at the beginning of the game by the professional players and the amateur players = C,
5) by summing the differences obtained = D,
6) for each player by adding A and D = X,
7) at last, by calculating CE_{xp} by adding the sum of the Xs for each of the players on the field.

[8]On a match, it is not uncommon for a "small team" to compete or even eliminate a more prestigious team. Exceptionally an amateur player can perform a fantastic technical gesture.

Estimating this indicator therefore implies being able to obtain some statistics that are currently widely produced by companies specializing in this sector of activity and to agree on the average level of performance among amateur athletes. This is not easy but not impossible[9]. In our opinion, the advantage of such an indicator would be to be able to supplement the indications provided by the CB calculation: the competitive balance. However, it is not yet entirely satisfactory. Why? Because in an even more visible way than in other sectors of activity, the value that can be *ex-post* attributed to the technical gestures made during a meeting is conditioned by the result of the match and even more by the consequences of this one and therefore by its competitive stakes.

Results and Competitive Stake

All economic production takes place first in continuous time but acquires its final value only at the precise moment of its finalization. For any good at this moment the value of exchange or the product in the exact sense of the term leaves room for the product value of use. For a sports match at the precise moment of the final whistle, the (technical) actions that contributed to the realization of the match turn into a result that often leads to a proofreading of the "game facts" observed during the match. This is a perfect illustration of the wave nature of production. The elementary production gestures (passes, dribbles, shots, etc.) made by the players during the match are at the origin of the result (coming) but at the same time it illuminates them differently (going). Economically, the production of a sports spectacle is thus also a wave movement, in other words a "coming and going" between the beginning of the match and the precise moment when the result is known and endorsed. An important question arises: what elements can lead to a particular appreciation of what happened during the match? In the professional sport it is about the consequences of the result obtained. Let us take a “stylised” example. In a football match where the loser is eliminated counting for an international competition, the referee validates the goal of a player scored while he was offside. The match ends 1-0.

The sporting and economic consequences of this elimination usually lead to reinterpreting this arbitration error as being the cause of the negative consequences for the losing team. In some cases, such a reading of the situation has even led a club president to file an attack on the referee in court (Italy) or his murder (Colombia). However, by definition, what one can lose or gain as a result of a particular enterprise corresponds to a precise notion: the notion of stake. Also, to appreciate the importance of the final result of a sporting event and thus the retrospective reading of the elementary actions of production requires in the sporting field to know what the consequences that can result from it are.

From a theoretical point of view, introducing the notion of stake indirectly amounts to introducing the notion of risk into the reasoning. To explore this

[9]We performed these calculations for the French league 1, the English Premier League and the Spanish Liga. The results will be presented at a conference in Paris in 2020.

question further, the use of risk and uncertainty theory (Knight 1921, Allais 1984, Pradier 2006) could therefore most certainly prove useful in the future.

Another perspective also seems possible: that of establishing a "table of competitive stakes". Based on the observation that the competition stakes is conditioned by past, present and future elements, such a table could be built in three stages consisting of:

- to "graduate" the factors influencing the issue of sports confrontations,
- to examine their simultaneity,
- to associate coefficients (weight) to the different distinguished situations.

The history of the confrontation may be characterized by a very significant cultural context (case of derbies), by recent one-off events (injury, arbitration errors, conflict between managers) or by the absence of any particular antagonism between the two clubs. The prestige of confrontation (present) finds its origin at several levels: exceptional character, important international dimension, rarity, context, etc. Finally, future consequences play an important role by definition. Classified in order of increasing involvement, can be distinguished: the continuation or maintenance in competition, the existence of sporting and economic consequences, the existence of economic or sporting consequences.

Therefore, by associating a multiplying factor to the different scenarios considered, it becomes possible to define the table of competitive stakes mentioned above. This one presents a double interest:

- it allows to associate a weight to the confrontations, a "friendly regional" confrontation being the one with the least stakes in this respect,
- it allows, subject to obtaining certain information very widely available in the specialized press, to predict the level of competitive stake of a match.

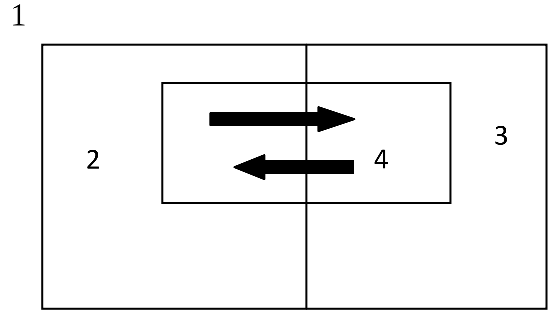
In this way, the notion of a competitive stake differs from the notion of sporting stakes usually presented in the literature (Jennet 1984, Borland 1987, Cairns 1987) where it appears to be the opportunity offered to teams to obtain the results necessary to achieve pre-determined objectives (title or accession to a qualifying place). In addition to its quantitative dimension, in our opinion its main interest, in addition to the indicator of competitive balance (which mainly relates to the preparation-reflection phase of a sports shows) and the competitive exceptionality indicator (allowing to appreciate the particular character of the elementary gestures realized during the production phase), is to make it possible to quantify the "importance of the result" which materialises the instantaneous finalization of this type of production, and thus to contribute to a better appreciation of the value of sports shows.

The Valuation of Sports Shows

The Necessary Amortization of the Specific Costs of Production

Beyond the necessary collaboration of the various stakeholders in the preparation-reflection phase, the production of a sports show also requires cooperation in its implementation phase. Three or four actors are systematically involved: the organizer of the competition, the (two) teams or players who compete and, when it is televised, the broadcaster. This necessary cooperation can be schematised as follows (Figure 2):

Figure 2. *Cooperative Process of Producing a Sports Show*



The competition organizers determine the rectangle 1: the "framework" in which the match will take place: place, date, rules, refereeing conditions, etc. The clubs that meet (rectangles 2 and 3) choose the production factors: preparation, team composition, substitutes, etc., who will participate in the confrontation (4). Broadcasters retransmit this one: choice of the type of retransmission, comments, analyses, etc. For example, in the extreme case where a club organizes a “friendly match” between their team "A" and their team "B" not televised, 1, 2 and 3 become one. Nevertheless, in all cases, the organization of such a match generates production costs that must be amortized.

The concept of depreciation is a notion that, from Adam Smith to some contemporary theoreticians of production, has attracted the attention of many authors. It corresponds to the need to "offset" the investments made to implement a production through a creation of equivalent value. Also, organizers must get a remuneration covering their organizational costs, producers their participation costs and broadcasters their broadcasting costs. At its core, an interest in the question of production costs therefore raises questions about the conditions for expressing the value created and its measurement. Measuring production by its utility is not satisfactory: if, by definition, a product has a certain utility, it is not a physical quantity but an immeasurable psychological quantity. Measuring production by counting for the time required to complete it also leads to a stalemate. By measuring the time during which work is done, we measure time and not work: the measurement is physical but not economical. Such a measure supposes the existence of a unit of work while only one unit of time is available. Only the introduction of money can solve the problem of measurement in economics. The production of sports shows is no exception. If it is possible to assign a value to this product it is because it is monetized. Here again, this monetization has three remarkable characteristics.

Exhibition, Monetization and Commercial Methods

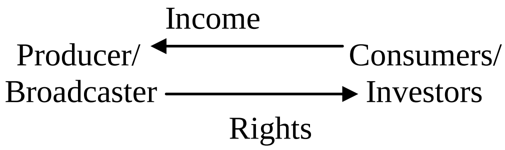
About thirty years ago, when a West German viewer asked someone: "Can you explain to me why you earn three million marks a year when I, as a locksmith, only earn 30,000?" a German football player replied with a mathematically logical formula: "It is because in Germany there are 300,000 locksmiths and only 300 football professionals" (Bouvet 1996, p.125). According to this answer, it would be because footballers have rare skills that they are extremely well paid. Today this answer no longer holds. In some sports and other sectors of activity, workers with extraordinary skills do not earn millions. So nowadays, when a neurosurgeon asks himself this question, a football player could answer: "it's because I'm on TV!"

This is one of the particularities of "sports work":

- the nature of the sport practised, individual or collective, most often determines the status of the sports worker, employed or self-employed,
- most professional sports activities are not accomplished in the public sphere but also in public.

