
Data science in Sports: A Game-Changer for Performance

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Abstract

This study aims to identify the adoption factors of data science in football clubs, exploring the factors influencing the adoption of technologies in the sport. The research examines how data science transforms efficiency, decision-making processes, and overall performance in football organizations. The study employs the Technology-Organization-Environment (TOE) framework and the Diffusion of Innovation (DOI) theory to analyse key factors shaping AI adoption. The methodology involves an Exploratory Case Study approach, combining qualitative to explore successful and unsuccessful data science technologies implementations in football clubs. Ethical considerations are prioritized, ensuring participant confidentiality and adherence to guidelines. The research contributes insights to the evolving intersection of football and data science, providing a foundational understanding for future developments.

Keywords: Data sciencer; Artificial Intelligence; Digitalization; Football; Clubs; 4rth Industrial Revolution; TOE and DOI.

Resumo

Este estudo procura identificar os fatores de adoção da ciência de dados nos clubes de futebol, explorando os fatores que influenciam a adoção de tecnologias de data science no desporto. A pesquisa examina como a data science transforma a eficiência, os processos de tomada de decisão e o desempenho geral nas organizações de futebol. O estudo utiliza o framework Tecnologia-Organização-Ambiente (TOE) e a teoria da Difusão de Inovações (DOI) para analisar os principais fatores que moldam a adoção de data science. A metodologia envolve uma abordagem de Estudo de Caso Exploratório, combinando métodos qualitativos para explorar implementações bem-sucedidas e malsucedidas de data science em clubes de futebol. Considerações éticas são priorizadas, garantindo a confidencialidade dos participantes e a adesão às diretrizes. A pesquisa contribui com perspectivas para a interseção em evolução entre o futebol e a data science, fornecendo uma compreensão fundamental para desenvolvimentos futuros.

Palavras-chave: Data science; Inteligência Artificial; Digitalização; Futebol; Clubes; 4ª Revolução Industrial; TOE e DOI.

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1. Introduction

The Fourth Industrial Revolution (also known as Industry 4.0 or i4.0), named by Schwab (2016), denotes a transformative era marked by the fusion of physical, digital, and biological domains. Exploiting the foundations laid by the Digital Revolution, it utilizes digital technologies to bridge the gap between these domains, creating a dynamic, interconnected ecosystem at both individual and urbanistic scales (Fletcher, 2016; Ross & Maynard, 2021). This shift impacts the nature of work, requiring a delicate balance between technological efficiencies and the evolution of employment concepts on a local and global scale (Ross & Maynard, 2021). Considering the technologies used on the 4th Revolution, the main pieces of this transformation are Cyber-Physical Systems (CPS), Internet of things (IoT) and artificial intelligence (AI) (Chiles, R. M., et al. 2021). IoT is described like a smart concept connecting everything to the internet, that facilitates data organization and information exchange (Atadjanova, S. 2022; Hassan et al., 2020). An enhanced CPS integrated through an IoT platform with artificial intelligence has the potential to fulfil the primary objectives of automation and adaptation.

Data science is another important tool of the 4th Revolution and it's defined as the ability to collect, organize, analyze, and interpret large sets of complex data to make informed decisions and solve problems (Davenport, T. H., & Patil, D. J. 2012). The merging of data science and sports analytics has led to an era of unparalleled insights, revolutionizing sports performance optimization and fan engagement (Obi, O. C et al., 2024). In this time where every movement, heartbeat, and strategic choice is measurable and analyzable, data science's role in sports serves as a driver for innovation and a transformative force for athletes, coaches, and fans alike (Najjar, 2023). Artificial Intelligence (AI) is the field dedicated to imbuing machines with the ability to perform tasks that traditionally necessitated human intelligence (Yarlagadda, T. 2018). It refers to the simulation of human intelligence processes by machines, typically computer systems. These processes include learning (the acquisition of information and rules for using it), reasoning (using rules to reach approximate or definite conclusions), and self-correction (Russell, et al., 2016). The application of AI technologies facilitates more efficient capital utilization, fostering the development of a scientific and innovative business model (Enholm, M., et al. 2022). Additionally, it contributes to the enhancement of customer service experiences within the industry (Peng Ding, 2019) and

holds substantial potential in developing decision-making. These decisions frequently occur under immense time pressure and carry significant financial implications in terms of potential gains or losses (Massey & Thaler, 2013).

There are several studies in marketing and fan engagement emphasizing the importance of new technologies, specifically the use of artificial intelligence (Byon, K. K., & Phua, J. 2021; Kuo, Y. K., et al. 2021). However, there are few that address the adoption of these new technologies. Plattfaut & Koch (2021) suggested that more research in these areas is necessary, exploring new adoption factors of innovative technologies in football.

The study aims to identify the adoption factors of data science in football clubs, analyzing the main conditions for its implementation, including drivers and barriers. This will be achieved through the utilization of the Technology-Organization-Environment (TOE) framework and the Diffusion of Innovation (DOI) theory, following the methodology outlined in the study by Plattfaut & Koch (2021).

The impact of sports on contemporary society is highlighted by its significance. In the EU-28, the sports sector provides employment for more than 1.5 million individuals, experiencing a growth rate of 11% between 2021 and 2022 (Eurostat, 2022). Consequently, it holds a prominent position on the EU's agenda (European Commission, 2017). Big sport events, such as the Olympics (Gammon & Robinson, 2003) or the FIFA World Cup (Briedenhann, 2011), now mobilize substantial investments. These investments yield positive outcomes, including improvements in infrastructure and benefits for tourism, leisure, and sports-related activities that are offered to fervent fans (Devine et al., 2010; Terjesen, 2008). Furthermore, this impact repercuss on a grand scale, extending to local economies and communities (Ciomaga, 2013). Besides that, projections indicate that the Data Science market, including the use of AI, is poised to attain a valuation of \$341 billion by the year 2027, with industry analysts anticipating that approximately 38% of this market value will be attributed to software (Martin, K., & Parmar, B. 2022).

2. Literature review

2.1. Digitalization

In the work by Clerck, J. (2017), digitalization is characterized as the utilization of digital technologies and data to generate revenue, enhance business operations, substitute or transform business processes, and establish a framework for digital business. This entails placing digital information at the core of these endeavours.

