Comparing league formats from a business oriented view: the case of Argentina's National Basketball League

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Abstract

During the last decades, the use of advanced optimization algorithms to generate sports timetables has caught the attention of both academics and practitioners. From a managerial standpoint, the competition's structure and the design of the league's schedule represent key strategic decisions with a direct impact in terms of revenue and other important indicators. Argentina's National Basketball League (LNB) has undergone a major transformation since 2014, implementing a tour-based schedule design to reduce the total distance traveled by the teams. In this work, we build upon this experience and evaluate the impact of an alternative league structure for the LNB, considering the interest of the games in a schedule as a key design element. We consider a league structure with a couple-based system and a time constrained schedule that increases the share of games played during weekends. We introduce a metric to measure the interest of a game and explore different Integer Linear Programming (ILP) models to construct the schedule, including a new framework that partially incorporates the touring scheme into the time constrained schedule in a more controlled fashion. Throughout extensive computational experiments over six LNB seasons, we show that our framework reduces the traveled distance in most of the instances and that it translates into higher revenue under moderate stadium attendance assumptions, with increments reaching up to 40 percent.
Keywords: OR in sports; sports scheduling; integer programming; tournament design; game importance

1 Introduction

During the last decades, both practitioners and academic have shown an increasing interest in using Analytics and quantitative methods as a key decision making tool within sports. This area, called *Sports Analytics*, tackles different problems ranging from organizational and business areas, forecast and predictions, to very specific aspects of the dynamics and the fashion in which the sport is played, among many others. As a result, there are cases (e.g., baseball and basketball) where the game itself suffered dramatic transformations regarding the style and the predominant actions executed by the players during games.

Within organizational aspects, scheduling problems have caught the attention of the Operations Research (OR) community, in particular the design of fixtures and schedules for sport leagues. The structure of a tournament depends on several factors. The teams can be considered as a unique group, or can be partitioned into the so-called conferences, usually grouping teams according to their geographical location. Sometimes conferences are further partitioned into divisions. Classical formats for the tournaments are round robin fixtures (usually single or double round robin), where teams play against each other team the same number of times. However, some leagues allow a more flexible design where some teams play more games against each other. Examples of such leagues are the National Basketball Association (NBA), the

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Major League Baseball (MLB) and the National Football League (NFL), where in the latter some teams are never scheduled as opponents during the regular season.

The schedule is organized in rounds, also called time-slots, where games among teams take place. A schedule is temporally constrained, or also referred as compact, if each team plays exactly one game per round. For instance, most soccer leagues around the world follow this format, where a round is usually defined by the games played within a weekend. However, this constraint can be relaxed by considering a larger number of rounds, usually referred as temporally relaxed schedules, where the fixture for a team has several rounds with no games scheduled. A team could play multiple games within a short period of time, without the need of returning home in between, creating a tour. This flexibility enables to improve some quality metrics of the schedule, such as reducing the distance travelled by the teams by scheduling consecutive games on the road (tours) to reduce the travelled distance. Another important characteristic for a tournament is the number of stages in which the games are scheduled. Mirrored round robin tournaments consider more than one round robin phase can be usually modelled as a collection of single round robin phases where the status of home and ways matches alternate between consecutive stages.

Research in this area is quite extensive. One stream of research is motivated mainly by concrete applications, where the objective is to find a feasible schedule to a real practical problem. In general, feasibility rules and business constraints are very dependent on the sport, the characteristics of the region, the traditions within the league, just to name a few. As a result, the problems considered and the resulting models are very rich, including plenty of domain specific characteristics. Another stream concentrates in the construction of the timetables, which also stands as a challenging computational problem motivating many papers dealing with theoretical, algorithmic and modelling developments. The specific characteristics imposed to the schedule impacts on the structure of the underlying problem, resulting in a family of difficult and interesting optimization problems related to sports scheduling.

From a managerial standpoint, a competition's structure and the design of a league's schedule represent key strategic decisions with a direct impact in terms of revenue and other important indicators. Current research is mainly devoted to tackle specific real-world cases and to provide methodological improvements for these particular problems. To the best of our knowledge the literature providing algorithmic comparisons or evaluating the impact of different league structures is rather scarce (see, e.g. Kendall et al. [2010a], Durán [2021]).

The Argentina's National Basketball League (LNB) has undergone a major transformation since 2014. Briefly, the LNB's regular season shifted from a 16-team tournament divided in two conferences in 2013-14 to a single-conference double round-robin touring system from the 2017-2018 season onwards, as described in Durán et al. [2019]. In this paper, we build upon the experience by Durán et al. [2019] and investigate the impact of considering an alternative league design, with a time-constrained structure and a different objective, using real data from six LNB seasons.

1.1 Literature review

The literature tackling sports scheduling is extensive. Early approaches date from the late 1970s with applications across different sports Cain and William [1977], Bean and Birge [1980], Armstrong and Willis [1993], Nemhauser and Trick [1998], Della Croce et al. [1999], together with some general purpose framework to help in the construction process of the schedule as proposed in Ferland and Fleurent [1991]. Kendall et al. [2010a] provide a complete survey on scheduling problems in sports, updated until 2010. Thus, we restrict our review to the articles relevant to our research, complement their review by including new papers with results published afterwards and refer the reader to Kendall et al. [2010a] for further details.

In terms of methodology, sport scheduling problems are strongly connected with graph theory, in particular with edge coloring problems (see, e.g. Januario et al. [2016]). A well known property for Round Robin Tournaments (RRT) is established in De Werra [1980], stating that the number of breaks should be at least $n - 2$. Integer Linear Programming (ILP) models for time-constrained RRTs are explored in Briskorn and Drexl [2009a]. In a follow up paper, Briskorn and Drexl [2009b] consider a setup where individual matches have a given cost that depends on the round to be scheduled and develop a Branch and Price (BP) algorithm to generate minimum cost RRTs with a minimum number of breaks.

Schedules are usually evaluated according to different qualitative criteria. Goossens et al. [2020] provide an updated overview regarding fairness in sports timetabling. One of the classical criterion is the minimization and distribution of the number of breaks among teams, although other criteria have been considered recently. Theoretical properties of schedules regarding the carry-over effect are studied in Anderson [1999] and Lambrechts et al. [2018]. Kidd [2010] develops a tabu search heuristic to minimize the carry-over effects. The strength of groups is studied in Briskorn [2009] and Briskorn and Knust [2010]. Rest times represent another critical factor affecting both the teams and the players, and different aspects have been addressed in Suksompong [2016], Atan and Çavdaroğlu [2018] and Çavdaroğlu and Atan [2020].

Another stream of research is motivated by the seminal work by Easton et al. [2001] introducing the Traveling Tournament Problem (TTP), where the teams are allowed to perform tours and the objective is to minimize the total distance traveled. Clearly, the TTP becomes specially relevant when designing schedules for sport leagues with teams distributed in large regions. From a computational standpoint, the TTP appears as an extremely difficult problem, where even small instances are difficult to be solved to optimality. The literature has been constantly increasing since the introduction of the TTP, considering both methodology and real-world applications. An updated review of some of these papers can be found in Van Bulck et al. [2020]. Recently, Siemann and Walter [2020] present a polyhedral study for the Unconstrained TTP.

In line with this, Wright [2006] propose a model for the New Zealand Basketball league whose objective function considers several aspects: consecutive home/away matches, stadium availability, TV networks requests, distance traveled and unevenness of schedule. Kendall [2008] carries out an exercise to schedule games in the English Premier League for the period between Christmas and New Year proposing an algorithm based on depth first search and local search procedures. Additionally, Goossens and Spieksma [2009] provide the details regarding the construction of the Belgian Football League schedule using a decomposition approach that improved the overall quality.

When restricted to Latin America, there are several success cases of advance optimization techniques effectively applied to scheduling in different sports. Noronha et al. [2006] and Durán et al. [2007] develop a Branch and Cut (BC) algorithm to design a highly constrained compact schedule for the Chilean Soccer League trying to maximize the number the number of pre-defined interesting matches assigned to a particular set of rounds. Bonomo et al. [2012] introduced a variation of the TTP using couples (i.e., pairing teams) instead of teams for the Argentinean Volleyball League, that is tackled with ILP models. The use of couples reduces the size of the instance to half the teams and rounds compared to a team-based schedule, fostering scalability. Moreover, if couples are constructed with pairs of teams that are close to each other, this would result in a model that produces a good fixture in terms of total distance travelled. In a different context, Durán et al. [2017] explore the impact of scheduling the CONMEBOL qualifying tournament for the FIFA World Cup, which consists of a double RRT where matches are played in nine pairs of matches over a span of more than two years. The paper explores different tournament formats to eliminate the so-called double-round breaks, and propose a specific tournament to be implemented in the 2018 qualifiers.