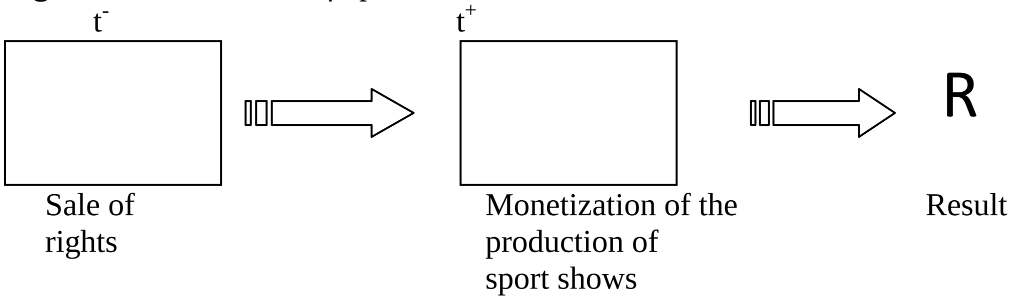
It is mainly because millions of viewers are interested in the feats of their favourite champions that some of them, precisely those whose productions are widely covered by the media, receive very high levels of remuneration. At first glance, this exchange seems to be able to be analysed as a relative exchange in which these high levels of remuneration are the counterpart of the exceptional performance achieved. Nevertheless, spectators and viewers do not directly remunerate professional sportsmen. The transaction is monetized. In other words, when a sports fan decides to sacrifice part of his income to "consume a sports show" he exchanges a levy right on the national product acquired through his direct or indirect participation in the production against an access right to the sports show. This transaction should rather be analysed as the "absolute" exchange of a right into another right. Therefore, the question arises of the conditions of monetization of the production of sports shows. And, again, the study of the chronology of operations is rich in lessons.

What do the producers of sports shows market? Except for the case of player trading in which a sports club decides to sell one of its factors of production that does not fall within the scope of our analysis, the answer is now well known. Producers of sports shows sell rights of four natures. Exhibition rights: rights sold in exchange for the highlighting of a name, a brand, a product. Access rights: entrance fees to stadiums. Broadcasting rights: rights that allow broadcasters to market the produced images. Naming rights ceded following naming operations. When are these rights commercialised? There too, and even in the limited case of access rights[10], they are before the matches. This exchange should not be schematised as below using two reciprocal arrows representing a concomitant movement:



Moreover, this representation is not acceptable for another reason: the rights transferred are used to finance the production of sports shows. In other words, the monetization of professional sport is based on pre-financing authorized by the sale of rights (Bouvet 2016, p.53). Rather, it should be represented schematically as follows (Figure 3):

Figure 3. *Monetization of Sports Shows*



Thanks to the sale of multiple rights, sports shows can take place. Their realization gives an object to the transferred rights which confers on them their final monetary value. At the point when the match ends, it disappears to give way to a series of numbers that expresses the result of the match. Sports rights have no intrinsic value. It is their association with the production of sports shows that creates it. This is anticipated by of rights buyers (viewers, spectators, sponsors, media, advertisers, etc.). It disappears when the show ends.

Finally, a last question deserves our attention: how are these rights marketed? They are also specific. For exhibition rights, because for many sponsors it is a particularly profitable communication technique, for access rights, because the capacities of sports venues are limited, for broadcasters and companies wishing to sign a naming contract, because they are exclusive, a call for competition is launched. The procedure for allocating retransmission rights is the best illustration of this. These are awarded according to the auction technique. The sports broadcasting rights are assigned at the end of a procedure allowing the owner of the property (single and indivisible) who wishes to sell it, to select the buyer from among several candidates (Cohen and Mougeot 2001). In this type of procedure,

[10]Logically sports clubs want to have many "subscribers" who then participate in the pre-financing of production.

the seller's objective is usually to obtain the highest possible transfer price[11] and therefore largely explains the amount of the contracts. For the allocation of sports broadcasting rights, submission under sealed envelopes is the technique most often used. For now, it is well suited to all actors because it has several practical advantages[12] and does not discourage buyers because of the quadruple potential utility of the result of sports confrontations.

The Quadruple Utility of the Result

All production finds its purpose in the utility that it provides to consumers. Generally, the target consumption is final consumption; consumption that allows satisfying needs of different kinds. Traditionally, this first form of consumption has been opposed to productive consumption: the utility of the initial production results then from the investments allowed by it. According to Attali and Guillaume (1990, p.131), final consumption influences well-being through three components:

- a utility component, which groups together what the product allows to achieve,
- a communication component, which allows each of us to integrate or differentiate,
- an imaginary component that allows one to escape, to dream, to transgress etc.

To these first three forms of consumption is added a productive component that aims to obtain delayed effects. On most of their purchases, consumers seek to combine these different components. The choice of a car makes it possible to satisfy a need of transport but can also make it possible to be integrated in a family of consumers (BMW) and for certain models to escape (cabriolet). When this vehicle is used as a working tool then it also has a productive function.

As we have seen, the purpose of the production of sports shows and therefore its utility lies in the result. However, it is symptomatic to realize that in this case the various stakeholders will be sensitive to the components mentioned above. The communication and imaginary components are the most important for sports fans[13]. Through the results of their teams and favourite players they feel valued, recognized, integrated and sometimes manage to forget their daily lives. For the

[11]However, it is not the only one. Other objectives can be sought: choose the buyer, influence the conditions of use of the property sold.

[12]The four main ones are:

- when the candidates are sensitive to the risk of losing the auction, each of them increases its bid to increase its probability of winning the bet;
- it makes it possible to fight against agreements between candidates;
- it gives the possibility to make an offer without having precise information on the price ready to pay by the buyers;
- it places buyers in perfectly transparent conditions.

[13]In some cases, this is also true for investors.

players the utility is more direct. Depending on the results, their remuneration and "ratings" may or may not increase.

For the organizers, the results justify the implementation of the production: the more "exceptional" they are, the easier it is to justify the existence of these events, which for them are a source of significant profits. Finally, for broadcasters, the results influence the profitability of their investments. Thus, for a television channel holding the image rights to a sports competition, the qualification of the national team is synonymous with important audiences that can be paid for by advertisers. Similarly, the presence of "his" team in an important competition ensures sponsors a wide audience.

In the field of sport, "results" take on considerable importance because their "retroactive" effect is tangible. Depending on the people concerned, they justify a symbolic investment (fan), personal (player) or economic (organizer and broadcaster). The production of sports shows only exists at its completion while requiring a series of actions taking place in the continuous time. Nevertheless, the result of the match, the score, has no time dimension. The production of sports shows is indeed a "flux-reflux". Although it requires exceptional technical gestures that can only be carried out by high-level producers (flux), it is only finalised at the point of the final whistle, when it is transformed into a number that retroactively confers a certain dimension (reflux).

Conclusion

Works dealing with the production of sports shows most often emphasize the joint nature of this production. Many authors nevertheless consider that such a living spectacle can be analysed as the fruit of the combination of several factors of production. In our opinion, it is now necessary to complete these analyses taking account of the "wave" dimension of this production. Like any production after the phase of "preparation-reflection" in which it is necessary to ensure that certain conditions (competitive balance), it takes place in the continuous time and ends at a precise moment. As summarized in Table 1, it thus presents "universal" characteristics, but also several singularities that condition very largely its monetization.

Insofar the various stages of its production are perfectly defined and lead to a quantifiable result, the production of a sports show is a sort of "stylised illustration" of more complex production phenomena. In "sports times", defined by the sports rules (the duration of a match for example), qualified technical gestures are made (competitive balance) which, not only arouse the interest of many fans, but also lead to a result to which it is possible to associate a precise number (competitive stake). To shed light on it in its entirety, the analysis must necessarily take account of the three in-dissociable stages that make it possible to define this production (which is not the case if we reason in terms of factors of production). To do this end, the concepts of competitive exceptionality and competitive stake should in the future make it possible to complete the work on competitive balance. The first can only be calculated *ex-post*. The second can be approximated *ex-ante*.

Its final calculation is however more easily *ex-post*. Beyond these technical difficulties, several ideas introduced in this reflection: use of the two new proposed indicators, analysis of sports and economic stakes using risk theory, study of the specific conditions of monetization using pre-financing through the sale of rights should most certainly be developed in the coming years by other researchers. In any case, that is our wish.

Table 1. *Synthesis*

Universalities	Singularities
- Several temporal divisions can be distinguished - The production of a sports show is a wave phenomenon - The production of a sports show is preceded by a phase of "reflection-preparation" - The actions contributing to the realization of the production take place in the continuous time - At the point of its finalization, the sports show is transformed into a "special useful form": the result of the match	- The production of a sports show requires the collaboration of several actors - Sports shows take place in a predetermined time by sports rules or conditioned by obtaining the expected result - The basic acts of production that take place in the continuum are of interest to others (sports fans) than those who realize them (players) - The nature of the sport practiced, individual or collective, most often determines the status of the sports worker, employee or independent - Most professional sports activities are not only carried out in the public sphere but in public - The monetization of professional sport is based on pre-financing authorized by the sale of rights - - The "result" of the matches presents a quadruple utility

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UEFA: A Successful Pan-European Organization during the Cold War

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The purpose of this paper is to analyse the formation of the Union Européenne de Football / European Football Association (UEFA) in the mid-1950s and its evolution during the period of the cold war. Post-World War II Europe was characterized for its division into two zones from an economic and political point of view. Countries from the two zones met in international organizations at the world level and created separate specifically European organizations for cooperation in several economic, political and cultural fields. However, there was an almost complete absence of specifically pan-European organizations bringing together countries from the two zones. The only significant exception was UEFA, which, from the mid-1950s onwards, succeeded in organizing regular football competitions between national and club teams from the whole continent without any significant problems, regardless of the different economic and political systems. This paper will discuss the reasons for such a remarkable achievement.