As per Digital Economy and Society Index (DESI), there has been significant progress in digital information, communication, and systems in recent years (Ordieres-Meré et al., 2020). The integration of intelligent technologies with these systems, constituting the Fourth Industrial Revolution, has the potential to exert a meaningful impact on the overall quality of life on Earth (Ordieres-Meré et al., 2020; Ribeiro-Navarrete et al., 2020).

In conjunction with the positive outcomes, such as increased efficiency in data transfer and reduced operational costs (Yli-Viitala et al., 2019), the phenomenon of digitalization is also marked by negative consequences, including the rise of new forms of digital fraud and an excessive enthusiasm for virtual reality (Chehabeddine & Tvaronavičienė, 2020).

However, given the imperatives of scientific and technological progress, along with the constraints posed by limited economic resources, there is a compelling need for the integration of digital technologies (Vasilev et al., 2020).

Digitalization impacts all businesses, and its influence is expected to grow in the future (Parviainen et al., 2017). Digitalization serves as a key facilitator for enhancing internal efficiency within organizations and exploring external opportunities, such as introducing new services or offerings to customers (Ordieres-Meré et al., 2020). Furthermore, the transformative effects of digitalization can lead to disruptive changes in a company's operating environment. Despite being a substantial and multifaceted concept, digital transformation can translate into success (Sibson, R., & Morgan, A.). Consequently, there is no one-size-fits-all solution for addressing the challenges posed by digitalization (Parviainen et al., 2017).

In the discourse surrounding digitalization, it is important to delve into artificial intelligence as an integral component. Artificial intelligence is a multifaceted system capable of interpreting external data, learning, and adapting to achieve specific tasks, encompassing

language understanding, learning systems, problem-solving, visual perception, and robotics (Avneet Pannu, 2015). A significant advantage of AI lies in its fact-based decision-making, devoid of emotional influences present in human decisions (Khanzode et al., 2020). The benefits of AI include faster task completion, ease in handling stressful and complex work, efficient completion of difficult tasks in a short period, multitasking capabilities, high success rates, reduced errors, enhanced efficiency, space efficiency, and the ability to calculate long-term and complex situations. However, the implementation of AI is not without its challenges. Ethical concerns arise, including privacy violations, bias, and potential misuse (Kravchenko et al., 2023). Additionally, there are concerns about the misuse of AI leading to mass scale destruction, program mismatches, dependence on programmers for creativity, lack of the human touch, potential laziness in the younger generation, the requirement of significant time and financial resources, and an increased dependency on technology (Khanzode et al., 2020). As AI holds the potential to transform industries positively, careful consideration, ethical development, and effective regulation are essential to maximize benefits while mitigating risks.

The influence of digitalization on sports, as noted by Patel, et al. (2020), is increasingly evident, reshaping the landscape for fans, athletes, clubs, and investors. Competing stakeholders, including rights owners and sponsors (Susiva, S. 2019), are also impacted. Digitalization manifests both on and off the field, employing wearables and video analytics for team and athlete management (Söhnlein & Borgmann, 2018).

Notably, digitalization is important in enhancing operational efficiency, encompassing tasks like stadium management, events, and league organization. Authors such as Chmait, N., & Westerbeek, H. (2020) accentuate its role in engaging fans through digital ticketing, sports streaming platforms, and sports betting systems.

Digital technologies, highlighted by Grüttner, A. (2019), provide advanced methods for organizing and managing athletes, teams, and clubs through comprehensive data assessment, performance-enhancing tools, and unique strategies. This intersection of sports and digitalization reflects a dynamic shift in the industry, impacting various facets from fan engagement to operational efficiency.

The investigation into digitalization in the literature review establishes the broader context of technological advancements and their impacts. As we go through into the TOE framework (Technology, Organization, and Environment) within the Diffusion of Innovations (DOI) theory, the focus shifts to understanding the factors influencing the

adoption of AI in football clubs. This transition seamlessly connects the general landscape of digitalization to the specific dynamics involved in adopting AI technologies, providing a framework to analyze the interplay of technological, organizational, and environmental factors in the context of football clubs.

2.2. Data Science

Data science, the ability to collect, organize, analyze, and interpret large sets of complex data to make informed decisions and solve problems (Davenport & Patil, 2012), can be applied in various sectors within football. For example, in the selection of football players, it is an innovative approach aimed at optimizing the recruitment process, minimizing the time required to choose the ideal players, and maximizing return on investment. Through advanced statistical techniques and correlation analyses, clubs can identify patterns of skills and common characteristics among players, facilitating informed decision-making regarding their suitability for different positions on the field. Additional factors such as nationality and market value of players are considered to assess their impact on the club's reputation and ability to attract external investments. Ultimately, this data-driven approach offers clubs a unique competitive advantage, driving long-term sporting and financial success (Rajesh, P., et al. 2020).

With the existence of data science frameworks based on a multidimensional and conscious evaluation of the role of football players' performance, valuable tools can be created. Additionally, experiments have revealed interesting patterns characterizing the performance of football players, such as the uneven distribution of excellent performances and the frequency with which top players achieve excellent performances. It is a valuable tool to support professional football scouts in evaluating, searching, ranking, and recommending football players. It can be extended and customized in various ways, such as incorporating more sophisticated algorithms for player role detection and integration with different data sources, such as video tracking and GPS data (Pappalardo, L., et al. 2019). It is also possible to extract significant information related to space occupation and space generation for teammates. In addition to the overview that global performance statistics from various matches can provide, understanding ball-less movements requires a need for more specialized analysis per match or even per situation (Fernandez & Bornn, 2018).

Despite the crucial role of data science, experts believe that football tactics cannot be fully understood solely from computed numbers without visualization and application of human capabilities for pattern understanding and reasoning. Spatial pressure analyses were considered difficult to understand by football experts, but upon understanding, they recognized the wealth of information and usefulness of these images. Experts also noted that pressure calculated from real data and visualized by methods can be difficult to match with coaches' ideas about desirable tactical behaviors of their teams (Andrienko, G., et al. 2017).