Argentina's National Basketball League (LNB) represents another success case, as it has undergone a sequence of major transformations since 2014. Briefly, the LNB's season moved from a 16 teams tournament divided in two conferences, playing first a regional and then a national phase in 2013-14, to a touring system in 2014-15. The number of teams has been increased to 18 and 20 teams in seasons 2014-15 and 2015-16, respectively. Due to the large number of games, starting in 2017-18 the season is a single-conference double round-robin system, where an auxiliary tournament is held before the season to compensate for the reduction in the number of games. The process and the current tournament format for the LNB is described by Durán et al. [2019]. The current tournament resembles the NBA, implementing a variation of the TTP aiming to minimize the travel distance while taking as input a list of *preferred* and *desirable* tours provided by each team. The problem is tackled via ILP models and the authors report a reduction on the total traveled distance. Overall, interesting new methodological contributions are proposed to deal with context-specific constraints and objectives. We refer the reader to Durán [2021] for a complete and updated survey.

Finally, the literature evaluating the impact of different league formats is rather scarce. Goossens et al. [2012] evaluate the course of different league formats for the Belgian Soccer League using simulation and historical data. Pawlowski and Nalbantis [2015] conduct an empirical study with real data to study the impact of the tournament format in terms of the champion uncertainty and attendance level for leagues in Austria and Switzerland, while Butler et al. [2021] does a similar exercise analyzing the League of Ireland Premier Division for two different tournament formats. Csató [2020] also uses simulation to evaluate different tournament designs for the World Men Handball Championship regarding the seeding process and according to different evaluation metrics.

1.2 Contributions

We build upon the work by Durán et al. [2019] and consider the LNB as a case study. Methodologically, we contribute by comparing a different tournament structure from a business oriented perspective, revisiting some models from solid literature on the topic and proposing new ideas and formulations. Our approach restores a couple-based system with a time-constrained schedule that increases the share of games played during the weekends and includes more games among teams that are closed to each other. One of our objectives is to explicitly incorporate the interest of the games as a key schedule design element. Thus, we propose a metric to measure the interest of a game based on information of the teams, used as an input by different ILP models to construct the schedule. We develop a new framework that integrates the touring scheme into the time constrained schedule in a more controlled fashion by solving a sequence of ILPs.

Another important contribution of our paper is the experimental setup. Benchmarking is not an easy task, specially when trying to provide accurate business insights. Using real data form six LNB's seasons, we conduct extensive computational experiments and show that several of our approaches also reduce the overall distance traveled. We investigate further business aspects in addition to the distance traveled, collect relevant information from public sources and provide strong evidence that under moderate assumptions regarding stadium attendance our model translates into higher expected profits when compared to the LNB. The new framework obtains the best performance, exploiting the benefits of the tours to reduce the distance traveled while increasing the attendance level. From a managerial standpoint, our work suggests that focusing only on the distance minimization can overlook other relevant business aspects of the leagues.

The rest of the paper unfolds as follows. Section 2 provides a motivation for our work including a summary on the recent history of the LNB, focused on the schedule construction, as well as an overview of the landscape of the schedules of other basketball leagues around the world. Section 3 describes the main components for our proposed league structure, including a detailed comparison with the current format and presents a new metric to measure the importance of a given game. Four different mathematical models are presented in Section 4, including a new approach that integrates some of the ideas proposed by Durán et al. [2019] into more classical approaches in literature. Section 5 provides the detailed results obtained by the different approaches for six LNB seasons. Finally, Section 6 concludes and discusses future research lines.

2 Motivation and preliminary analysis

2.1 Brief history of the LNB schedule

The LNB was officially launched in 1982, becoming a milestone for the Argentinean Basketball community. Regarding the sport itself, the LNB represented the first step in the professional career of many internationally renowned basketball players, having its peak with the well known *Golden Generation* that won the Olympics in 2004. Nowadays, the LNB is going through a process of growth and modernization. Specific actions to improve the infrastructure, enhance the team jerseys with better designs, and provide support to deploy a better marketing strategy and a more aggressive campaign on social networks are being implemented.

Aligned with this modernization efforts, the scheduling methodology of the LNB has had major changes since the 2014-15 season. Prior to this tournament, the schedule was defined manually, with games being held only on Fridays and Sundays (a Friday and Sunday made up a *weekend*). Teams were also divided into two conferences (North and South) and paired into couples. These couples traveled together throughout the schedule of the regular season (i.e. on a weekend, one couple visited another). The 16 teams played a double round-robin *regional* stage against teams of the same conference, and then a double round-robin against all the other teams which we name the *national* stage. After this, the champion was decided in a classical playoff setup built upon the standings of the regular season.

Motivated by the territorial extension of Argentina and the fact that teams belonging to the LNB span across the entire country, the LNB adopted a tour-based model resembling the NBA schedule as described in Durán et al. [2019]. In this setup, games can be held in any day of the week, which allows the inclusion of tours, aiming to reduce logistics' costs by allowing a team to play several consecutive away games against nearby rivals, reducing the distance traveled. Tours are not extensively explored and, instead, used as a consensus tool to reduce inquiries on the final schedule. Teams are requested to provide for the optimization a set of both preferred as well as less desirable tours, from which essentially the schedule for each team is constructed. The current format represents the conclusion of a sequence of transformations over the last 10 years, as depicted in Table 1. Note that for the 2017-2018 season on-wards there is a reduction in the number of games played in the regular season.

Season	Teams	Organization	Tours	Games	Matches per rival (same conf. | diff. conf.)
2012-13	16	Couples	No	Weekends	4 | 2
2013-14	16	Couples	No	Weekends	4 | 2
2014-15	18	Teams	Yes	All days	4 | 2
2015-16	20	Teams	Yes	All days	4 | 2
2016-17	20	Teams	Yes	All days	4 | 2
2017-18	20	Teams	Yes	All days	2 | 2
2018-19	20	Teams	Yes	All days	2 | 2

Table 1: LNB structure over the years

2.2 Basketball leagues around the world

From a business perspective, perhaps one of the key differences between the NBA and the LNB lies in the overall league characteristics. Regarding the teams, while in the NBA they are international brands, in the LNB they are mostly civil associations with a great social impact in the local community, with only a few exceptions having national and regional exposure. Another difference is the underlying league structure. Although basketball gathers a large community of fans and practitioners, in Argentina most of the media and the attention is devoted to soccer. Indeed, during the last years there have been some conflicts and disruptions with respect to broadcasting contracts of the LNB. Further examples are related to attendance records, as the LNB does not keep a centralized record of attendance to the stadiums, leaving this task to the teams. The detail and maturity of the available information varies significantly, in some cases with no records at all. Overall, these observations may justify some of the concerns related to the attendance level and the viability for some of the institutions to afford the more sophisticated schedules mentioned before.

To complement this analysis, we further investigate some of the strongest leagues outside of the United States in terms of the percentage of games played during *weekends* (i.e., Friday, Saturday or Sunday) in the 2018-19 season. Table 2 summarizes this information. Note that with the exception of China, all leagues play more than half of the games on weekends. When restricting to European leagues, with the exception of France, this number increases to nearly 80%. In the case of the LNB, this number is slightly above 45%.