Keywords: *UEFA, Europe, cold war, economic and political systems, cooperation*

Introduction

Post-World War II Europe was characterized for its division into two zones from an economic and political point of view. On one side were countries with market economies and democratic or right-wing authoritarian political regimes. On the other side were countries with centrally planned economies and communist political regimes. From the economic point of view, the division was completed in 1948, when the Organization for European Economic Cooperation (OEEC) and the Council for Mutual Economic Cooperation (COMECON) were formed. Austria, Belgium, Denmark, France, Great Britain, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Sweden, Switzerland and Turkey, together with the American, British and French occupation zones in Germany, which later formed the Federal Republic of Germany, became members of the OEEC. Albania, Bulgaria, Czechoslovakia, Hungary, Poland, Romania and the USSR, together with the Soviet occupation zone in Germany, which later formed the German Democratic Republic, became members of COMECON. Only two European market economies were absent from the OEEC: Spain, because the USA excluded it from the Marshall Plan for political reasons (it was to join the OEEC one decade later), and Finland, because of Soviet diplomatic pressure (it

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was later to find ways of informal cooperation with the OEEC). Only one centrally planned economy was absent from COMECON: Yugoslavia, because of its ideological dissension with the USSR (it would become a leader of the so-called non-aligned movement, created in 1955, and tried to develop an original form of market socialism one decade later). From a political point of view, the division was confirmed in 1949, when the formation of the North Atlantic Treaty Organization (NATO) took place, and in 1955, when the formation of the Warsaw Pact Organization took place. Belgium, Canada, Denmark, France, Great Britain, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal and the USA were the founding members of NATO (Greece, Turkey and the Federal Republic of Germany were to join later). Membership of the Warsaw Pact Organization coincided at first with membership of COMECON (which was later joined by non-European countries). At the beginning of the 1960s, Albania aligned with the People's Republic of China, when its ideological dissension with the USSR occurred, and left COMECON and the Warsaw Pact Organization for all practical purposes (although not from a formal point of view). Other countries managed to achieve a relative autonomy within their groups (France and Romania are the most evident cases), but the limits of any experiment of this type were clearly illustrated by the outcome of the revolt of Hungary in 1956, the so-called Prague spring of 1968, or the revolutionary process in Portugal between 1974 and 1976.

Countries from the two zones only met in international organizations at the world level, especially the United Nations Organization (UNO), and its specialized agencies. However, countries with centrally planned economies and communist political regimes were absent from the organizations designed to form the framework for the international economic order, namely the International Monetary Fund (IMF), the International Bank for Reconstruction and Development (the core of the World Bank group) and the General Agreement on Tariffs and Trade (GATT), which became the superstructures of the capitalist part of the world economy.

Countries from the two zones created separate specifically European organizations for cooperation in several economic, political and cultural fields. Besides the OEEC/COMECON and the NATO/Warsaw Pact Organization pairs already mentioned, an interesting case in point is the twin organizations created for cooperation in the field of radio and television. As a matter of fact, the development of radio and television broadcasting led quite naturally to international cooperation in the field. In Europe, as was to be expected, this meant two separate international organizations: the European Broadcasting Union (EBU), usually known by the name of its operational service, Eurovision, was created in 1950, with its headquarters in Geneva and brought together broadcasting organizations from European and Mediterranean countries with market economies and democratic or right-wing authoritarian political regimes; the International Radio and Television Organization (IRTO), usually known by the name of its operational service, Intervision, was also created in 1950, with its headquarters in Prague and brought together broadcasting organizations from countries with centrally planned economies and communist political regimes. France, the Federal Republic of Germany, Italy, Luxembourg, Switzerland, and the United Kingdom were the founding members of Eurovision, which was later joined by Austria, Belgium, Denmark, Finland, Greece, Iceland, Ireland, Monaco, the Netherlands, Norway, Portugal, Spain, Sweden, Turkey, and Yugoslavia. Bulgaria, Czechoslovakia, the German Democratic Republic, Finland, Hungary, Poland, Romania and the USSR belonged to Intervision. In this particular instance, there was one exception to the general rule: Finland belonged to both organizations. However, it was clear that the Intervision affiliation was purely formal for Finland, from both the technical and the programming point of view. Albania and Yugoslavia were in the opposite situation and remained absent from international television cooperation – in the case of Yugoslavia, this situation continued until it joined Eurovision already in its 1960s market socialism phase.

There was an almost complete absence of specifically pan-European organizations bringing together countries from the two zones. An interesting case in point was the Economic Commission for Europe (ECE), which the UNO tried to implement and which soon became a lethargic organization after the OEEC and COMECON had come into being. Only between 1972 and 1975 was it possible to bring together all European countries (with the exception of Albania) under the same umbrella, at a Conference for Security and Cooperation in Europe in Helsinki, and, in spite of the agreement on the so-called Final Act of the Helsinki Conference, only in 1990, after the collapse of the Soviet sphere of influence, although before the collapse of the Soviet Union itself, was it possible to create the Organization for Security and Cooperation in Europe (OSCE).

In this context, it is truly remarkable that the 1950s should have witnessed the foundation of an organization that brought all the European countries together and thereafter remained successfully active throughout the whole period of the so-called cold war. Of course, it was neither an economic nor a political organization, but an organization linked to one aspect of the cultural field of social life: football. The organization in question was (and is) the Union Européenne de Football/ European Football Association (UEFA) and this paper will discuss the reasons for such a remarkable achievement. A brief survey is made of the constitution, membership and organization of UEFA in Section 2. Section 3 shows how UEFA has been able to organize regular competitions between national and club teams from the whole continent without any significant problems, regardless of the different economic and political systems, since the mid-1950s. Special attention is given to the most prestigious competitions organized under the auspices of UEFA, namely the European Championship, the Champions Cup/Champions League, the Cup Winners' Cup, and the Inter-Cities Fairs Cup/UEFA Cup/Europa League. This did not take place without a number of political problems having to be faced, as Section 4 shows. Some concluding remarks follow.

Constitution, Membership and Organization

UEFA was founded in Basle on 15 June 1954, as a result of the decision taken in 1953 by the Fédération Internationale de Football/International Football Association (FIFA), founded in 1904, to stimulate the formation of football associations at a continental level. The first UEFA Congress took place in Vienna on 2 March 1955.

UEFA originally had thirty one members: the national football associations of Albania, Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, England, Finland, France, the Federal Republic of Germany, the German Democratic Republic, Greece, Hungary, Iceland, Ireland, Northern Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Saarland, Scotland, Spain, Sweden, Switzerland, the USSR, Wales and Yugoslavia[1]. The football association of Saarland ceased to be a member in 1957, after the referendum that determined the territory becoming a German state (and not a French department). Until the end of the cold war, there were six additions to the member list: Malta (1960), Cyprus (1962), Turkey (1962), Liechtenstein (1974), San Marino (1988) and the Faroe Islands (1990).

After the end of the cold war, membership activity increased for a while. The German Democratic Republic ceased to be a separate UEFA member when the country was absorbed by the Federal Republic of Germany (1990). The divisions of Czechoslovakia, the USSR and Yugoslavia produced a net increase of fourteen members between 1992 and 1996. The seventeen new members were Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, the Czech Republic, Croatia, Estonia, Georgia, Latvia, Lithuania, Macedonia, Moldova, Russia, Slovakia, Slovenia, Ukraine and Yugoslavia (later Serbia-Montenegro). Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, also emanating from the USSR, became members of the Asian Football Confederation. During the same period, Israel and Andorra were also accepted as members. In the case of Israel, the reason was that it was impossible to link it peacefully to the Asian Football Confederation, to which it belonged geographically. 21st century admissions include Kazakhstan (which preferred to switch from Asia to Europe for football purposes) in 2002, Serbia and Montenegro as a result of the political split between the two countries in 2006, Gibraltar in 2013 (overcoming Spanish resistance), and Kosovo in 2016 (overcoming Serbian resistance), raising the present membership to fifty-five.

Thus, it may be said that no European country was excluded from UEFA, regardless of its economic and political orientation, especially during the period of the cold war. As an unplanned symbol of this fact, the very first match of the first competition organized by UEFA was played between teams from two countries with different economic and political orientations, which did not maintain diplomatic relations[2].