There are also challenges and issues involved in the analysis of team sports data, highlighting the importance of data acquisition, quality, and comparison of data sources. The choice of data acquisition methods, such as video analysis, position sensors, or manual encoding, is crucial as it determines the potential analysis that can be performed. Additionally, modeling, integration, and data cleaning need to be considered, each representing significant work steps. Meaningful analysis depends on domain requirements from external experts, such as coaches and analysts, who are interested in the analysis, prediction, and monitoring of their teams' performance. Effective modeling is essential to evaluate individual player performance or team tactics and strategies. The study emphasizes the importance of collaboration between data science and sports science to develop appropriate analysis systems (Stein, M., et al. 2017).

2.3. Artificial Intelligence

AI finds application in diverse sectors (Rajpurkar, P., et al. 2022; Chen, L., et al. 2020), including sports. Within the domain of team sports, comprising teams, governing bodies, and youth academies, a variety of technologies have been embraced to gather extensive data from both training sessions and matches (Söhnlein & Borgmann, 2018). This data encompasses player movements during games, health statistics, and in-game performance. Through the integration of various sensors, players undergo monitoring during training and competitions, offering valuable insights into their performances (Hammes, F., et al. 2022). As a result, it assists coaches and managers in optimizing training sessions and elevating the performance of players (Beal, R. 2022).

In the dynamic landscape of modern sports, technology adoption, particularly related with Artificial Intelligence (AI), has emerged as a central determinant of success for sports clubs (Lichtenthaler, U. 2020). As we investigate deeper into the significance of adopting AI in sports, it's important to highlight the multifaceted aspects and implications of this adoption on sports club sustainability. The adoption of sports technologies, such as wearables and mobile apps, has generated notable attention due to its potential to enhance athlete performance, foster physical activity, and revolutionize the fan experience (Oc & Toker, 2022). Technological integration is decisive, not just for achieving immediate performance improvements, but also for attracting and retaining fans, which is crucial for the long-term sustainability of sports clubs.

Among these advancements, Artificial Intelligence has emerged as a powerful tool of team sports. As well, AI proves crucial in reorganization different facets of sports business operations, impacting revenue generation, strategies for engaging fans, and the economic viability of sports entities (Byon, K. & Phua, J. 2021). However the incorporation of AI in sports goes beyond immediate performance improvements, encompassing long-term sustainability and fan engagement, which are vital for the success of sports clubs. The review features that AI technologies play a role in advancing player development, improving cognitive skills, decision-making, and athletic performance (Araújo, D., et al. 2021).

Current studies in the use of AI in football analyses the role of leadership styles (Lichtenthaler, U. 2020), Injury prediction (Claudino, J. et al. 2018) and marketing engagement (Burgess et al., 2020; Yen-Ku Kuo et al., 2022). However, there are few that address the adoption of these new technologies. Plattfaut & Koch (2021) suggested that more research in these areas is necessary, exploring new adoption factors of innovative technologies in football.

2.4. DOI and TOE

Current dissemination of data science and technological innovation on the performance of football clubs, lead to the discussion about the factors that lead clubs to adopt data science's technologies. The TOE (Technology, Organization, and Environment) framework and DOI (Diffusion of Innovations) theory are the main concepts used in this debate.

The Diffusion of Innovations (DOI) theory, developed by Everett M. Rogers (1961), delineates the process by which new ideas or technologies propagate within a social system. The theory consists of five stages: Knowledge, where awareness of the innovation begins; Persuasion, where potential adopters assess the innovation's merits; Decision, involving the determination to adopt or reject based on perceived advantages; Implementation, where the innovation is put into practice; and Confirmation, reinforcing adoption decisions through feedback.

Rogers identified key factors influencing diffusion, including Relative Advantage, Compatibility, Complexity, Trialability, and Observability. These factors contribute to the varying rates of adoption within a social system. Additionally, Rogers categorized adopters into groups such as Innovators, Early Adopters, Early Majority, Late Majority, and Laggards based on their readiness for innovation (Rogers, M. 1961).

The TOE framework provides insights into how the adoption of technology by organizations is shaped by the interplay of technological, organizational, and environmental factors. Its purpose is to take into consideration specific organizational elements when evaluating the decision-making process related to the adoption of innovation (Karunagaran et al., 2019):

One of them is technological readiness. Defined as a firm's ability to adopt new technology, involves both internal and external considerations (Richey et al., 2007). Internal factors include the firm's technology infrastructure, while external factors encompass technologies existing in the market (AlSheibani et al., 2018). The complexities and challenges associated with adopting new technology necessitate a careful examination of technological readiness, as it offers valuable insights into the anticipated benefits of technological implementation (Richey et al., 2007). Inside of technological readiness exists 2 important factors: compatibility and Relative advantage.

Compatibility, denoting the extent to which an innovation aligns with current technological situations and addresses the needs of expected adopters, is a aspect influencing intention to adopt (Yang, 2015). This positive relationship between compatibility and innovation adoption emphasizes the importance of perceived value and experience derived from the innovation (Rogers, M. 1995). Identified as a crucial attribute of data science adoption (AlSheibani et al., 2020), it is highlighted the necessity of a solid business case that aligns with existing business strategies and organizational values. Zhu's findings (2020) support the idea that a greater match between the adoption process and the diffusion of

technology innovation facilitates easier adoption. Relative advantage, referring to the perceived benefits of adopting AI and data science at the firm level, plays a significant role in organizational intention to adopt innovative technology (AlSheibani et al., 2018). Building on prior research (Yang, 2015), the relative advantage of new technology, provides organizations with a competitive edge, cost reduction opportunities, and avenues for entering new business domains (Ransbotham et al., 2017). The adoption of AI has the potential to enhance top-line profits, increase efficiency, and amplify human intelligence (Curran & Purcel, 2017).