Country	League	% of matches on weekends
Australia	NBL	52.5
China	CBA	30.8
France	LNB Pro A	54.6
Greece	HEBA A1	79.0
Italy	Lega Basket Serie A	86.8
Spain	Liga ACB	87.1
Argentina	**LNB**	**45.2**

Table 2: Percentage of games played on Friday, Saturday or Sunday in the 2018-19 season for different basketball leagues. Source: basketball-reference.com

3 Proposed tournament structure

3.1 Description

Based on the previous analysis, our proposal consists in a 2-stage tournament organized as follows: (i) a regional stage where teams of the same conference play a double round-robin schedule; and (ii) a national stage where, depending on the season, all teams play either a single or a double round-robin schedule. This adjustment is done to maintain the total number of matches the same between the implemented schedule and our approach. The seasons prior to 2017-18 are the ones considering a double-round robin for the national stage. We re-introduce the couples system and generate a more regular schedule, restricting matches to take place only on specific rounds, assumed to be known in advance, such as weekends. Additionally, standings and the classification to playoffs could be organized by conference, or a unique standing could be also generated by resorting to more sophisticated indicators, but this aspect is out of the scope from our study. Overall, the general structure resembles the one that existed prior to the 2014-15 season, specially for the regular season.

As regards the travel costs, if games are only held on weekends, it is reasonable to assume that a setting like the TTP may not suitable as the total distance traveled is fixed under the assumption that teams return home between consecutive weekends. For instance, if a game is held on a Sunday and the next one is held on a Friday, teams may return to their home in-between. In the current tour system described by Durán et al. [2019], the traveled distance is not explicitly minimized by the model and is rather implicitly encoded in the tours provided by the teams. Our approach also aims to control the traveled distance in two ways. First, in the context of the current touring system, a couple-based system introduces tours of exactly two matches by design. Secondly, as couples are composed by nearby teams, when a couple visits another one in a particular weekend, the distance traveled between matches should be close to the one that should be produced by a potential tour in the TTP model.[1] In this fashion, couples do not only help in reducing the computational effort and scale to larger instance, but also impact on the total distance traveled. Moreover, the tournament design schedules more games between teams that are closer, i.e. belong to the same conference. This is aligned also with the NBA schedule, where a team plays a higher number of games against teams form the same division, followed by games against teams from the same conference and, finally, against other teams.

Adopting a couple system is of course is not negligible for the schedule. One observation is the impact on the carry-over effect, which measures the number of times a two teams play consecutive games against the same rival. We expect this metric to increase for our tournament proposal. However, as reported by Goossens and Spieksma [2012] for the Belgium Soccer League, the influence in terms of fairness and the impact on the results could be moderate. Another business concern could be a substitution effect (see, e.g. Wallrafen et al. [2022]) in the attendance to the stadiums by scheduling the games on weekends. A precise quantification of this effect may difficult to estimate, since the LNB does not keep records of attendance to

[1]For the sake of consistency, we apply the same methodology for all seasons from 2012-13 to 2018-19, except for season 2014-15 where the number of resulting couples is odd.

the stadiums for all teams. More intuitively, for the context of Argentina this effect, if present, would be caused mostly by soccer. Nowadays, the current national professional soccer league also schedules games within weekdays. Together with international competitions, arguably this effect would be at some extent present in the current format as well. In addition, many of the LNB teams do not correspond to recognized football teams playing in the highest divisions. Overall, although it is indeed one of our motivations and we use it in the experiments, the framework is general enough and does not assume explicitly that games are held on weekends.

Connected to this aspect, however, it is well known that games within a tournament have the different importance. Derby matches against teams from the same region or games among top-tier teams usually represent key events within a tournament, becoming also relevant from a managerial standpoint. Thus, we propose a general framework to explicitly manage the distribution of the interesting games throughout the schedule via ILP models, with different constraints and objectives.

3.2 Notation and problem definition

We first introduce some basic definitions used throughout the paper. Let $T = \{1, \ldots, 2n\}$ bet the set of teams, and $P = \{1, 2, ..., n\}$ the set of couples defined for the tournament. To reflect the separation into conferences, we consider the partition $P = C_N \cup C_S$, where C_S and C_N denote the couples in the southern and northern conferences, respectively. For the ease of exposition, we assume n to be even as well, although this is not always the for the LNB and models should be slightly adjusted. To model the tournament, let $WE = \{0, 1, \ldots, m, m+1\}$ be the set of time-slots, also referred as rounds (i.e., weekends), where the games take place, where 0 and $m+1$ are two artificial slots indicating the start and the end of the tournament.

For a double round-robin tournament, we simply set $m = 2n$ since two games are considered for every time-slot, with the only exception for the weekends assigned for the intra-couple matches. We further define $F = \{1, 2, ..., m\}$ as the subset of time-slots dedicated to the tournament, and let $F = F_1 \cup F_2$, with $F_1 = \{1, \ldots, r\}$ and $F_2 = \{r+1, \ldots, m\}$ indicating the two rounds of the tournament. For simplicity, intra-couple matches dates are assumed to be fixed and scheduled in time-slots $I = \{1, r+1\}$, i.e. at the beginning of each round, and the set of weekends with inter-couple matches, that is, $E = F/I$. In case n is odd, $I = \emptyset$ and the intra-couples games are not grouped and left as a decision.

All our experiments consider a couple-based system in order to scale to real-world instances. To simplify the notation, we present all models with the necessary adaptations to a couple format, although the models and ideas proposed can be implemented in team-based schedules with minimum adjustments.

3.3 Measuring the level of interest of a game

The relevance of a given game and, more generally, its importance with respect to other matches in the schedule depends on several factors, sometimes difficult to quantify precisely. In this section, we define a metric that incorporates two key characteristics associated with the teams involved in a given match, that can be used as an input to construct the schedule via ILP methods, as described later in Section 4.

Let $\rho_{ij} \in \{0, 1\}$ be a constant taking value 1 if teams i and j are considered *rivals*, and 0 otherwise. In addition, assume available as input a *ranking* $\nu \in \mathbb{N}^{|T|}$, providing an ordering for the teams. We define the *level of interest* for a game played by teams $i, j \in T$, denoted by ψ_{ij}, as

$$\psi_{ij} = \frac{1 + \rho_{ij}}{1 + |\nu_i - \nu_j|}. \tag{1}$$

The rationale for this metric is as follows. First, if the two teams are rivals the interest of the game increases. These rivalries may represent a derby, i.e. teams belonging to the same city or region, or sometimes simply by a common history between the teams. Note that a team may have more than one rival. Secondly, the interest of a game is positively influenced by the closeness of the teams in ranking ν. A first argument would be that teams with a similar ranking have a similar strength, and thus the game between the teams could be close when reaching the *clutch*. We also assume ν represents a good estimation of the final position of the teams in the tournament. Clearly, the games between teams having the highest ranks are interesting as they will possibly influence their position in the playoffs. On the other hand, games between teams with the lowest ranks usually define who is relegated to the second division. Finally, teams with mid-rankings usually struggle to get the last places into international competitions or the tournament playoffs. For simplicity, we consider the final standings of the previous season as a proxy for ν, but these values may be obtained by a different methods such as forecasts, estimations or simply the (subjective) perspective of an expert.

In order to incorporate this metric in our model, we extend the definition to couples. Let $\psi_{AB}^{\text{couple}}$ be the level of interest when couple $A = (i, j)$ plays against couple $B = (k, l)$, involving teams $i, j, k, l \in T$, which is simply aggregating the interest of the four games, i.e.

$$\psi_{AB}^{\text{couple}} = \psi_{ik} + \psi_{il} + \psi_{jk} + \psi_{jl}. \tag{2}$$

When needed, we extend this idea for an intra-couple match by defining $\psi_{AA}^{\text{couple}} = 4 \times \psi_{ij}$, for $A = (i, j)$. This is to avoid defining the intra-couple weekend as the less interesting weekend, simply because it has a lower number of matches. In addition, this also avoids trivial solutions.

3.4 Evaluation metrics

In order to get a general understanding and to provide meaningful managerial insights, we evaluate the different schedules across multiple dimensions that are present in sports scheduling literature. Given a schedule, we consider the following metrics:

- Distance (dist): computed as the sum of the total kilometres travelled by the teams throughout the tournament. Reductions in this metric is considered as one of the success indicators for the generated schedule in Durán et al. [2019].
- Breaks (br): a break is counted when a team plays two consecutive home or two consecutive away games. Given a schedule, this value represents the total number of breaks over all teams.
- Carry-Over coefficient (co-c): team i gives a carry-over effect to team j if a team k plays consecutively against i and j (see e.g. Kendall et al. [2010b]). Considering a matrix Λ_{ij}, whose items λ_{ij} count the number of carry-over effects given by teams, we define a carry-over coefficient matrix defined by co-c $= \sum_{i \in T} \sum_{j \in T} \lambda_{ij}^2$.