In spite of the absence of any discrimination in terms of UEFA membership based on a country's economic and political orientation, it is possible to say that the leadership of the organization during the cold war years always belonged to the market economy members. This was clearly expressed in the choices for the siege

[1]Notice the separation of the football associations of the various parts of the United Kingdom, which dates back to the time of the institutionalization of the game in the British Isles.

[2]The match between Sporting Lisbon (representing Portugal) and Partizan Belgrade (representing Yugoslavia) for the Champions Cup of the 1955-1956 season was played in Lisbon on 4 September 1955 (ending appropriately in a three-all draw).

of the organization, for the President, Secretary-General and membership of the Executive Committee, and also of venues for the main competitions and matches.

The siege of UEFA was established in Paris between its foundation and 1959. Then it moved to Switzerland, first to Bern, and in 1995 to Nyon (where a House of European Football was inaugurated in 1999).

During the six and a half decades of its existence, UEFA has had nine presidents: Ebbe Schwartz (Denmark, 1954-1962), Gustav Wiederkher (Switzer-land, 1962-1972), Sandor Barcs (Hungary, as interim president after Wiederkher's death), Artemio Franchi (Italy, 1973-1983), Jacques George (France, 1983-1990), Lenhart Johanssen (Sweden, 1990-2005), Michel Platini (France, 2006-2015), Angel María Villar (Spain, as interim president after Platini's suspension) and Alexander Čeferin (Slovenia, 2016 to the present). Only almost three decades after the end of the cold war, did the organization have an elected President who came from a country that had had a centrally planned economy and a communist political regime (Barcs' interim office between 1972 and 1973 being clearly an unexpected exception to the rule of prevalence of Western origin).

The rule of prevalence of Western origin also applies to the eight men who have held the position of Secretary-General of the organization: Henri Delaunay (France, 1954-1955), Pierre Delaunay (France, 1956-1959), Hans Bangeter (Switzerland, 1960-1988), Gerhard Eigner (Germany, 1989-2003), Lars-Christer Olsson (Sweden, 2004-2007), David Taylor (Scotland, 2007-2009), Gianni Infantino (Switzerland, 2009-2016) and Theodore Theodoridis (Greece, 2016 to the present).

Two Hungarians (Gustav Sebes 1955-1960, and Sandor Barcs 1962-1978), one Czechoslovakian (Vaclav Jira 1978-1992) and one Soviet (Nikolay Ryashentsev 1982-1994) were Vice-Presidents of UEFA during the cold war years, but they amounted to only 18% of the 22 people performing that function, and nobody from the countries with centrally planned economies and communist political regimes was ever chosen as Treasurer. Membership of the Executive Committee was also clearly biased against those countries: only 6 out of 39 (15%) of members came from those countries.[3]

Competitions

As might be expected, UEFA's main activity has been the organization of regular football competitions. When the organization was founded, there were proposals for three different competitions:

[3]As a matter of fact, the situation did not change much after the end of the cold war: only two vice-presidents, Grigoriy Surkis (Ukraine) and Sándor Csányi (Hungary), came from countries that had had centrally planned economies and communist political regimes; no treasurer came from those countries; and membership of the Executive Committee rose to only 27% (12 places out of 45).

a) A national team competition similar to the World Cup already organized by FIFA – This led to the European Championship, first organized in 1958-1960, and at four-year intervals since then.
b) A club team competition between the national champions of member countries – This led to two different competitions: the Champions Cup, first organized in 1955-1956, and thereafter on a yearly basis (since 1991-1992, this competition has been known as the Champions League); and the Cup Winners' Cup, first organized in 1960-1961, and thereafter on a yearly basis until 1998-1999 (in 1999-2000 this competition was merged with the UEFA Cup).
c) A competition between teams from the main European cities – This led to the Inter-Cities Fairs Cup, first organized between 1955 and 1958, then between 1958 and 1960, with the participants being city teams or club teams representing the cities. From 1960-1961 to 1964-1965, this competition became a yearly competition between club teams acting as representatives of the cities; after that the competition involved the best European teams not participating either in the Champions Cup or in the Cup Winners' Cup, being renamed the UEFA Cup in 1971-1972. It absorbed the Cup Winners' Cup in 1999 and became the Europa League in 2009-2010.

In 1955, UEFA also took over responsibility from FIFA for the organization of a junior national team competition, which had begun in 1948 with only European participants.

The number of UEFA competitions was later greatly increased in several ways:

a) Additional club team competitions – The UEFA Super Cup played between the winners of the Champions Cup and the Cup Winners' Cup, since 1974 (after 2000, the Cup Winners' Cup winner was replaced by the UEFA Cup winner), and the Intertoto Cup, a summer competition started in 1961 outside UEFA jurisdiction, included in the UEFA calendar in 1995, and discontinued since 2008.
b) A wider range of junior national team competitions differentiated by age groups: under-17 since 1980; under-19 since 1974; under-21 since 1992.
c) Women's competitions, namely a women's European Championship for national teams since 1984, the UEFA Women's Cup for club teams since 2001-2002, the European Women's under-18 national team championship since 1997-1998 (which became under-19 in 2001-2002), and the European Women's under-17 national team championship since 2007-2008.
d) (Male) futsal (an indoor five-a-side version of the outdoor eleven-a-side game) competitions, namely the European Futsal Championship for national teams since 1995, and the Futsal Cup for club teams since 2002.
e) (Male) competitions organized together with other continental football associations, namely the Intercontinental Cup, a yearly club team competition between the winner of the Champions Cup and the winner of

the Copa Libertadores da América started in 1960, which became the FIFA Club World Cup in 2006, and the Meridian Cup, a youth competition organized with the African Football Confederation since 1997.

f) A (male) amateur competition between regional teams, the Regions Cup, which existed between 1965 and 1978, and was resumed in 1996.
g) A (male) junior club team competition, the Youth League, parallel to the Champions League, since 2013.

The (male) European Championship between national teams and the three main cups for club teams – Champions Cup/Champions League, Cup Winners' Cup and Inter-Cities Fairs Cup/UEFA Cup/Europa League – have always featured as the main competitions organized by UEFA and deserve some additional attention.

The European Championship

Participation in the first European Championship (1958-1960) was far from enthusiastic: only seventeen countries – Austria, Bulgaria, Czechoslovakia, Denmark, France, the German Democratic Republic, Greece, Hungary, Ireland, Norway, Poland, Portugal, Romania, Spain, Turkey, the USSR and Yugoslavia – played the qualification matches, leading to a final stage held in France. However, the absences had nothing to do with politics, as all the three political groups of democratic, right-wing authoritarian and communist countries were evenly represented. The absences were simply due to a lack of interest in a new competition that as yet carried no prestige[4].

Such a situation changed during the 1960s. By the end of the decade, all of UEFA's members were to participate in the competition, held every four years, with a final stage being held in the same year as the Olympic Games took place, and with qualifying matches being played during the previous two years. This scheme and the regularity of the event have remained unchanged until today, with very few absences.

Table 1 summarizes the venues for the final stages and the winners of the European Championships.

[4]It should be remembered that a similar situation had befallen the first FIFA world championship, held in Uruguay in 1930, with only fifteen participants out of forty-seven FIFA members.

Table 1. *Venues for the Final Stages and Winners of the European Championships*

Years	Number of participants	Venue for the final stages	Winner
1958-1960	17	France	USSR
1962-1964	29 (1 withdrawal)	Spain	Spain
1966-1968	31	Italy	Italy
1970-1972	32	Belgium	F. R. Germany
1974-1976	32	Yugoslavia	Czechoslovakia
1978-1980	32	Italy	F. R. Germany
1982-1984	33	France	France
1986-1988	33	F. R. Germany	Netherlands
1990-1992	34	Sweden	Denmark
1994-1996	48	England	Germany
1998-2000	51	Belgium/Netherlands	France
2002-2004	51	Portugal	Greece
2006-2008	52	Austria/Switzerland	Spain
2010-2012	53	Poland/Ukraine	Spain
2014-2016	54	France	Portugal

Source: www.uefa.com

The venues for the final stages show a clear asymmetry towards countries with market economies and democratic regimes before the end of the cold war: six times out of eight. The two exceptions were Spain, a market economy but an authoritarian right-wing regime, which was chosen as organizer of the final stage in 1964, and Yugoslavia, which was experimenting with market socialism when it was chosen to organize the final stage in 1976. COMECON/Warsaw Pact countries were never awarded the organization of final stages.[5]

In the same period, COMECON / Warsaw Pact countries performed better in terms of victories: the USSR and Czechoslovakia managed to register their names on the roll of honour at the same level as Spain, Italy, France and the Netherlands, and only below the Federal Republic of Germany (two victories).[6]

The Champions Cup/Champions League

Sixteen clubs were invited to participate in the first Champions Cup in the 1955-1956 season: they came from Austria, Belgium, Denmark, France, the Federal Republic of Germany, Hungary, Italy, the Netherlands, Poland, Portugal, Saarland, Scotland, Spain, Sweden, Switzerland and Yugoslavia. The competition was organized on a simple knock-out basis, which would remain in force until the 1990-1991 season. From 1956-1957 onwards, the Champions Cup was open to the

[5]Only in 2012 two former COMECON / Warsaw Pact countries, Poland and Ukraine, jointly hosted the final stage of the European Championship. The 2020 final stage will be played in several cities around Europe: Amsterdam, Baku, Bilbao, Bucharest, Budapest, Copenhagen, Dublin, Glasgow, London, Munich, Rome and Saint-Petersburg. Four out of twelve are located in former COMECON/ Warsaw Pact countries.