The second one is the organizational readiness for data science adoption. Achieving organizational readiness involves navigating multifaceted factors beyond technological considerations. It is necessary to have top Management Support leadership to exist commitment at the highest level is (Wijayati, et al. 2022). This involves integrating AI into organizational strategy and fostering awareness throughout the organization (Alsheibani et al., 2018). Another important factor is the organization size. Organizational size directly influences readiness (Alsheibani et al., 2018). Larger organizations tend to possess greater capabilities to adopt technology, providing them with a strategic advantage (Alsheibani et al., 2018). Beyond technological resources, readiness relies on human, enterprise, and information technology resources (Alsheibani et al., 2018; Jönk et al., 2020). These encompass the critical components needed to support and sustain new innovation adoption efforts, including computer hardware, data, networking, and human expertise (Alsheibani et al., 2018). Furthermore, change management is vital for addressing employee concerns and fostering a positive environment (Fountain et al., 2019; Wade & Hulland, 2004). Overcoming misconceptions regarding job security is crucial to ensuring a smooth transition (Jönk et al., 2020). Such Change Management, collaboration among domain experts, data science specialists, and IT departments is critical (Fountain et al., 2019). It helps overcome siloed approaches, identify new use cases, and ensures employees with diverse skills can complement each other (Jönk et al., 2020). To finalize the organizational readiness, data availability and data-driven decision-making are the factors that remain. Effective data management, including availability, is a key factor for organizational readiness (Jönk et al., 2020; Alsheibani et al., 2018). Ensuring quick access to relevant data sources enables data scientist specialists to prototype and develop AI models (Catalyst Fund, 2020) and a culture of data-driven decision-making (DDDM) is crucial for AI readiness (Iansiti and Lakhani,

2020). DDDM not only leads to performance improvements but also supports the integration of AI into organizational decision processes (Jarrahi, 2018).

And lastly environmental readiness. Organizations, in their pursuit of innovation, are profoundly influenced by their environmental conditions, encompassing the competitive landscape and regulatory frameworks within which they operate (Tornatzky & Fleischer, 1990). Environmental readiness, in this context, is the organization's perception of external factors that influence the adoption (Ifinedo, 2005).

Competitive pressure, denoted as the threat of losing a competitive advantage, serves as a significant motivator for organizations to embrace new innovations such as data science (Aboelmaged, 2014). Research by Yang (2015) recognizes competitor pressure as a crucial factor driving the diffusion of innovations. The external circumstances, including socio-economic factors, can impact business activities and necessitate adaptation (Hung et al., 2016). Gartner's report (2017) features the strategic importance of developing an AI strategy for technological progression, acknowledging AI's potential to drive innovation and create opportunities (Fast & Horvitz, 2017). In addition to competitive pressure, government regulatory issues emerge as another critical consideration for firms (Yang, 2015). Regulatory issues, in this context, pertain to the assistance provided by government authorities to encourage the adoption of data science innovations at the organizational level. Diverse government policies contribute to the varying landscapes of data science adoption across different regions.

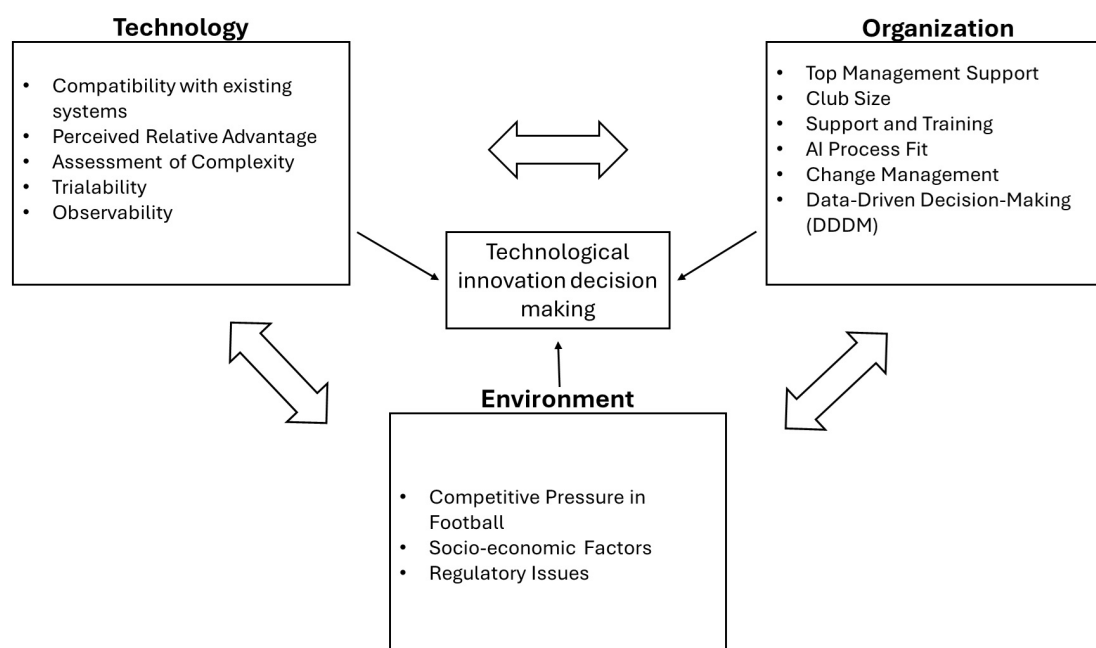


Figure 1- TOE Framework of football clubs

3. Methodology

3.1. Methodological approach

This research adopts an Explanatory Case Study, as outlined by Plattfaut and Koch (2021), combining qualitative and, to investigate the adoption factors of data science in football clubs. This study aims to explore and understand the specific conditions influencing the acceptance and implementation of data science technologies in football settings.

The Technology-Organization-Environment (TOE) framework and the Diffusion of Innovation (DOI) theory will guide the analysis of qualitative data. These frameworks will be applied to assess the technological, organizational, and environmental factors influencing data science adoption by football clubs.

3.2. Case selection

Careful consideration was given to selecting cases for investigation, ensuring a diverse representation of football clubs. To provide a comprehensive overview, the study adopts a structured league-wise analysis, categorizing football clubs based on their respective divisions. This segmentation includes 1st Division clubs with significant resources, 2nd Division clubs balancing competitiveness and resource limitations, 3rd Division clubs with potential financial constraints, and nonprofessional clubs operating below officially recognized tiers.

Workers from innovation department, coaches, and some analysts that use new technologies. This allows for a comprehensive exploration of the factors affecting data science adoption in football.

3.3. Data collection

The research methodology employed for this study involves conducting in-depth interviews with key stakeholders within football clubs, prioritizing innovation related workers. These interviews serve as a necessary means of gathering qualitative data to explore the intricacies surrounding the adoption of data science in football operations.

The participants in these interviews represent distinct perspectives within the football ecosystem. Workers from the innovation department, responsible for implementing and managing data science systems, provide insights into the technological aspects of integration.

Their role is decisive in understanding how data science technologies are practically applied within the club's operations, shedding light on the technical intricacies, challenges, and opportunities associated with data science adoption. This group offers valuable perspectives on the hands-on implementation of data science strategies.