We emphasize that, although we construct the schedule using the couples system, these metrics are computed at a team-level.

4 Mathematical models

Within each phase (regional or national), we generate the schedule formulating an ILP model for both stages of the double RRT simultaneously. Note that for the regional stage, the optimization problem can be decomposed into two independent problems, one per conference. Thus, let $C = C_N, C_S$ or P be a generic conference depending on the stage and setup of the tournament.

4.1 Proposed formulation

Let c_{ijt} denote the interest when couple $i \in C$ faces couple $j \in C$ in time-slot t. Let further $\hat{E} \subseteq E \times E \times E$ be the set of triplets of three consecutive increasing time-slots in E, which is used to limit the number of home and away games. We define binary variables x_{ijt} take value 1 if couple $i \in C$ plays at home against couple $j \in C$ at time-slot $t \in WE$. We present next the model adjusted for the regional stage (where the teams face each other twice). Recall that the LNB's tournament format changed during the period considered, and thus the overall number matchups between teams depends on the season. Due to space limitations we omit the details, although the modifications are rather simple to incorporate.

$$\max \sum_{i\in C}\sum_{j\in C}\sum_{t\in F} c_{ijt}x_{ijt} \tag{3}$$

$$\text{s.t. } x_{iit} = 1 \qquad \forall i \in C, \forall t \in I \tag{4}$$

$$x_{iit} = 1 \qquad \forall i \in C, t = 0, m+1 \tag{5}$$

$$\sum_{j\in C} x_{ijt} + \sum_{j\in C} x_{jit} = 1 \qquad \forall i \in C, \forall t \in WE \tag{6}$$

$$\sum_{j\in C} x_{ijt} + \sum_{j\in C} x_{ijt_1} + \sum_{j\in C} x_{ijt_2} \le 2 \qquad \forall i \in C, \forall (t,t_1,t_2) \in \hat{E} \tag{7}$$

$$\sum_{j\in C} x_{jit} + \sum_{j\in C} x_{jit_1} + \sum_{j\in C} x_{jit_2} \le 2 \qquad \forall i \in C, \forall (t,t_1,t_2) \in \hat{E} \tag{8}$$

$$\sum_{t\in F_1} x_{ijt} + \sum_{t\in F_1} x_{jit} = 1 \qquad \forall i,j \in C, i \neq j \tag{9}$$

$$\sum_{t\in F} x_{ijt} + \sum_{t\in F} x_{jit} = 2 \qquad \forall i,j \in C, i \neq j \tag{10}$$

$$\sum_{t\in WE} x_{ijt} = 1 \qquad \forall i,j \in C, i \neq j \tag{11}$$

$$x_{ijt} \in \{0,1\} \qquad i,j \in C, t \in WE \tag{12}$$

The objective function (3) maximizes the aggregated interest, assigning more weight to games scheduled closer to the end of the season. Constraints (4) fix intra-couple matches, while constraints (5) make teams to be home both at the beginning and the end of the tournament. Constraints (6) limit couples to have one assignment per weekend. Constraints (7) and (8) restrict the number of consecutive weekends playing at home or away matches to two for each team, respectively. These constraints are based on the ones proposed by Bonomo et al. [2012] for the National Volleyball League in Argentina. Note that they impose shared conditions between the two rounds. Moreover, equations (9) force teams play once against each other in the first round, while equations (10) make teams play twice against each other in the entire tournament. Constraints (11) force the home condition of a particular match is seen only once. Finally, (12) define the domain of the variables.

This formulation resembles the one proposed by Briskorn and Drexl [2009b]. While Briskorn and Drexl [2009b] force the schedule to have the minimum number of breaks (i.e. $|C|-2$ per round), we tackle this via constraints (7) and (8). Also, this model generates a couple-level schedule, which can be easily translated into a team-level schedule. Finally, observe that the objective function considers generic weights c_{ijk}. For experimentation purposes, we consider a customization that maximizes the interest of the games at the end of each stage. Based on our definition of interest from Section 3.3, we set $c_{ijt} = t \times \psi_{ij}^{\text{couple}}$ for $i, j \in C$. We note, however, that the approach is general enough to consider other tailored definitions.

4.2 Briskorn and Drexl

For the sake of completeness, in this section we present the compact ILP model described in Briskorn and Drexl [2009b], adapted to a double RRT and with some customization for our setup. Define binary variables br_{it} to take value 1 if and only if couple $i \in C$ has a break in round $t \in F$. The ILP model reads

$$\max \sum_{i\in C}\sum_{j\in C}\sum_{t\in F} c_{ijt}x_{ijt} \tag{13}$$

$$
\begin{aligned}
\text{s.t. } & (4) - (6), (9) - (11) \\
& \sum_{j \in C, j \neq i} (x_{ijt-1} + x_{ijt}) - br_{it} \leq 1 && i \in C, t \in F, t \geq 2 && (14) \\
& \sum_{j \in C, j \neq i} (x_{jit-1} + x_{jit}) - br_{it} \leq 1 && i \in C, t \in F, t \geq 2 && (15) \\
& \sum_{i \in C} \sum_{t \in F_1, t \geq 2} br_{it} \leq |C| - 2 && && (16) \\
& \sum_{i \in C} \sum_{t \in F_2, t \geq r+2} br_{it} \leq |C| - 2 && && (17) \\
& x_{ijt}, br_{it} \in \{0, 1\} && i, j \in C, t \in F && (18)
\end{aligned}
$$

The objective function (13) is the same as in the previous case, as well as with some of the constraints handling the interactions between the two rounds. Constraints (14) and (15) are new and essentially activate the corresponding variable br_{it} whenever a break occurs in the schedule. Constraints (16) and (17) force the total number of breaks in each stage of the tournament to be less than or equal than the minimum. Finally, constraints (18) define the domain of the variables.

4.3 Distributed interest

We further consider an extension of the model proposed in Section 4.1 following a different objective, aiming to generate schedule where the interest of the games in each round is homogeneously distributed throughout the schedule. For this purpose, we modify the objective function to maximize the minimum interest of any given round. Let Z be a continuous variable indicating the minimum aggregated interest in any of the rounds in F. The resulting ILP model is the following

$$
\begin{aligned}
& \max Z && && (19) \\
& \text{s.t. } (4) - (12) \\
& \quad \sum_{i \in C} \sum_{j \in C} c_{ijt} x_{ijt} \geq Z && t \in F && (20)
\end{aligned}
$$

Based on our definition of interest, in this case we set $c_{ijt} = \psi_{ij}^{\text{couple}}$ in order to obtain the corresponding aggregated interest of round $t \in F$.

4.4 Integrating tours

Inspired by the TTP, Durán et al. [2019] transformed the LNB fixture by shifting to a tour-based schedule. Among others, one of the drivers for adopting this new format is to reduce the travel costs by allowing the teams to play several consecutive away games against nearby opponents, and therefore reducing the total distance travelled. In this section, we devise an approach incorporates tours to the classical time-constrained schedule to further reduce the distance travelled by the teams. Again, we present these ideas for couples.

Our proposed method is as follows. The construction of the schedule is divided into two consecutive stages. The first stage involves the design of the tours for each couple, that take place at specific rounds and have a predefined length. We refer to these rounds as *tour windows*. The number of tour windows and their location within the schedule is assumed to be fixed and known in advance, as an input. The tours for each couple are obtained by means of a tailored ILP model as part of a complete schedule for the rounds comprised by the tour windows. Note that the output of the first stage represents a partial schedule. Then, the second stage involves the computation of the schedule for the remaining rounds to obtain a complete fixture, satisfying all the constraints, while maintaining the schedule for the tour windows unchanged. We note that Kendall [2008] suggests a similar idea to schedule football matches on holiday periods.

Let K be the predefined number of *tour windows* to be scheduled within the season, each of them of $\hat{m}$ of consecutive rounds. For $l = 1, \ldots, K$, let $W_l^{\text{tour}} = \{t_l, t_l + 1, \ldots, t_l + \hat{m} - 1\}$ denote the set of consecutive rounds for the tour window l, and $\underline{t}_l = t_l - 1$ and $\bar{t}_l = t_l + \hat{m}$ denote two (artificial) rounds indicating the origin and end of tours in round l, respectively. We assume the tour windows to be non overlapping, i.e. $W_l^{\text{tour}} \cap W_k^{\text{tour}} = \emptyset$ for $l \neq k$, and define $W^{\text{tour}} = W_1^{\text{tour}} \cup \cdots \cup W_K^{\text{tour}}$ as the set time-slots dedicated to tours.