[6]Actually, the performance of Eastern Europe national teams was even worse after the end of the cold war. Denmark, Greece and Portugal (one victory each) joined the list of winners, France and Germany also had one victory each and Spain got two victories.

national champions and the winner of the previous year's Champions Cup (and the runner-up in the national championship whenever the national champion was also the previous season's European champion). It may be said that, by the early 1960s, all the national champions of the different European countries were participating in the competition.[7]

Table 2 presents the list of the cities chosen as the venues for the final matches of the Champions Cup and the respective winners.

Table 2. *Venues for Finals and Winners of the Champions Cup/Champions League*

Year	Number of participants	Venue for final	Winner
1955-1956	16	Paris	Real Madrid
1956-1957	22	Madrid	Real Madrid
1957-1958	24	Brussels	Real Madrid
1958-1959	29 (2 withdrawals)	Stuttgart	Real Madrid
1959-1960	27 (1 withdrawal)	Glasgow	Real Madrid
1960-1961	28 (2 withdrawals)	Berne	SL Benfica (Lisbon)
1961-1962	29 (1 withdrawal)	Amsterdam	SL Benfica (Lisbon)
1962-1963	30	London	AC Milan
1963-1964	31	Vienna	Internazionale (Milan)
1964-1965	32	Milan	Internazionale (Milan)
1965-1966	31	Brussels	Real Madrid
1966-1967	34 (1 withdrawal)	Lisbon	Celtic (Glasgow)
1967-1968	32 (1 withdrawal)	London	Manchester United
1968-1969	32 (3 withdrawals)	Madrid	AC Milan
1969-1970	33	Milan	Feyenoord (Rotterdam)
1970-1971	33	London	Ajax (Amsterdam)
1971-1972	33	Rotterdam	Ajax (Amsterdam)
1972-1973	30	Belgrade	Ajax (Amsterdam)
1973-1974	31	Brussels	Bayern (Munich)
1974-1975	30 (1 withdrawal)	Paris	Bayern (Munich)
1975-1976	32	Glasgow	Bayern (Munich)
1976-1977	31	Rome	Liverpool FC
1977-1978	33	London	Liverpool FC
1978-1979	33	Munich	Nottingham Forest
1979-1980	33	Madrid	Nottingham Forest
1980-1981	33	Paris	Liverpool FC
1981-1982	33	Rotterdam	Aston Villa (Birmingham)

[7]In 1991-1992, the Champions Cup (after 1992-1993 called the Champions League) underwent several changes in its format and rules for participation: the traditional knock-out scheme was combined with a group stage (in the seasons from 1999-2000 to 2002-2003 two group stages); for a while (from 1994-1995 to 1996-1997) participation was restricted to the champions of countries whose teams had performed best in previous editions of the European club competitions; afterwards the champions of all European countries were again allowed to take part, and participation was further extended to include the highest placed clubs in the national championships of those countries whose teams had performed best in previous editions of the European club competitions. Of course, all of these changes were closely linked to the increase in UEFA's revenue from TV advertising and sponsorship: the aim was to increase the number of matches played by clubs from countries that had a higher per capita income and where football enjoyed greater popularity.

Year	Number of participants	Venue for final	Winner
1982-1983	33	Athens	Hamburg SV
1983-1984	31	Rome	Liverpool FC
1984-1985	32	Brussels	Juventus (Turin)
1985-1986	31	Seville	Steaua (Bucharest)
1986-1987	31	Vienna	FC Porto
1987-1988	32 (1 withdrawal)	Stuttgart	PSV (Eindhoven)
1988-1989	31	Barcelona	AC Milan
1989-1990	32	Vienna	AC Milan
1990-1991	32	Bari	Red Star (Belgrade)
1991-1992	32	London	FC Barcelona
1992-1993	36	Munich	Olympique Marseille
1993-1994	46	Athens	AC Milan
1994-1995	24	Vienna	Ajax (Amsterdam)
1995-1996	24	Rome	Juventus (Turin)
1996-1997	24	Munich	Borussia Dortmund
1997-1998	53	Amsterdam	Real Madrid
1998-1999	54	Barcelona	Manchester United
1999-2000	71	Paris	Real Madrid
2000-2001	72	Milan	Bayern Munich
2001-2002	72	Glasgow	Real Madrid
2002-2003	72	Manchester	AC Milan
2003-2004	72	Gelsenkirchen	FC Porto
2004-2005	72	Istanbul	Liverpool FC
2005-2006	74	Paris	FC Barcelona
2006-2007	74	Athens	AC Milan
2007-2008	76	Moscow	Manchester United
2008-2009	76	Roma	FC Barcelona
2009-2010	76	Madrid	Internazionale (Milan)
2010-2011	76	London	FC Barcelona
2011-2012	76	Munich	Chelsea (London)
2012-2013	76	London	Bayern Munich
2013-2014	76	Lisbon	Real Madrid
2014-2015	77	Berlin	FC Barcelona
2015-2016	78	Milan	Real Madrid
2016-2017	78	Cardiff	Real Madrid
2017-2018	79	Kiev	Real Madrid
2018-2019	79	Madrid	Liverpool FC
2019-2020	79	Istanbul	?

Source: www.uefa.com

Once more, a complete asymmetry is to be found in the cities chosen as the venues for the finals: only countries with market economies were chosen. Again, the one possible exception is Belgrade, which hosted the 1973 final at a time when the market socialism process was being followed in Yugoslavia.[8]

[8]Only in 2008 and 2018 did former Warsaw Pact capitals, Moscow and Kiev respectively, host a Champions League final.

As far as victories go, only the Romanian club Steaua Bucharest in 1986 and the Yugoslavian (nowadays Serbian) club Red Star Belgrade in 1991, from among all the Eastern European competitors, have won this competition. This may be deemed a very poor performance as the following table shows.

Table 3. *Summary of Champions Cup/Champions League winners*

Country		**City**		**Club**	
Spain	18	Madrid	13	Real Madrid	13
		Barcelona	5	FC Barcelona	5
England	13	Liverpool	6	Liverpool FC	6
		Manchester	3	Manchester United	3
		Nottingham	2	Nottingham Forest	2
		Birmingham	1	Aston Villa	1
		London	1	Chelsea	1
Italy	12	Milan	10	AC Milan	7
				Inter	3
		Turin	2	Juventus	2
F. R. G. / Germany	7	Munich	5	Bayern	5
		Hamburg	1	Hamburg SV	1
		Dortmund	1	Borussia Dortmund	1
Netherlands	6	Amsterdam	4	Ajax	4
		Rotterdam	1	Feyenoord	1
		Eindhoven	1	PSV	1
Portugal	4	Lisbon	2	SL Benfica	2
		Porto	2	FC Porto	2
Scotland	1	Glasgow	1	Celtic	1
Romania	1	Bucharest	1	Steaua	1
Yugoslavia / Serbia	1	Belgrade	1	Red Star	1
France	1	Marseilles	1	Olympique Marseille	1

Source: computation from Table 2.

The Cup Winners' Cup

The Cup Winners' Cup was organized from 1960-1961 to 1998-1999 between the winners of the national cups (or the runners up, if the winners were to participate in the Champions Cup). As in the case of the Champions Cup, the previous year's winner was also allowed to participate (unless it was able to participate in the Champions Cup). The competition was always played on a simple knock-out basis.

Table 4 shows the list of the cities where the final was played and the respective winners.