The investigation within each league division examines the presence or absence of an innovation department, the reasons underlying such decisions, and the active utilization of data science technologies within these departments. Furthermore, the study scrutinizes the decision-making processes, observable comparative advantages, and implementation difficulties, offering a nuanced understanding of how data science adoption varies across different football clubs and its diverse impacts on performance and operations.

Interviewee	Professional Position	Division	Country
1	Chief of Technology Department	1st	Portugal
2	Football coordinator	4rd	Portugal
3	Football Coordinator	1st	Portugak
4	Chief of technology department	Liga Portugal	Portugal
5	Football Player	Mostly 1st division	Portugal, Spain, Poland

Table 1- interviewee profile

3.4. Data analysis

The qualitative data collected through in-depth interviews with key stakeholders, including innovation department workers, will undergo a rigorous thematic analysis to derive meaningful insights into the adoption of data science in football clubs. Vaismoradi and Snelgrove (2019) provide a comprehensive discussion on the use of themes in qualitative content analysis (QCA) and thematic analysis (TA), highlighting their importance in systematically categorizing responses and observations to identify recurring topics.

The initial phase of analysis involves identifying the main themes and patterns that emerge from the qualitative data. This process entails systematically categorizing responses and observations to highlight recurring topics related to data science adoption. Themes may

encompass decision-making factors, challenges faced, motivations driving adoption, and the perceived impact on various facets of football club operations (Vaismoradi & Snelgrove, 2019).

Digitalization	- Club usage - Club's Search	2, 4
Technological Readiness	- Compatibility with existing systems - Perceived Relative Advantage - Assessment of Complexity - Trialability - Observability	3, 5, 8, 11, 12, 14
Organizational Dynamics	- Top Management Support - Club Size - Support and Training - AI Process Fit	4, 6, 7, 9, 10
Environmental Factors	- Competitive Pressure in Football - Socio-economic Factors - Regulatory Issues	7, 13, 15, 16

Table 2- Interview Questions

Ultimately, the goal is to develop a comprehensive understanding of the qualitative data, going beyond surface-level observations. By employing thematic analysis, the study aims to uncover the underlying patterns, connections, and insights that can contribute to a richer understanding of the factors influencing data science adoption in football clubs. This in-depth analysis will form the basis for drawing meaningful conclusions and implications from the qualitative findings.

3.5. Ethical Concerns

Ethical considerations will be primary throughout the research process. Informed consent will be obtained from all participants, and measures will be in place to ensure confidentiality and anonymity. The research will adhere to ethical guidelines established by relevant institutions.

3.6. Limitations

Acknowledging potential limitations, such as sample size constraints and potential biases, is essential. Transparent reporting of limitations will contribute to the overall rigor and reliability of the study.

4. Results

Digitization has been a trend across most football clubs in Portugal, representing a significant shift in operational processes. Interviewees emphasized that the introduction of new software, especially for scouting and video editing, is transforming how the club conducts its daily operations, enhancing player analysis and selection processes. Interviewee 1 mentions that the implementation of digital solutions has streamlined tasks such as stadium visit management and hotel selection for European competitions, emphasizing the pursuit of efficiency and transparency. Digitization is seen as an opportunity to reduce paper usage, with the transition from manual evaluations to assessments conducted entirely on computers, demonstrating the gradual adoption of digital solutions to improve the club's efficiency and organization.

To get a generalized overview, in this study a point of view from Liga Portugal is given, offering a deep insight into the dynamics and challenges faced in integrating data analysis in football. The interviewee highlights the importance of tools like WT Vision in gathering game data, providing immediate statistics such as shots and crosses. However, the lack of an official tracking service is emphasized, identifying internal obstacles hindering progress in this regard. Another relevant tool is the Wyscout platform, which allows efficient video filtering and analysis. Although not currently utilized by the league, its potential for tactical evaluation and player scouting is recognized, contributing to a deeper understanding of the game. The importance of a centralized approach in providing data and analysis tools to all clubs is evident, aiming to improve performance, prevent injuries, and promote national talent. However, the need to reach a consensus among clubs to implement technologies like tracking, which can provide a significant competitive advantage, is acknowledged. The discussion on the evolution of data work over the years reflects a continuous focus on automation and the use of advanced technologies such as machine learning to optimize processes and provide more precise insights. References to partnerships with leagues like

LaLiga and the aspiration to learn from them highlight the pursuit of best practices and innovation within Liga Portugal.

A football player who had an international career and played for several renowned clubs was interviewed to provide a more practical perspective. When asked about the evolution of football over time, he emphasized significant improvements in working conditions, both for players and coaches. According to him, this evolution extends beyond technique alone, encompassing a broader understanding of the game and higher quality in all areas, driven by available technologies and knowledge. Technologies were a recurring theme in the interview, with the player acknowledging their positive impact on football. He highlighted the importance of detailed statistics in individual and collective performance analysis: “the technologies have had a great impact. Nowadays, we can see detailed statistics such as the number of passes, sprints, accelerations, among other things. This allows for a more precise analysis of the game, especially at an individual level. From this data, we can identify our strengths and weaknesses and work to improve”. However, he also reflected on the possible excess of analysis and monitoring, which could make the process tiresome for players, interfering with the fluidity of training and gameplay. The use of videos and visual analyses to observe opponents and one's own team was underscored as a valuable tool too by him. This technology allows for a more precise understanding of the game, correcting misconceptions and aiding in strategic preparation.

The presented overview demonstrated that digitalization, and the use of different sources of data, is a trend in professional football of different categories. In that sense, from a TOE Framework perspective, technological organizational and environmental factors lead to the adoption of data science by Portuguese football clubs.

Regarding the Technology category, all factors presented in our model were observed, as listed below:

Compatibility:

Football is an elite sport, and for those clubs that play in the top leagues, the use of data science has a greater compatibility than in leagues with less financial resources, which can be a crucial factor for the adoption of data science. This is because the top clubs have departments and human resources that can maximize the exploitation of new data science technologies. They do not hide the fact that they invest more in certain departments than others but also highlight that no one can complain that something was not done due to a lack of technology, as stated by interviewee 3: "(...) we have both the departments and capable

human resources who are digitally literate, so to speak." Compatibility issues arise due to the existing difficulty in changing behaviours, as described by interviewee 1: "while there are people who might deliver the dashboard and never look at it again, and I have to stay on top of them to ensure it happens."