Similarly to the TTP, let d_{ij} denote the distance between teams $i, j \in T$ and $d_{ijk} = d_{jk}$ the distance traveled by team i when traveling from j to k, $i, j, k \in T$. We further extend this definition to couples as follows. Given couples $A = (i_1, i_2), B = (j_1, j_2), C = (k_1, k_2) \in P$, let $\bar{d}_{ABC}$ be the total distance traveled when couple A visits couple C immediately after playing at B. At a couple level, if $A = B = C$, then $\bar{d}_{ABC} = 0$ as this is representing back-to-back games between the teams i_1 and i_2. Otherwise, $\bar{d}_{ABC} = d_{j_2 k_1} + d_{j_1 k_2} + 2 \times d_{k_1 k_2}$. Let y_{ijkt} take value 1 if couple i travels from j to k after time-slot t, and 0 otherwise. Recall that variables x_{ijt} take value 1 if couple i plays at home against couple j in time-slot t. The mathematical model for the first stage defining the tours is the following:

$$\min \sum_{i \in P} \sum_{j \in P} \sum_{k \in P} \sum_{t \in W^{\text{tour}}} \bar{d}_{ijkt}\, y_{ijkt} \tag{21}$$

$$\text{s.t.} \sum_{j \in P} x_{ijt} + \sum_{j \in P} x_{jit} = 1 \qquad i \in P, t \in W^{\text{tour}} \tag{22}$$

$$\sum_{t \in W^{\text{tour}}} x_{ijt} \leq 1 \qquad i, j \in P, i \neq j \tag{23}$$

$$x_{ii\underline{t}_l} = x_{ii\bar{t}_l} = 1 \qquad i \in P, l = 1, \ldots, K \tag{24}$$

$$x_{jit} + x_{kit+1} - y_{ijkt} \leq 1 \qquad i, j, k \in P, t \in W^{\text{tour}} \tag{25}$$

$$x_{jit} + x_{ikt+1} - y_{ijit} \leq 1 \qquad i, j, k \in P, t \in W^{\text{tour}} \tag{26}$$

$$x_{ijt} + x_{kit+1} - y_{iikt} \leq 1 \qquad i, j, k \in P, t \in W^{\text{tour}} \tag{27}$$

$$x_{ijt} + x_{ikt+1} - y_{iiit} \leq 1 \qquad i, j, k \in P, t \in W^{\text{tour}} \tag{28}$$

$$x_{ijt}, y_{ijkt} \in \{0, 1\} \qquad i, j, k \in P, t \in W^{\text{tour}} \tag{29}$$

The objective function (21) minimizes the total distance traveled by the couples. Constraints (22) impose that each couple has exactly one match per time slot. Constraints (23) impose that each couple may host another at most once considering all tour windows in order to establish some fairness regarding the tours. Constraints (24) state that, before and after each tour, couples are assumed to be at home. This is used as an upper bound for the total distance traveled due to the tours as the teams may eventually travel directly to the first game from a different location. Constraints (25) - (28) link x_{ijt} and y_{ijkt} variables and constraints (29) restrict the variables to be binary. We note that variables y_{ijkt} are slightly different compared to the classical TTP models that discard the index regarding the round (see, e.g. Siemann and Walter [2020]). We present the model in this more general fashion to enable some trips to occur more than once within the schedule; otherwise, the total distance may be miscalculated.

Some customization is required for particular cases depending on the tournament design and the characteristics of the instance. If the distance matrix is symmetric and no additional constraints are present related to games scheduled in different tour windows, the problem can be separated into K smaller problems, one per tour-window. In addition, if tours span over more than two consecutive rounds, constraints (7) and (8) must be also included to enforce that the maximum number of consecutive home or away rounds scheduled for any team is at most two.

Further adaptations are required depending on the value of n. Recall that if n is odd exactly one intra-couple match takes place is planned in order to guarantee that the schedule is compact. This can be modelled by incorporating the following constraints

$$\sum_{i \in P} x_{iit} = 1 \qquad t \in W_l^{\text{tour}}, l = 1, \ldots, K \tag{30}$$

which, combined with constraints (22) and (23) for $j = i$ force the schedule to consider exactly one intra-couple match per round. On the contrary, if n is even, all intra-couple matches are scheduled together in a given round. This should be explicitly considered to prevent the model assigning intra-couple matches and, therefore, reducing the distance travelled. Constraints (30) impose that no intra-couple games must be scheduled within a tour window.

$$x_{iit} = 0 \qquad i \in P, t \in W_l^{\text{tour}}, l = 1, \ldots, K \tag{31}$$

Extending the (partial) schedule obtained through the model (21) - (29) by completing the remaining time-slots using the formulations presented in Section 4 may not be always feasible, as some key constraints could be violated when incorporating tour windows. Example 1 illustrates this situation.

Example 1. *Consider an example with four couples, A, B, C and D. Assume a single RRT, where where a tour-windows is set for rounds 2 and 3. Table 3 shows a feasible design of tours for rounds 2 and 3, where essentially teams B and D play both rounds away while A and C play at home. By design, intra-couple matches are played in round 1. Observe that it is not possible to schedule round 4 without violating constraints (7) or (8). Couple B must play against D, violating constraints (7). Similarly, the match between A and C would violate constraints (8).*

Round / Team	A	B	C	D
2	B	@A	D	@C
3	D	@C	B	@A

Table 3: Feasible design tours in the running example.

This aspect is not present in other approaches from similar contexts. Note that Kendall [2008] does not explicitly consider other operational constraints regarding the overall fixture when fixing the holiday matches. Furthermore, the fixture designed by Durán et al. [2017] for the FIFA World Cup qualifiers is comparable to define only the tour windows, eventually with different objectives and constraints, but without a more general schedule where the solution must be inserted and further feasibility constraints need to be satisfied.

One alternative to avoid this type infeasibilities is to impose a minimum number of teams that must play at home during the tour window, enforcing some variability to the feasible home-away patterns. For simplicity, consider tour windows with two rounds (i.e., tours with at most four games in the couple system). Let δ_l denote a minimum number of couples that must play at home at least once during tour window l, $l = 1, \ldots, K$, to be determined experimentally. Define binary variables z_{it} to take value one if couple $i \in P$ plays at home in round $t \in W^{\text{tour}}$. Additionally, let binary variables w_{il} indicate whether couple $i \in P$ played at least one game at home during tour window $1 \le l \le K$, and zero otherwise. We extend formulation (21) - (29) as follows:

$$z_{it} = \sum_{j \in P} x_{ijt} \qquad i \in P, t \in W^{\text{tour}} \tag{32}$$

$$w_{il} \ge z_{it} \qquad i \in P, 1 \le l \le K, t \in W_l^{\text{tour}} \tag{33}$$

$$w_{il} \le \sum_{t \in W_l^{\text{tour}}} z_{it} \qquad i \in P, 1 \le l \le K \tag{34}$$

$$\sum_{i \in P} w_{il} \ge \delta_l \qquad 1 \le l \le K \tag{35}$$

$$z_{it}, w_{il} \in \{0, 1\} \qquad i \in P, t \in W^{\text{tour}}, 1 \le l \le K \tag{36}$$

Constraints (32) define variables z_{it} in terms of variables x_{ijt}. Constraints (33) activate variables w_{il} when i plays at least one home game during tour window l, while (34) set variables w_{il} to zero if no home games are played by team i in tour window l. These two sets of constraints model correctly the value of variables w_{il}, which are necessary in constraints (35) to impose the minimum number of couples with home games in each tour window. Finally, constraints (36) define the variables to be binary.

Recall the situation described in Example 1, where the partial schedule obtained cannot be extended to a feasible, complete schedule. By setting $\delta = 3$ for the tour window, the schedule can be extended with an additional round while still deciding the best tour to implement, if any. For larger instances, finding a value for $n/2 \leq \delta_l \leq n$ with a tradeoff between feasibility and optimality represents a key input for the approach. Finally, note that for instances having $\hat{m} > 2$ these constraints need to be replicated only at the rounds at the endpoints of each tour window, to guarantee the overall feasibility with the complete schedule.