Table 4. *Venues for the Finals and Winners of the Cup Winners' Cup*

Year	Number of participants	Venue for the final	Winner
1960-1961	10	Glasgow – Florence *	Fiorentina
1961-1962	23	Glasgow – Stuttgart **	Atlético Madrid
1962-1963	25 (1 withdrawal)	Rotterdam	Tottenham (London)
1963-1964	30	Brussels – Antwerp **	Sporting CP (Lisbon)
1964-1965	31	London	West Ham (London)
1965-1966	31	Glasgow	Borussia Dortmund
1966-1967	32	Nuremberg	Bayern (Munich)
1967-1968	32	Rotterdam	AC Milan
1968-1969	30 (3 withdrawals)	Basle	Slovan (Bratislava)
1969-1970	33	Vienna	Manchester City
1970-1971	34	Athens – Athens **	Chelsea (London)
1971-1972	34	Barcelona	Glasgow Rangers
1972-1973	32	Salonika	AC Milan
1973-1974	32	Rotterdam	FC Magdeburg
1974-1975	32 (1 withdrawal)	Basle	Dynamo Kiev
1975-1976	32	Brussels	Anderlecht (Brussels)
1976-1977	33	Amsterdam	Hamburg SV
1977-1978	33	Paris	Anderlecht (Brussels)
1978-1979	31	Basle	FC Barcelona
1979-1980	34 (1 withdrawal)	Brussels	Valencia CF
1980-1981	34	Dusseldorf	Dinamo Tbilisi
1981-1982	33	Barcelona	FC Barcelona
1982-1983	34	Gothenburg	Aberdeen FC
1983-1984	33	Basle	Juventus (Turin)
1984-1985	32	Rotterdam	Everton (Liverpool)
1985-1986	31	Lyon	Dynamo Kiev
1986-1987	32	Athens	Ajax (Amsterdam)
1987-1988	33	Strasbourg	KV Mechelen
1988-1989	33	Berne	FC Barcelona
1989-1990	33	Gothenburg	Sampdoria (Genoa)
1990-1991	33	Rotterdam	Manchester United
1991-1992	34	Lisbon	Werder Bremen
1992-1993	36	London	Parma FC
1993-1994	43	Copenhagen	Arsenal (London)
1994-1995	44	Paris	Real Zaragoza
1995-1996	48	Brussels	Paris Saint Germain
1996-1997	49	Rotterdam	FC Barcelona
1997-1998	47	Stockholm	Chelsea (London)
1998-1999	49	Birmingham	Lazio (Rome)

Source: www.uefa.com

*This final was played on a two-leg home-and-away basis; ** These finals were replayed after a draw in the first match.

No final match in this competition was ever played in a non-market economy, nor even in Yugoslavia. However, the competition was won five times by clubs from the COMECON/Warsaw Pact area, namely Slovan Bratislava (1969), FC Magdeburg (1974), Dynamo Kiev (1975 and 1986) and Dinamo Tbilisi (1981). Anyway, once more, this European area shows a rather poor performance, as can be seen in the following table.

Table 5. *Summary of the Winners of the Cup Winners' Cup*

Country		City		Club	
England	8	London	5	Chelsea	2
				Tottenham	1
				West Ham	1
				Arsenal	1
		Manchester	2	Manchester City	1
				Manchester United	1
		Liverpool	1	Everton	1
Spain	7	Barcelona	4	FC Barcelona	4
		Madrid	1	Atlético Madrid	1
		Valencia	1	Valencia CF	1
		Zaragoza	1	Real Zaragoza	1
Italy	7	Milan	2	AC Milan	2
		Florence	1	Fiorentina	1
		Turin	1	Juventus	1
		Genoa	1	Sampdoria	1
		Parma	1	Parma FC	1
		Rome	1	Lazio	1
F. R. G./Germany	4	Dortmund	1	Borussia Dortmund	1
		Munich	1	Bayern	1
		Hamburg	1	Hamburg SV	1
		Bremen	1	Werder Bremen	1
G. D. R./Germany	1	Magdeburg	1	FC Magdeburg	1
Belgium	3	Brussels	2	Anderlecht	2
		Malines	1	KV Mechelen	1
U. S. S. R./Ukraine	2	Kiev	2	Dynamo Kiev	2
U. S. S. R./Georgia	1	Tbilisi	1	Dinamo Tbilisi	1
Scotland	2	Glasgow	1	Glasgow Rangers	1
		Aberdeen	1	Aberdeen FC	1
Netherlands	1	Amsterdam	1	Ajax	1
Portugal	1	Lisbon	1	Sporting CP	1
Czechoslovakia/ Slovakia	1	Bratislava	1	Slovan	1
France	1	Paris	1	Paris Saint-Germain	1

Source: Computation from Table 4.

The Inter-Cities Fairs Cup/UEFA Cup/Europe League

As explained above, the first edition of the Inter-Cities Fairs Cup was played between 1955 and 1958, and the second edition between 1958 and 1960, with either city teams or club teams representing the cities as participants. The first edition combined both a group stage and a knock-out stage, but the second one adopted a pure knock-out format, which remained in force until 2003-2004. Since

1960-1961, this competition (after 1971-1972 called the UEFA Cup) has been a yearly competition between club teams. In the early 1960s, clubs still participated as representatives of cities, but since 1964-1965 the teams involved have been the highest placed clubs in the national championships of the previous year not participating in either the Champions Cup or the Cup Winners' Cup**.** The previous year's winner was also allowed to participate, as was the case in the other European club competitions (unless it was able to participate in either of the other European club competitions).[9]

Table 6 shows the list of the cities where the final was played and the respective winners.

Table 6. *Venues for the Finals and Winners of the Inter-Cities Fairs Cup/UEFA Cup/Europe League*

Years	Number of participants	Venue for final	Winner
1955-1958	12 (2 withdrawals)	London – Barcelona *	FC Barcelona
1958-1960	16	Birmingham – Barcelona *	FC Barcelona
1960-1961	16	Birmingham – Rome *	AS Roma
1961-1962	28	Valencia – Barcelona *	Valencia CF
1962-1963	32	Zagreb – Valencia *	Valencia CF
1963-1964	32	Barcelona	Real Zaragoza
1964-1965	48	Turin	Ferencvaros (Budapest)
1965-1966	48	Barcelona – Zaragoza *	FC Barcelona
1966-1967	48	Zagreb – Leeds *	Dinamo Zagreb
1967-1968	48	Leeds – Budapest *	Leeds United
1968-1969	64 (2 withdrawals)	Newcastle – Budapest *	Newcastle United
1969-1970	64	Brussels – London *	Arsenal (London)
1970-1971	64	Turin – Leeds *	Leeds United
1971-1972	64 (2 withdrawals)	Wolverhampton – London *	Tottenham (London)
1972-1973	64 (1 withdrawal)	Liverpool – Mönchengladbach *	Liverpool FC
1973-1974	64	London – Rotterdam *	Feyenoord (Rotterdam)
1974-1975	64 (1 withdrawal)	Düsseldorf – Enschede *	Borussia Mönchengladbach
1975-1976	64	Liverpool - Brugge *	Liverpool FC
1976-1977	64	Turin – Bilbao *	Juventus (Turin)
1977-1978	64	Bastia – Eindhoven *	PSV (Eindhoven)
1978-1979	64	Belgrade – Düsseldorf *	Borussia Mönchengladbach
1979-1980	64	Mönchengladbach – Frankfurt *	Eintracht (Frankfurt)

[9]Since 1999-2000, the winners of national cups have also participated in the UEFA Cup, which has also started to receive some of the clubs eliminated from the Champions League. Since the 2004-2005 season, the UEFA Cup has included a group stage combined with several knock-out stages. From 2009-2010 on, it was renamed Europa League.

Years	Number of participants	Venue for final	Winner
1980-1981	64	Ipswich – Amsterdam *	Ipswich Town
1981-1982	64	Gothenburg – Hamburg *	IFK (Gothenburg)
1982-1983	64	Brussels – Lisbon *	Anderlecht (Brussels)
1983-1984	64	Brussels – London *	Tottenham (London)
1984-1985	64	Szekesfehervar – Madrid *	Real Madrid
1985-1986	64	Madrid – Berlin *	Real Madrid
1986-1987	64	Gothenburg – Dundee *	IFK (Gothenburg)
1987-1988	64	Barcelona – Leverkussen *	Bayer Leverkussen
1988-1989	64	Naples – Stuttgart *	SSC Napoli
1989-1990	65	Turin – Avellino *	Juventus (Turin)
1990-1991	64	Milan – Rome *	Inter (Milan)
1991-1992	64	Turin – Amsterdam *	Ajax (Amsterdam)
1992-1993	64	Dortmund – Turin *	Juventus (Turin)
1993-1994	64	Vienna – Milan *	Inter (Milan)
1994-1995	91	Parma – Milan *	Parma FC
1995-1996	98	Munich – Bordeaux *	Bayern (Munich)
1996-1997	102	Gelsenkirchen – Milan *	Schalke 04 (Gelsenkirchen)
1997-1998	102	Paris	Inter (Milan)
1998-1999	102	Moscow	Parma FC
1999-2000	90	Copenhagen	Galatasaray (Istanbul)
2000-2001	93	Dortmund	Liverpool FC
2001-2002	93	Rotterdam	Feyenoord (Rotterdam)
2002-2003	93	Seville	FC Porto
2003-2004	92	Gothenburg	Valencia CF
2004-2005	125	Lisbon	CSKA Moscow
2005-2006	124	Eindhoven	Sevilla FC
2006-2007	123	Glasgow	Sevilla FC
2007-2008	137	Manchester	Zenit (Saint Petersburg)
2008-2009	195	Istanbul	Shakthar Donetzk
2009-2010	192	Hamburg	Atlético Madrid
2010-2011	194	Dublin	FC Porto
2011-2012	194	Bucharest	Atlético Madrid
2012-2013	193	Amsterdam	Chelsea
2013-2014	194	Turin	Sevilla FC
2014-2015	195	Warsaw	Sevilla FC
2015-2016	192	Basel	Sevilla FC
2016-2017	192	Stockholm	Manchester United
2017-2018	190	Lyon	Atlético Madrid
2018-2019	213	Baku	Chelsea (London)
2019-2020	213	Gdansk	?