Relative Advantage: First, it is necessary to understand that most of data science technologies used are dedicated to football, and usually, there are three main areas according to interviewee 1: technical, scouting, and analysis. He also mentions that one of the goals is to reduce the gap to rivals by signing players (creating algorithms to reflect the player's value), for example, "to understand if the player we are signing will actually reduce the gap to a certain rival we want to use as a metric. And in football, that's more of what we work on specifically." Looking at the Portuguese league standings, we can see that there is indeed a relative advantage among those who are more advanced in terms of data science. According to interviewee 3, they are always in contact with rival clubs, which is an important factor for adopting these new technologies: "We are also paying attention to what is happening with the competition, we keep informed, we are constantly in contact with clubs."

Complexity:

To implement any kind of innovation, it is important to make it as simple and intuitive as possible. This is what all clubs try to do by creating departments or investing in human capital, where interviewee 1 explains this very well with the following example: "I have beside me the so-called two nerds, pure and hard, who only talk about programming issues and so on. And I have that conversation with them, the next moment I'm talking to the President. And when talking to the President, if I start saying we're having a problem with Python with this and that, the President will look at me and say 'what are you saying?' That is, part of my job is to see who I am talking to and adapt, translating things for the person." If it were not possible to create this kind of harmony, it would be very difficult to adopt these kinds of technologies involving data science, as classified by interviewee 2: "The main challenges that could influence the decision-making process would be mainly related to the costs associated with the implementation of technologies involving data science and the technical complexity involved in using these technologies. It could require a certain level of expertise, which could affect the club's willingness to adopt them."

Triability:

Innovations that can be tested or experimented with on a limited scale without a large investment of time or resources are more likely to be adopted. This allows potential users to

evaluate the benefits and better understand how the innovation will work in their specific context, reducing the uncertainty associated with adoption. An example of this is the example cited by interviewee 3: "It is important, that is, when we don't know something, a product we've never had, we have an incentive to change for the better if that happens. If I have a weak car, I will buy a better one, if I can take a test drive, it will likely be a positive thing and will motivate me to buy it. In some cases, it is possible, in others not, but it is necessary, in the case of software, to have a premium version, for example, if we can try it, it is relevant and provides comfort."

Observability:

When the benefits and positive results of an innovation are easily observable by others, adoption will increase. The visibility of successful results encourages others to adopt the innovation, as they can clearly see the value and effectiveness of the new idea or technology. An example of this is the increased use of clouds, where at different times everyone mentions that adopting these was very important for the club's evolution.

Regarding the Organizational category, all factors presented in our model were observed, as listed below:

Top Management Support:

In the football world, there is still clearly a great responsibility on the presidents, as they are the ones who make the big decisions in an authoritative manner. Often, information comes from below about less positive aspects that can be improved and must be conveyed clearly to the president for him to then decide what to do. Another sector that has a lot of power in this aspect is the technical team, because if they want to use more data science in their daily activities, the club will seek more options; otherwise, it will be more difficult to streamline, as interviewee 1 says: "In other words, we are basically, in many quotes, 'slaves' to the technical team. That is, the technical team says how things are, and we make it happen. Then, how they use it, is up to them."

Club Size: In this case, we have to understand that we are dealing with technologies that require significant investments, so the larger the club, the greater the investment. Interviewee 1 confirms this when he says: "we are a very innovative club, a club that invests a lot in these areas and has no reason to complain, but there it is, if we have a budget of half a million, we want to have a budget of one million, if we have a budget of one million, we want to have a budget of 1.5 million. Those things that if the President tells me 'you have 10

million', there will never be any money left. I can invest in all kinds of technology." This means that data science adoption will likely be greater according to the size of the club, "Generally, being a smaller club can limit the use of new technologies due to the cost and practical benefit" – interviewee 2.

AI-Process Fit:

Most clubs use data sources from their own companies. There are companies that already do this collection. As mentioned earlier, almost all clubs use Wyscout, which provides the platform with a machine learning system that "through video generates statistical data on players that will be very important for various areas of the club," as specified by interviewee 1. To understand the importance of adopting this process, I leave a quote from interviewee 3: "Famalicão, in 5 years, managed to achieve success at the sports level, in youth development (placing players in the first team), and selling players for high values to very good European clubs. This was achieved very quickly, both through accurate decisions and the resources used, and part of these resources includes artificial intelligence."

Data Availability and Data-Driven Decision-Making (DDDM) in Football:

All clubs are currently seeking DDDM solutions to make everything around football more practical. It is so important that even lower league clubs, as in the case of interviewee 2, are already starting to look for technologies of this caliber: "We are looking for software that helps us in the technical and physical part of the club, including game evaluations, training, and accessible team management. At the moment, we use a cloud as a database and are actively looking to improve this service." Larger clubs also place importance on the use of the cloud, to the extent that interviewee 1 states that its use is already crucial: "the connection with the data only really started this season, and it is that almost, let's say, addictive relationship, almost like a vice that at this moment, if we say, 'look, we won't work with data anymore,' I think professional football could no longer live without the data." Thus, we see that the adoption of DDDM is already widespread.

Regarding the Environment category, all factors presented in our model were observed, as listed below:

Competitive Pressure in Football:

In this context of competitive pressure in the Portuguese league, it can be said that three clubs are considerably ahead of the others: "Benfica is on a completely different level from everyone else, it has almost infinite investment, carte blanche, everything that exists in

the market, Benfica has it. Then, there are Braga and Sporting on a tier below, where the project is already advancing and everything else. After that, there's Porto, which is not very connected to this technological aspect and doesn't invest much in it. I would say that all the others are almost just trying to survive, paying employees, and paying the players." It is noteworthy that the use of technologies by rivals can lead to the adoption of technologies as suggested by interviewee 3: "We are also attentive to what is happening with the competition, we keep informed, we are constantly in contact with other clubs."

Regulatory Issues in Football: Considering regulatory factors specific to football, such as league rules and guidelines, and how they may impact the adoption of AI technologies, nothing was mentioned in the interviews about this topic.