4.5 Incorporating teams' preferred road trips

One of the innovative elements introduced by Durán et al. [2019] is the ability for the teams to provide the LNB organization with a list of *preferred trips* to be considered for their schedule. In this fashion, the schedule partially exploits the benefits of tours to reduce the distance while incorporating specific qualitative preferences from the teams. Additionally, to foster feasibility this set is augmented by a set of *reasonable trips* suggested by the league's organization. The length of these trips ranges from 1 to 4 consecutive games, and the objective is to maximize the number of games scheduled in the set of preferred trips.

In this section, we discuss some modelling alternatives to incorporate this aspect to our approach. We remark, however, that this discussion is kept at a conceptual level for two different reasons. First, as one may expect given the intrinsic characteristics of the problem, the detailed information about the trips suggested by each team is not public, possibly due to both non-disclosure agreements of the authors but also due to competitive reasons. Second, as the trips are provided individually by each team, translating this idea to a couple system seems non-trivial and may require some consensus, at least, from the teams. Some straightforward alternatives could be to jointly provide the set of preferred trips, or to consider as reasonable trips the union of the set of preferred trips for each team in the couple, among others. Then, these developments are not implemented and we do not conduct experiments incorporating preferred trips. However, since our model can be adapted to a team setup, we provide some initial theoretical results that may foster future approaches to investigate these ideas. Then, the constraints and formulas are developed referring to teams (T) instead of couples (P).

In terms of modelling, a first direct option is to reformulate the model (21) - (29) – adapted to a team setup – by incorporating some of the ideas developed in Durán et al. [2019]. Indeed, the decision variables x_{ijk} lie at the core of both formulations and, therefore, our model can be tailored to consider similar restrictions and objectives by introducing the necessary variables and constraints. This approach, however, does not account explicitly for the impact of the traveled distance incurred by the trips, besides the quality implicitly inherited by the teams' experience. The minimization of the travel distance could be enforced by adjusting the objective function provided therein accordingly.

Another alternative approach to incorporate teams' preferences by still obtaining the minimum distance schedule for the tour windows but restricted to only to those trips considered either preferred of reasonable. Following some of the definitions introduced in Durán et al. [2019], a trip τ for a team $i \in T$ is sequence of length $|\tau|$ teams different than i, representing a series consecutive games played on the road. For a team $i \in T$, let Γ_i denote the set off all possible trips τ (where Durán et al. [2019] consider $1 \leq |\tau| \leq 4$), Δ_i the set of both preferred and reasonable trips for team i and $\bar{\Delta}_i = \Gamma_i \backslash \Delta_i$ its complement. For simplicity, we indicate with τ_k to the k-th team in trip τ, with $1 \leq k \leq |\tau|$.

The key idea is to forbid trips $\tau \in \bar{\Delta}$ to be part of the feasible solutions by incorporating tailored constraints, resembling the well-known *infeasible path elimination constraints* proposed by Ascheuer et al. [2000] for the Asymmetric Traveling Salesman Problem with Time-Windows (ATSPTW). Consider a round $t \in W_l^{\text{tour}}$ for the beginning of trip $\tau \in \bar{\Delta}$ for a team $i \in T$, for some $1 \leq l \leq K$, where $t + |\tau| < \bar{t}_l$. Note that if trip τ begins at round t, then i must play at home on rounds $t-1$ and $t + |\tau|$. Assume first a trip $\tau \in \bar{\Delta}_i$ consisting of only two games, i.e. $\tau = (j, k)$. Then, adding the constraint

$$z_{it-1} + x_{jit} + x_{kit+1} + z_{it+2} \leq 3 \tag{37}$$

prevents the model from assigning trip τ in round t to team i as part of as feasible solution. More generally, the *infeasible trip elimination constraints* (ITEC)

$$z_{it-1} + \sum_{k=1}^{|\tau|} x_{\tau_k it+k-1} + z_{it+|\tau|} \leq |\tau| + 1, \qquad i \in T, t \in W^{\text{tour}}, \tau \in \bar{\Delta}_i, |\tau| > 1 \tag{38}$$

enable to incorporate the preferred trips provided by the teams as part of the fixture. Observe that these constraints consider $|\tau| + 2$ consecutive rounds, including the round preceding and following the trip, respectively, in addition to the games defining the trip itself.

Similarly to the ATSPTW, the ITECs (38) are weak and strengthened versions of these constrains can easily derived. For $i \in T$ and $t \in W^{\text{tour}}$, consider variables v_{it} taking value one if i has scheduled an away game in round t, and zero otherwise. Note that these variables can be retrieved from the model as follows

$$v_{it} = \sum_{j \in T, j \neq i} x_{jit}. \tag{39}$$

Based on these definitions, we present the following family of valid inequalities. Due to space limitations, the proof is omitted as it can be easily obtained by an argument similar to (38) and using equations (39).

Proposition 1. *Let $i \in T$, $t \in W^{tour}$ and an infeasible trip $\tau \in \bar{\Delta}_i$. Then, constraints*

$$z_{it-1} + \sum_{k=1}^{|\tau|} x_{\tau_k it+k-1} + z_{it+|\tau|} \leq \sum_{k=1}^{|\tau|-1} v_{ik} + 2 \tag{40}$$

are valid and dominate the ITEC (38).

Infeasible trips can be modelled in alternative ways using the other variables in the model. We begin by noting that the objective function (21) guarantees the values assigned to variables x_{ijt} and y_{ijkt} are consistent with their definition in any optimal solution of formulation (21) - (29), although some infeasible combinations are considered as feasible solutions. Thus, the model can be strengthened by incorporating explicitly the following constraints

$$y_{ijkt} \leq x_{jit} \qquad i, j, k \in T, i \neq j \neq k, t \in W^{\text{tour}}, \tag{41}$$

$$y_{ijkt} \leq x_{kit+1} \qquad i, j, k \in T, i \neq j \neq k, t \in W^{\text{tour}}. \tag{42}$$

Intuitively, if i is on a trip visiting j and k this can be directly reflected into variables x_{jit} and x_{kit+1}. Trips τ consisting in more than one away game can be forbidding in a similar fashion using the traveling variables y_{ijkt}. For simplicity, consider a trip $\tau = (j, k, l)$ composed of three games. Then, trip τ can be forbidden for team i at round t by adding the following constraint to the model

$$z_{it-1} + y_{ijkt} + y_{iklt+1} + z_{it+2} \leq x_{kit+1} + 2, \tag{43}$$

The following result formalizes this idea for infeasible trips of arbitrary length. Again, due to space limitations, we omit the details of the proof.

Proposition 2. *Let $i \in T$, $t \in W^{tour}$ and an infeasible trip $\tau \in \bar{\Delta}_i$, $|\tau| > 1$. Then, the constraint*

$$z_{it-1} + \sum_{k=1}^{|\tau|-1} y_{i\tau_k \tau_{k+1} t+k-1} + z_{it+|\tau|} \leq \sum_{k=2}^{|\tau|-1} x_{\tau_k it+k-1} + 2, \tag{44}$$

is valid.

Note that the constraints discussed in this section remove *exactly* a given trip $\tau \in \bar{\Delta}$. It is reasonable to assume that depending on the (so far unknown) structure and the underlying properties of Δ_i and, consequently, $\bar{\Delta}_i$ these constraints can be further strengthened and tailored. Moreover, choosing the appropriate modelling decision to incorporate preferred trips would arguably depend on the definition of Δ_i. If $|\Delta_i| \ll |\bar{\Delta}_i|$, then incorporating the ideas proposed in Durán et al. [2019] would probably result in a manageable ILP model. On the contrary, if $|\Delta_i| \gg |\bar{\Delta}_i|$ the formulation would increase significantly, as the number of variables and constraints depend on the number of preferred trips. Then, incorporating the ITEC on demand, similarly to the ATPSTW, could result in a more efficient alternative. Overall, such a decision would require significant developments and an experimental setup that goes beyond the scope of our work.