Source: www.uefa.com.
*These finals were played on a two-leg home-and-away basis.

Only after the end of the cold war, were cities in Eastern Europe chosen to organize the final match of the UEFA Cup/Europe League.[10] Note that as, until 1997-1998, the finals were mostly played on a two-leg home-and-away basis, several of these final matches were played in Eastern Europe: in the Yugoslavian (now Croatian) city of Zagreb in 1963 and 1967, in the Hungarian cities of Budapest in 1968 and 1969 and Szekesfehervar in 1985, and in the Yugoslavian (now Serbian) city of Belgrade in 1979.

Table 7. *Summary of the Winners of the Inter-Cities Fairs Cup/UEFA Cup*

Country		City		Club	
Spain	17	Seville	5	Sevilla FC	5
		Madrid	5	Atlético Madrid	3
				Real Madrid	2
		Barcelona	3	FC Barcelona	3
		Valencia	3	Valencia CF	3
		Zaragoza	1	Real Zaragoza	1
England	13	London	5	Tottenham	2
				Chelsea	2
				Arsenal	1
		Liverpool	3	Liverpool FC	3
		Leeds	2	Leeds United	2
		Newcastle	1	Newcastle United	1
		Ipswich	1	Ipswich Town	1
		Manchester	1	Manchester United	1
Italy	10	Turin	3	Juventus	3
		Milan	3	Inter	3
		Parma	2	Parma FC	2
		Rome	1	AS Roma	1
		Naples	1	SSC Napoli	1
Germany	6	Mönchengladbach	2	Borussia Mönchengladbach	2
		Frankfurt	1	Eintracht	1
		Leverkussen	1	Bayer Leverkussen	1
		Munich	1	Bayern	1
		Gelsenkirchen	1	Schalke 04	1
Netherlands	4	Rotterdam	2	Feyenoord	2
		Eindhoven	1	PSV	1
		Amsterdam	1	Ajax	1
Portugal	2	Porto	2	FC Porto	2
Sweden	2	Gothenburg	2	IFK	2
Russia	2	Moscow	1	CSKA Moscow	1
		Saint Petersburg	1	Zenit	1
Belgium	1	Brussels	1	Anderlecht	1
Hungary	1	Budapest	1	Ferencvaros	1
Yugoslavia/Croatia	1	Zagreb	1	Dinamo Zagreb	1
Turkey	1	Istanbul	1	Galatasaray	1
Ukraine	1	Donetsk	1	Shaktar	1

Source: Computation from Table 6.

[10]Namely Moscow in 1999, Bucharest in 2012, Warsaw in 2015 and Gdansk in 2020.

Once more, clubs from Eastern Europe seldom appear in the winners' list, as table above shows: Ferencvaros from Budapest in 1965 and Dinamo Zagreb in 1967 were the only exceptions during the cold war period.[11]

Political Problems

Although political problems never paralysed the functioning of UEFA and the organization of its competitions, this does not mean that such problems did not exist. They may be classified under three main types: visa problems, boycotts and exclusions.

As UEFA (2004) acknowledges "[…] visa problems arose for delegations, […], teams and media representatives, […], not to mention spectators". The most significant visa problem was the refusal by Spanish authorities to issue visas to allow the Spanish and Soviet national teams to play the quarter-finals of the first European Championship. This led to the exclusion of Spain from the final stage of the 1958-1960 European Championship**.** However, Spain was assigned the organization of the next final stage in 1964, in which the USSR national team was one of the participants, proving that the previous diplomatic difficulties had been overcome.

Boycotts were attempted twice by COMECON/Warsaw Pact countries. In 1961, the German Democratic Republic withdrew from the International Youth Tournament to be held in Portugal, and Hungary and Yugoslavia followed suit out of solidarity. In the following season, the Portuguese authorities retaliated by refusing to grant visas making it possible for the Motor Jena team from the German Democratic Republic to come to Portugal to play the quarter-finals of the Cup Winners Cup. As a consequence, the Portuguese representative, Leixões, was forced to play both the home and away fixtures in the German Democratic Republic (with unfavourable results). The retaliation character of the decision was clear, because in the previous knock-out stage Progresul Bucharest from Romania, a communist country that had participated in the 1961 International Youth Tournament in Portugal, had been given visas to play in Portugal. In 1968, following the crisis triggered by the invasion of Czechoslovakia by Warsaw Pact countries, teams from the USSR, Bulgaria, Hungary, and the German Democratic Republic pulled out of UEFA club competitions. In both cases, the boycott petered out.

To sum up: UEFA never gave in to pressures to take political decisions against its members during the cold war years. Such a strategy paid off, as visa refusals to teams and boycotts remained few in number and quite limited in time. It was after the end of the cold war that the only exclusion for political reasons was to occur: as a consequence of the United Nations sanctions against Yugoslavia, the country was forbidden to play the final stage of the 1992 European Championship for

[11]After the end of the cold war CSKA Moscow, Zenit Saint Petersburg and Shaktar Donetsk also joined the list.

which it had qualified[12]. This isolated breach in the political neutrality of UEFA was again short-lived and had no long-term consequences.[13]

Concluding Remarks

UEFA's success as the only pan-European organization to thrive during the cold war years may be explained by two reasons: the popularity of football, and UEFA's political neutrality. As for the sport's popularity, it is significant that television programme exchanges between the two rival international radio and television broadcasting organizations, Eurovision and Intervision, during the cold war years consisted mainly of broadcasts of football matches. As for political neutrality, the attitude towards the political problems mentioned in Section 4 was quite clear.

Moreover, the importance of football grew with the increase in disposable income and leisure time, which happened all over Europe, albeit at different rates in different countries. Thus, football gradually became a key common element in European culture. Poor representation on UEFA's highest bodies, an almost complete absence from major events, and even a fairly unsuccessful participation in UEFA's competitions could not deter COMECON/Warsaw Pact countries from participating in such a popular endeavour.

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National football associations (see appendix).

[12] Curiously, Denmark, called in to replace Yugoslavia, then became European champions.

[13] Other exclusions occurred, both during the cold war period and more recently, but they were the consequence of bad behaviour of fans. The most important case was the exclusion of English teams for five years after the incidents at the final of the Champions Cup of 1985 in Brussels that led to the death of 39 people. Moreover, political clashes have led to decisions to avoid matches between some pairs of countries as much as possible. Active restrictions of this type today include Armenia/ Azerbaijan, Gibraltar/Spain, Kosovo/Bosnia and Herzegovina, Kosovo/Serbia and Russia/Ukraine matches.

Appendix. *UEFA Members*

Name of national football association and date of foundation according to the national football association website when available, or according to the FIFA website otherwise. Date of FIFA affiliation according to the FIFA website. Date of UEFA affiliation according to the UEFA website.