Socio-Economic Factors in Football: The Portuguese socio-economic reality does not help, as the technologies are too expensive compared to the realities of the clubs, as emphasized by interviewee 1: "I think Portugal, as I also started by saying, is very behind from a technological point of view, but it is also somewhat a reflection of the economic point of view." Therefore, clubs usually prefer to give importance to factors that influence the short term, such as hiring new players who make the team score more goals or concede fewer. From the point of view of interviewee 1, the change has to come from the responsible body of the League where it is necessary to have a shift in mentality, and "this shift will only happen when it comes from the league itself offering incentives (in Spain, this happens with agreements that provide a basic data platform). If then Real Madrid wants to have the best thing in the world, it is up to them, but no one can say that they do not have a basic question in Portugal; that does not happen." Although the league's main objective is to promote competitions (improve effective playing time, competitiveness, etc.), they now assume that their goal is also "(...) to have a platform where all clubs can access. In addition to collecting tracking data, it is important to have a platform that analyzes and organizes it all in a way that is simple, easy to consult, and to draw conclusions from." That is, we can understand that efforts are being made to facilitate the adoption of data science by the clubs.

5. Discussion

Digitalization has become a significant trend across most Portuguese football clubs, representing a considerable shift in operational processes. Interviewees emphasized that new software, particularly for scouting and video editing, is transforming club operations,

enhancing player analysis and selection processes. Interviewee 1 noted that digital solutions have streamlined tasks such as stadium visit management and hotel selection for European competitions, emphasizing efficiency and transparency. Digitization is seen as an opportunity to reduce paper usage, transitioning from manual evaluations to computer-based assessments, demonstrating a gradual adoption of digital solutions to improve club efficiency and organization.

These findings align with the literature's view that digitalization enhances internal efficiency and operational processes. The emphasis on software for scouting and video editing supports Clerck's (2017) assertion that digital technologies transform business processes. The focus on reducing paper usage and streamlining tasks echoes the literature's emphasis on increased efficiency and cost reduction (Yli-Viitala et al., 2019).

However, the interviews also reveal specific challenges, such as adapting to new digital solutions and the need for ongoing adjustments. These challenges align with the literature's view that digitalization is complex and requires a tailored approach (Parviainen et al., 2017). The emphasis on efficiency and transparency reflects the literature's discussion on the benefits of digitalization but also highlights the practical difficulties faced by clubs with fewer resources.

Data Analysis Tools and Platforms

The role of data analysis tools like WT Vision and Wyscout, as highlighted in the interviews, aligns closely with the literature's discussion on the importance of data science in football. WT Vision's ability to provide immediate game statistics and Wyscout's utility in efficient video filtering and analysis are practical applications of the data science principles discussed by Rajesh et al. (2020). These tools enable clubs to perform detailed performance analyses, which are critical for tactical evaluations and player scouting.

The interview results also highlight challenges in integrating these technologies universally across clubs. The absence of an official tracking service and the requirement for consensus among clubs to implement advanced technologies like tracking systems reveal internal obstacles that were less emphasized in the literature. This indicates a gap between the theoretical potential of data science tools and their practical implementation within the league.

Evolution of Data Science in Football

The literature review emphasizes the evolution of data science techniques, including advanced statistical methods and machine learning, to optimize processes and provide precise insights (Pappalardo et al., 2019). This evolution is mirrored in the interview results, where there is a continuous focus on automation and the use of advanced technologies to improve football operations, but nothing is said about techniques that include machine learning. The partnerships with leagues like LaLiga and aspirations to learn from their best practices underscore a proactive approach to innovation and excellence in Liga Portugal.

Practical Implications and Challenges

From a practical perspective, the interview with the former international football player offers valuable insights into the tangible benefits and potential drawbacks of data science in football. The player's emphasis on the importance of detailed statistics for performance analysis echoes the literature's findings on the benefits of data-driven approaches (Fernandez & Bornn, 2018). Nevertheless, the player's concern about the potential for excessive analysis, which may disrupt the fluidity of training and gameplay, underscores a significant challenge. This aligns with Andrienko et al. (2017), who noted that while spatial pressure analyses provide valuable information, they can be difficult for coaches to integrate with their tactical strategies without proper understanding.

Integration and Collaboration

The importance of collaboration between data scientists and football experts is a recurring theme in both the literature and the interview results. Effective data analysis in football requires not only robust data acquisition and cleaning but also the integration of domain expertise to interpret and apply insights meaningfully (Stein et al., 2017). The interviewees' recognition of the need for a centralized approach to provide data and analysis tools to all clubs highlights the potential for collaborative efforts to enhance overall league performance, prevent injuries, and promote national talent.

TOE Framework

In this section, the three areas of the TOE and their respective factors will be discussed individually.

Technology Factors

- **Compatibility:** Literature emphasizes that the compatibility of an innovation with existing technologies and workflows significantly influences its adoption (Yang, 2015; AlSheibani et al., 2020). In practice, football clubs with higher financial resources demonstrate greater compatibility with data science technologies, as they possess the necessary departments and digitally literate human resources. However, a notable challenge is the resistance to behavior change, as mentioned by an interviewee, highlighting the difficulty in ensuring consistent utilization of new tools across all levels.
- **Relative Advantage:** Relative advantage, or the perceived benefits of adopting new technologies, is a critical factor for adoption (AlSheibani et al., 2018; Curran & Purcel, 2017). Interviewees highlighted that data science technologies provide substantial advantages in technical, scouting, and analytical areas, helping clubs reduce gaps with rivals and improve decision-making. Observations in the Portuguese league standings correlate with the notion that advanced data science adoption contributes to competitive success.
- **Complexity:** The literature suggests that the complexity of technology can hinder adoption if it is perceived as too difficult to use (Rogers, 1995). Interviewees stressed the importance of simplifying complex data science concepts for different stakeholders within the club. This involves translating technical jargon into understandable terms for decision-makers, thus facilitating smoother adoption and implementation processes.
- **Trialability:** Innovations that can be tested on a limited scale are more likely to be adopted (Rogers, 1961). In practice, football clubs benefit from trial opportunities, such as premium versions of software, which allow them to evaluate the technology's effectiveness before full-scale implementation. This aligns with the notion that trialability reduces uncertainty and enhances adoption likelihood.
- **Observability:** The visibility of successful results from adopting new technologies encourages further adoption (Rogers, 1961). The increased use of cloud-based solutions in football clubs exemplifies this, as the observable benefits of improved data management and analysis drive wider adoption across clubs.