5 Computational experiments

We evaluate the tournament structure proposed in Section 3 with the different customization provided by the alternative methods to obtain the schedule as described in Section 4 by conducting computational experiments, using real-world data and comparing these schedules with the ones implemented by the LNB by back-testing the seasons. The experiments are executed on an AMD Athlon Silver 3050U CPU @ 2.30GHz with 16 GB of RAM. The models are coded in Python 3.7 using the CPLEX 12.9 API as an ILP solver.

5.1 Experimental setup

The instances are constructed using as input the teams participating in the LNB form the 2012-13 up to the 2018-19 season. For each season, the distance matrix $D = (d_{ij})$ denoting the distance between teams $i, j \in T$ is computed using the Google Distance Matrix API. Moreover, if there are more than 3 days between games, we assume teams return home in between. Couples are constructed using a standard minimum weighted matching algorithm using the distance matrix as input. To make a fair comparison, we construct schedules with exactly the same total number of games as in the implemented fixture as follows:

- seasons 2012-13, 2013-14, 2015-16, 2016-17: four games against teams of the same conference and two against teams of the other conference;

- seasons 2017-18, 2018-19: four games against the team of the same couple, three games against teams of the same conference and one against teams of the other conference. Note that the original season is not divided into conferences. In this case, we heuristically infer the conferences by sorting the couples according to their geographical location, from North to South.

Recall that, for simplicity, season 2014-15 is not considered since each conference has an odd number of teams, and therefore the couple system cannot be directly implemented. With respect to the implemented fixtures, our analysis modifies the number of matches per rival only for seasons 2017-18 and 2018-19. However, in all cases there are more matches against teams that are nearby (i.e. teams belonging to the same conference).

We consider the following variants for the tournament structure proposed in Section 3.1, customized by applying the corresponding method to construct the schedule:

- IntLast: the ILP model proposed in Section 4.1, where the objective maximizes the interest of the games assigned for the last rounds.

- Briskorn: the model proposed in Section 4.2 that generates a schedule with the minimum number of breaks, having the same objective function as IntLast.

- Distr: formulation described in Section 4.3, aiming to generate an evenly distributed schedule in terms of the interest of the games.

- TOUR-k: hybrid approach incorporating k tour windows to INTLAST as described in Section 4.4, where the location of the tour windows varies depending on the case. We consider $k = 1, 2$ and fixed tour windows of four consecutive matches (i.e., length two due to the couple format).

We further denote by LNB-R to the real schedule implemented by the LNB. We acknowledge that our comparison may overlook some relevant aspects, such as inconvenient dates for some specific teams or preferences by the television broadcaster to schedule certain matches on specific dates. As expected, this detailed information is not public due to privacy and disclosure issues. However, the impact of such cases should be moderate. First, we highlight that our model is capable of incorporating these aspects, for instance by preventing some games from happening in a given round by setting the corresponding variables to zero in the model. Second, with the only exceptions of the tour windows in the TOUR-k approach, the specific days for each round could be somehow customized to minimize the impact of these kind of requirements. Finally, we note that Durán et al. [2019] accounts for the television broadcasting constraints in the second stage, when the game days are assigned after selecting the tours. Therefore, comparisons in terms of the distance traveled are not affected by this aspect.

The quality of the different schedules is evaluated according to the metrics introduced in Section 3.4: the total distance traveled (dist), measure in thousands of kilometres; the number of breaks (br); and the carry-over coefficient (co-c). For the experiments, we set a time limit of 12 hours (43200 seconds) or 14Gb of RAM usage for the execution. For the instances 2015-16 and 2016-17 of the DISTR model, we further set an optimality gap threshold value of 5.5%. Finally, for the model that setups the schedule during the tours in the TOUR-k model, we set an optimality gap of 5%.

5.2 Impact of the tournament and schedule design

In Table 4 we first report these metrics for the schedules obtained by the DISTR, INTLAST and BRISKORN variants, together with the results for the LNB-R, for the six LNB seasons considered.

The main message of in Table 4 is that the proposed approaches are able to reduce the total traveled distance in four out of the six analyzed instances, in some cases up to 15%, and that there are no significant difference in this metric among them. The drivers behind these results depend on the season. Recall that for the seasons 2012-13 and 2013-14 the schedule was computed manually, and we are using an ILP-based method. For seasons 2015-16 and 2016-17 we observe an increase in the distance traveled, possibly showing the positive effect of incorporating tours and reducing the number of long travels in LNB-R, avoiding to return home after every weekend. On the contrary, for seasons 2017-18 and 2018-19 our approaches again show a decrease in the total traveled distance. These two seasons act as a proxy on the impact of changing the mix of games for each team in the design of the tournament: while in LNB-R each team plays exactly the same number of games against every other team, in the other variants the teams play more games with rivals of the same conference.

Season	DISTR			INTLAST			BRISKORN			LNB-R		
	dist	br	co-c	dist	br	co-c	dist	br	co-c	dist	br	co-c
2012-13	355.2	448	7768	355.2	440	7896	355.2	416	7832	398.2	411	7402
2013-14	337.6	456	7624	337.6	448	8192	337.6	416	7976	385.8	388	7574
2015-16	489.1	706	16012	489.1	718	16132	-	-	-	432.4	640	6744
2016-17	595.9	714	16548	595.9	696	16028	-	-	-	589.1	637	6742
2017-18	416.2	468	7400	415.2	488	6916	-	-	-	490.2	432	2860
2018-19	386.7	486	7336	384.1	480	7020	-	-	-	446.7	441	3132

Table 4: Schedule comparison in terms of the evaluation metrics for variants without tours, compared to LNB-R.

Besides the traveled distance, some further insights can be derived from the comparison. Regarding the number of breaks, we first note that BRISKORN is only capable to produce solutions within the imposed time limit in two cases, showing that minimizing the number of breaks might be computationally challenging. Note, however, that DISTR and INTLAST only present 5%-7% more breaks for the available cases. When compared with LNB-R, the increment ranges from 5% to 16%, reaching the lowest values for the last two seasons. Finally, as expected, the co-c increases significantly as a consequence of implementing a couple-based format for the tournament.

We next report the results obtained for the TOUR-k variants in Table 5, including also the results for LNB-R to ease the comparison. The key to the table remains the same with respect to the previous case. The number of breaks and the carry-over coefficient are aligned with the previous variants, without significant variations. The main difference is the reduction in the total travel distance as a result of the inclusion of the tours as part of the schedule, both at the regular and the national stage. During these special rounds, the tours allow some of the teams to reduce the distance by not returning home during these weekends and, instead, travel directly to play the next (away) match. For the four seasons already improved without tours the TOUR-k variants emphasize this behavior, reaching up to a 25% reduction in the travel distance in the 2017-18 season when implementing TOUR-2. A similar pattern is observed for the remaining two seasons, now showing also a positive impact with a 7% reduction with respect to the LNB-R for the 2016-17 season.

Season	TOUR-1			TOUR-2			LNB-R		
	dist	br	co-c	dist	br	co-c	dist	br	co-c
2012-13	340.2	456	7652	335.7	460	7680	398.2	411	7402
2013-14	325.5	456	8060	319.4	460	7768	385.8	388	7574
2015-16	473.5	728	16096	464.9	740	15948	432.4	640	6744
2016-17	578.4	730	15932	558.6	732	15980	589.1	637	6742
2017-18	395.0	482	6936	370.6	478	6980	490.2	432	2860
2018-19	366.1	490	6968	349.2	482	7140	446.7	441	3132

Table 5: Comparison of the different metrics for the TOUR-k variants with respect to LNB-R.

It is interesting to evaluate the match assignments that were made by the tour setup model, which minimizes total distance for this set of weekends. In particular, when evaluating the geographic location of teams (for example, the location of teams of the 2018-19 season is available in A), we can see that most teams are located in Central and Northern Argentina, while there are only two teams in the southern provinces of the country. Therefore, it makes sense that, for example, in all tours of the 2018-19 season, Hispano Americano and Gimnasia (CR) play all their tour matches away, as it wouldn't make sense to have them play one pair of games at home and one pair of games away, given the existing distance.