Country	National football association	Foundation	FIFA affiliation	UEFA affiliation	Website
Albania	Federata Shqiptare e Futbollit	1930	1932	1954	www.fshf.org
Andorra	Federació Andorrana de Futbol	1994	1996	1996	www.faf.ad
Armenia	Football Federation of Armenia	1992	1992	1992	www.ffa.am
Austria	Österreichischer Fussball-Bund	1904	1905	1954	www.oefb.at
Azerbaijan	Azärbaycan Futbol Federasiyalari Assosiasiyasi	1992	1994	1994	www.affa.az
Belarus (a)	Belaruckia Federatsia Futbola	1989	1992	1993	www.bff.by
Belgium	Union Royale Belge des Sociétés de Football-Association	1895	1904	1954	www.footbel.com
Bosnia-Herzegovina	Nogometni Fudbalski Savez Bosne i Herzegovine	1992	1996	1998	www.nfsbih.ba
Bulgaria	Bulgarski Futbolen Suyuz	1923	1924	1954	www.bfunion.bg
Croatia (b)	Hrvatski Nogometni Savez	1912	1992	1993	www.hns-cff.hr
Cyprus	Kupriaké Omospondia Podosfairou	1934	1948	1962	www.cfa.com.cy
Czech Republic (c)	Ceskomoravsky Fotbalovy Svaz	1901	1907	1954	www.fotbal.cz
Denmark	Dansk Boldspil-Union	1889	1904	1954	www.dbu.dk
England	Football Association	1863	1905	1954	www.thefa.com
Estonia (d)	Eesti Jalgpalli Liit	1921	1923	1992	www.jalgpall.ee
Faroe Islands	Fótbóltssamband Føroya	1979	1988	1990	www.football.fo
Finland	Suomen Palloliitto	1907	1908	1954	www.palloliitto.fi
France (e)	Fédération Française de Football	1919	1904	1954	www.fff.fr
Georgia	Georgian Football Association	1990	1992	1992	www.gff.ge
Germany (f)	Deutscher Fussball-Bund	1900	1904	1954	www.dfb.de
Gibraltar	Gibraltar Football Association	1895	2016	2013	www.gibraltarfa.com
Greece	Ellenike Podosfairike Omospondia	1926	1927	1954	www.epo.gr
Hungary	Magyari Labdarúgó Szövetség	1901	1906	1954	www.mlsz.hu
Iceland	Knattspyrnusamband Íslands	1947	1947	1954	www.ksl.is

Country	National football association	Foundation	FIFA affiliation	UEFA affiliation	Website
Ireland	Football Association of Ireland	1921	1923	1954	www.fai.ie
Israel (g)	Israel Football Association	1928	1929	1994	www.Israel-football.org.Il
Italy	Federazione Italiana Giuoco Calcio	1898	1905	1954	www.figc.it
Kazakhstan (h)	Kazakstannyn Futbol Federatchisy	1914	1994	2002	www.fsk.kz
Kosovo (i)	Federata e Futbollit e Kosovës	1946	2016	2016	www.fkk.kosova.com
Latvia (j)	Latvijas Futbolas Federacija	1921	1922	1992	www.lff.lv
Liechtenstein	Liechtensteiner Fussballverband	1934	1974	1974	www.lfv.li
Lithuania (k)	Lietuvos futbolo federacijos	1922	1923	1992	www.lff.lt
Luxembourg	Fédération Luxembourgeoise de Football	1908	1910	1954	www.football.lu
Macedonia (l)	Fudbalska Federatsija na Makedonia	1948	1994	1994	www.ffm.com.mk
Malta	Malta Football Association	1900	1959	1960	www.mfa.com.mt
Moldova	Federatia Moldoveneasca de Fotbal	1990	1994	1993	www.fmf.md
Montenegro (m)	Fudbalski Savez Crne Gore	1931	2007	2007	www.fscg.co.me
Netherlands	Koninklije Nederlandse Voetbalbond	1889	1904	1954	www.knvb.nl
Northern Ireland (n)	Irish Football Association	1880	1911	1954	www.irishfa.com
Norway	Norges Fotballforbund	1902	1908	1954	www.fotball.no
Poland	Polski Zviazek Pilki Noznei	1919	1923	1954	www.pzpn.pl
Portugal	Federação Portuguesa de Futebol	1914	1923	1954	www.fpf.pt
Romania	Federatia Romana de Fotbal	1909	1923	1954	www.frf.ro
Russia (o)	Rossiickii Futbolunuii Soyuz	1912	1912	1954	www.rsf.ru
San Marino	Federazione Sammarinese Giuoco Calcio	1931	1988	1988	www.fsgc.sm
Scotland	Scottish Football Association	1873	1910	1954	www.scottishfa.co.uk
Serbia (p)	Fudbalsky Savez Srbije	1919	1921	1954	www.fss.org.rs
Slovakia (q)	Slovensky futbalovy zväz	1938	1994	1993	www.futbalsfz.sk
Slovenia (r)	Nogometna Zvena Slovenije	1920	1994	1994	www.nzs.si
Spain	Real Federación Española de Futbol	1909	1913	1954	www.rfef.es

Country	National football association	Foundation	FIFA affiliation	UEFA affiliation	Website
Sweden	Svenska Fotbollförbundet	1904	1904	1954	www.svenskfotboll.se
Switzerland	Schwizerischer Fussballverband	1895	1904	1954	www.football.ch
Turkey	Türkiye Futbol Federasyonu	1923	1923	1962	www.tff.org
Ukraine	Federatsia Futbolu Ukraïna	1991	1992	1992	www.ffu.org.ua
Wales	Football Association of Wales	1876	1910	1954	www.faw.org.uk

Notes: (a) The Belarus football association was founded in 1989, when the country was part of the USSR. It became a separate national association after 1991, when the country became fully independent.

(b) The Croatian football association was founded in 1912, when the country was part of Austria-Hungary. It became a separate national association between 1941 and 1945 and again after 1991, when the country became fully independent. Between 1919 and 1941 and between 1945 and 1991, the country was part of Yugoslavia. Between 1941 and 1945, the Croatian football association was a member of FIFA.

(c) The Czech football association was founded in 1901, when the country was part of Austria-Hungary, but it still obtained FIFA affiliation in spite of this. In 1919, it was transformed into the Czechoslovakian football association, when the country became fully independent and united with Slovakia. Between 1938 and 1945, a separate Slovak football association was created, as a Czech-Slovak Federation was established in 1938 and Slovakia seceded from that Federation in 1939. Between 1945 and 1993, Czechoslovakia was united once more, and the Czech football association became the Czechoslovakian football association again. A new separation of Czech and Slovak Republics occurred in 1993 and distinct Czech and Slovak football associations were re-established in that year.

(d) Between 1940 and 1991, there was no separate national Estonian football association, because the country was part of the USSR.

(e) France was represented in the foundation of FIFA by the Union des Sociétés Françaises de Sports Athlétiques. The first French football association was founded in 1906. This association split later, and only in 1919 was a single association reformed again.

(f) When UEFA was founded, there were two German states, the Federal Republic of Germany and the German Democratic Republic, and the territory of Saarland was still awaiting its definitive status. Thus, three German football associations became founding members of UEFA in 1954. The affiliation of the Saarland football association lapsed when the territory became a state of the Federal Republic of Germany in 1957. The affiliation of the German Democratic Republic football association lapsed when the country was absorbed by the Federal Republic of Germany in 1990.

(g) The foundation of the Israel football association occurred in 1928 when the country was part of Palestine, a British mandate of the League of Nations. The state of Israel was proclaimed in 1948.

(h) The Kazakhstan football association was founded in 1914, when the country was part of the Russian Empire. It became a separate national association after 1991, when the country became fully independent. Between 1914 and 1924, the country was part of Russia, and between 1924 and 1991 the country was part of the USSR.

(i) The Kosovo football association was founded in 1946, when the country was part of Yugoslavia. It became a separate national association after 2008, when the country proclaimed its independence, which has not yet (2019) been recognised by the former sovereign power, Serbia.

(j) Between 1940 and 1991, there was no separate national Latvian football association, because the country was part of the USSR.

(k) Between 1940 and 1991, there was no separate national Lithuanian football association, because the country was part of the USSR.

(l) The Macedonian football association was founded in 1948, when the country was part of Yugoslavia. It became a separate national association after 1991, when the country became fully independent.

(m) The Montenegrin football association was founded in 1931, when the country was part of Yugoslavia. It became a separate national association after 2007, when the country became fully independent. Until 1991, the country was part of Yugoslavia, and between 1991 and 2006 the country was part of the Serbia-Montenegro Federation (officially called Yugoslavia until 2003).

(n) The Irish football association was founded in 1880 and was transformed in 1921 into the Northern Ireland football association. At the same time, a separate football association for the new Republic of Ireland was founded.

(o) Between 1924 and 1991, the Russian football association was transformed into the USSR football association. The USSR included the present-day states of Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Moldova, Russia and Ukraine, whose football associations are members of UEFA, and Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, whose football associations are not members of UEFA. After 1940, it also included the present-day states of Estonia, Latvia, and Lithuania, whose football associations are members of UEFA.

(p) The dates indicated refer to the Yugoslavian football association. Yugoslavia included the present-day states of Bosnia-Herzegovina, Croatia, Macedonia, Montenegro, Serbia and Slovenia (and Kosovo, not recognised by Serbia). Its football association became the Serbia-Montenegro football association (until 2003 officially called the Yugoslavian football association) after the other parts of Yugoslavia had seceded. In 2006, it became the Serbian football association, when Montenegro also seceded.

(q) Between 1945 and 1993, there was no Slovak football association, because the country was part of Czechoslovakia.

(r) The Slovenian football association was founded in 1920, when the country was part of Yugoslavia. It became a separate national association after 1991, when the country became fully independent. Between 1920 and 1941 and between 1945 and 1991, the country was part of Yugoslavia; between 1941 and 1945, the country was part of Croatia.