Organization Factors

- **Top Management Support:** Top management support is crucial for the adoption of new technologies (Wijayati et al., 2022). Interviewees indicated that presidents and technical teams play significant roles in decision-making and the adoption of data science. The alignment of technology adoption with organizational strategies and goals, driven by top management, is essential for successful implementation.
- **Organizational Size:** Larger organizations with more resources are more capable of adopting new technologies (Alsheibani et al., 2018). Interviewees confirmed that larger clubs with bigger budgets invest more in data science.
- **AI-Process Fit:** The integration of AI into existing processes is critical for adoption (AlSheibani et al., 2020). Most clubs use platforms like Wyscout, which integrate machine learning to provide valuable player statistics and analysis. The success stories of clubs like the one that represents interviewer 3 underscore the importance of AI in achieving rapid success through informed decision-making and resource utilization.
- **Data Availability and Data-Driven Decision-Making (DDDM):** Effective data management and a culture of data-driven decision-making are vital for AI readiness (Jönk et al., 2020; Iansiti & Lakhani, 2020). The use of cloud-based solutions and the emphasis on DDDM by interviewees highlight the importance of quick access to relevant data and the integration of data insights into organizational decision processes.

Environment Factors

- **Competitive Pressure:** Competitive pressure is a significant motivator for innovation adoption (Aboelmaged, 2014; Yang, 2015). Interviewees noted that the use of data science technologies by rival clubs drives the adoption of similar technologies to maintain competitive parity. The disparity in technology adoption among Portuguese league clubs also illustrates how competitive pressure influences adoption rates.
- **Regulatory Issues:** Although interviewees did not specifically discuss regulatory factors, literature indicates that government policies and regulations can impact technology adoption (Yang, 2015). The lack of an official tracking service and the

need for a centralized data platform, as mentioned by interviewees, suggest that regulatory support could facilitate wider adoption of data science technologies.

- Socio-economic factors influence the capacity of clubs to adopt new technologies (Hung et al., 2016). Interviewees highlighted that the financial limitations of Portuguese clubs hinder technology adoption, emphasizing the need for league-level incentives and support to bridge the technological gap.

Despite the literature suggesting that top clubs have already been implementing data science, in Portugal there are clubs that achieve sporting success without placing much importance on adopting these new technologies. Another interesting point from this study is that the policies the management incorporates into a club are not related to the choice of the coach. That is, even if a club is very innovative, if they decide to hire a coach who does not know how to work with new technologies or whose ideologies are even against their use, the club will change its approach in this aspect. Thus, we can understand that the technical team has a significant influence on the importance given to the use of data science. In spite of this, larger clubs acknowledge that they could no longer survive and achieve their objectives without these new technologies.

6. Conclusion

The primary objectives of this study were to explore the use of data science in Portuguese football clubs, identify the tools and platforms used for data analysis, and understand the practical implications and challenges of implementing these technologies. Additionally, the study aimed to assess the alignment between theoretical frameworks and real-world applications within these clubs. Interviews with club managers and a former international football player provided practical insights into how digital tools are transforming club operations and decision-making processes.

The principal conclusion of this study is that while Portuguese football clubs are increasingly adopting digital and data science technologies and it is also understood what the main factors leading to the adoption of these types of technologies are, significant disparities exist in their implementation and integration. Clubs with higher financial resources and top management support are more likely to benefit from these technologies, enhancing their

competitive edge. Conversely, smaller clubs face substantial challenges, including financial constraints and resistance to behavioral change. This study contributes to the understanding of digital transformation in football by highlighting both the potential benefits and the practical hurdles faced by clubs.

The theoretical contribution of this dissertation lies in the absence of studies that connect the TOE framework with data science technologies in the sports context, particularly in football. Therefore, this study can serve as a foundation for further research both in Portugal and internationally.

The findings of this study provide significant managerial insights for football clubs regarding the adoption and utilization of data science technologies. The integration of these technologies can streamline various operational aspects, such as scouting, video analysis, and match preparation, leading to more efficient and effective decision-making processes. Club managers are encouraged to prioritize investment in digital tools and human capital to fully exploit the potential of data analytics. The study also features the importance of top management support and the alignment of technological initiatives with the club's strategic objectives. Additionally, it highlights the need for continuous training and education of staff to ensure the successful implementation and utilization of data science technologies. Emphasizing collaboration and knowledge sharing among clubs can further enhance the overall competitive advantage of the league.

This study is not without limitations. The sample size of interviewees is relatively small, which may limit the generalizability of the findings. Additionally, the focus on Portuguese clubs means that the results may not be directly applicable to clubs in other regions with different financial and organizational contexts.

Future research should consider larger and more diverse samples, including clubs from different countries and leagues. Longitudinal studies tracking the evolution of digitalization and its impact on performance over time would provide deeper insights. Additionally, exploring the role of advanced data science techniques, such as machine learning, in football operations could further enrich the understanding of technology's transformative potential in sports.

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Appendix A - Script for the Interviews - Football Clubs

1. Provide a brief overview of your football club and your role in the organization.
2. What is the primary use of digitization by your football club?
3. Which data science applications are most suitable for the club?
4. How does your organization seek new technologies, digitization, and data science?
5. What have been the main advantages observed since the implementation of digital technologies, including data science? Can you elaborate on the perceived advantages or benefits that your club expects to achieve with the adoption of data science technologies compared to current practices?
6. What is the process of adopting data science in your organization (including key decision-makers, the decision-making process, etc.)?

7. Considering the potential complexity associated with implementing data science technologies in football operations, what challenges or considerations influenced your club's decision-making process?
8. Has the club explored the possibility of conducting tests or "pilot" phases for data science adoption, and if not, what factors contribute to this decision?
9. What is the level of support from the club's management regarding the potential adoption of data science technologies?
10. To what extent does the club's size contribute to the decision not to explore advanced technologies?
11. In the context of football operations, how do you assess the compatibility of potential data science solutions with existing systems and equipment?
12. What are the perceived advantages or benefits that your club expects to achieve through the adoption of data science technologies in comparison to current practices?
13. What are the industry trends in the adoption of data science technologies?
14. How has the use of data science influenced the club in terms of performance?
15. What are the main drivers in the adoption of data science in the club?
16. What are the main barriers to the adoption of data science in the club?