Complementary to this analysis, we further investigate the structure of the schedule in terms of the game importance index defined in Section 3.3. Figure 1 shows a visualization of the interest level of each round for LNB-R, INTLAST and DISTR for the 2015-16 season. Each row represents a weekend and the intensity of green of a cell indicates the aggregated importance of the matches scheduled for that weekend. As expected, since the schedule is not designed following this objective, the LNB shows no clear pattern regarding this index. DISTR presents a rather homogeneous pattern, showing that the corresponding model tries to evenly distribute the games throughout the tournament according to their interest. Finally, INTLAST shows a clear trend with increasing values for different segments of the fixture. These segments either indicate a change in the stage (i.e., weekends 1-10 define the regional) or to the round change within each stage (i.e., weekend 5 for the regional and weekend 20 for the national).

5.3 Computation times

In this section, we present the detailed the results derived from the execution of the ILP models. Although it is not the main driver of our paper, obtaining good quality solutions for these models is computationally challenging, eventually conditioning their effective implementation in practice.

Table 6 shows the results obtained by DISTR, INTLAST and TOUR-k in all instances (when an instance has an asterisk in its execution time, it means the model was interrupted due to a timeout or because the

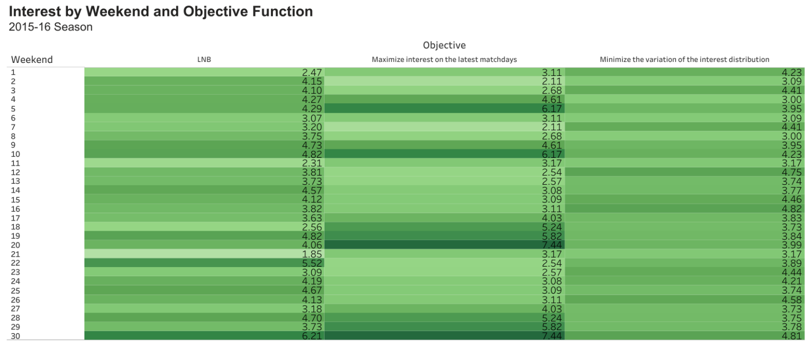

Figure 1: Interest distribution by round and scheduling method

Season	DISTR			INTLAST			TOUR-1			TOUR-2		
	time	%G r.	%G n.	time	%G r.	%G n.	time	%G rt.	%G nt.	time	%G rt.	%G nt.
2012-13	25627	0.0%	0.0%	0.2	0.0%	0.0%	1.4	2.2%	4.7%	118.0	0.0%	5.0%
2013-14	43200*	0.0%	2.8%	0.4	0.0%	0.0%	2.2	2.5%	4.7%	79	0.0%	5.0%
2015-16	43247*	5.5%	7.1%	1.1	0.0%	0.0%	2.9	2.7%	5.0%	9266	4.9%	5.0%
2016-17	459	5.5%	5.4%	0.7	0.0%	0.0%	5.9	4.1%	5.0%	43202*	5.0%	7.2%
2017-18	24680*	0.0%	1.5%	0.3	0.0%	0.0%	2.2	4.2%	5.0%	13740	4.9%	5.0%
2018-19	12219*	0.0%	1.4%	0.6	0.0%	0.0%	2.1	3.9%	5.0%	41755	5.0%	5.0%

Table 6: Execution times and optimality gaps for the different variants.

memory threshold was met). For each method, we report the following columns: time reports the total execution time, measured in seconds, for both the national and regional stage; %G r. and %G n. stand for the the optimality gap of the corresponding ILP model for the regional and national stage, respectively; and for the TOUR-k variants, %G rt. and %G nt. stand for the optimality gap of the solution obtained for the model defining the tours for the regional and national stage, respectively.

BRISKORN is not reported as it provides reasonable solutions within the time limit only for the seasons 2012-13 and 2013-14, which are the smaller ones with 16 teams and, therefore, 8 couples. INTLAST obtains optimal solutions in all cases in a few seconds. From a practical perspective, INTLAST stands an interesting alternative to implement since, as depicted in Section 5.2, the number of breaks increases moderately.

On the contrary, when modifying the objective function and considering DISTR the computation times increase considerably. The national stage for the 2015-16 season cannot provide a solution with an optimality gap below 5.5%. On average, DISTR requires approximately 7 hours to produce a schedule with guaranteed optimality, which is still feasible in a practical context as the problem represents a tactical decision.

Lastly, the TOUR-k execution times show that incorporating more tours generates an important increase in execution times as TOUR-2 takes considerably longer than TOUR-1. Moreover, when we increase the number of couples from 8 (first two seasons) to 10, execution time for TOUR-2 also increases considerably.

5.4 Economic analysis and managerial insights

Besides the mathematical models, one of the motivations behind our approach is to regain some regularity by scheduling more games during weekends to increase the stadium attendance. In this section, we provide some evidence of the impact and provide a business analysis integrating explicitly the attendance to the stadium. Recall that the LNB does not keep official attendance records nor ticket prices[2], which is left as a

[2]At least by the time consulted in early 2020, before the beginning of the pandemic

decision to the teams. Therefore, we reconstruct the critical information needed for this exercise from public sources, including contacts to more than 10 different teams to collect information and insights regarding the attendance level to the stadiums.

As a proxy for the operations involved when a team hosts a game, we build upon the information provided in Cardone [2020]. This article estimates the average ticket price at ARS 200 and the fixed cost for the stadium logistics' (i.e., security, administrative staff, etc.) at approximately ARS 50,000 per game, dated in March, 2019. For comparison purposes and to account for price variations, inflation and economic disruptions, these values are adjusted using inflation indexes and the daily USD-ARS exchange rate to calculate values in nominal USD at a game level. Travel costs estimations reported in Durán et al. [2019] consider an average of 2 USD per kilometre travelled, without including accommodation expenses. We further collected through diverse sources the maximum capacity of the stadium for each team $i \in T$, as reported in B.

Regarding the stadium occupation, from the (informal) discussions with a subset of teams we obtained the following insights:

- It is reasonable to assume that the two of the most popular teams (Boca Juniors and San Lorenzo, also very popular in football) have 100% occupancy when they play at home, independently of the day the game is held.
- Approximately 15% of the teams we contacted claimed they were very satisfied with the format, usually having 75% of occupancy. In each season, we apply this criterion for randomly selecting 15% percent (2 or 3 teams) of the teams in each season.
- For the rest of the teams, as disclosed by one of them, we assume a 50% occupancy on weekends and a 30% otherwise.

This survey suggests that some relevant aspects cannot be assumed independent from the schedule of the tournament. We incorporate this information to estimate the profit at a game level, accounting also for variations in the attendance to the stadium and some fixed operational costs. Overall, this analysis provides a richer proxy for some operational margins with a more general assessment of the impact of the schedule besides the total traveled distance.

Let G represent the schedule with the games of the season. For each $g \in G$, let ticket_g be the adjusted price ticket (in USD), $\text{occup}_g \in [0, 1]$ the occupancy factor (depending on the home team and the scheduled day), cap_g the capacity of the stadium of the home team and cost the associated fixed operational cost. Recall that dist accounts for the total distance traveled by the teams in the season. Then, given a schedule of a season, we approximate its profit (restricted to the discussed dimensions) as follows:

$$\text{profit} = -2 \times \text{dist} + \sum_{g \in G} (\text{ticket}_g \times \text{occup}_g \times \text{cap}_g - \text{cost}).$$

Table 7 shows this profit estimation (measured in million nominal USD) for each season for the INTLAST, TOUR-1 and TOUR-2 variants and for LNB-R, i.e. the implemented schedule.

Season	LNB-R	INTLAST	TOUR-1	TOUR-2
2012-13	1.5	1.8	1.8	1.7
2013-14	1.1	1.5	1.5	1.5
2015-16	3.0	3.8	3.8	3.7
2016-17	3.8	5.0	5.0	4.9
2017-18	2.7	3.7	3.7	3.7
2018-19	1.6	2.4	2.4	2.3

Table 7: Expected profits (in million USD) by season and tournament variant.

In general, we observe that the proposed tournament structure, in all cases, brings up consistently higher profits. The reductions in the distance traveled of course decrease the logistics costs. However, under the scenario described, the share of matches scheduled for the weekends seem to impact to a greater extent by increasing total revenue than the costs saved by reducing the distance traveled. Indeed, note that in several cases, the introduction of tours by TOUR-2 marginally reduces the profit. The explanation for this reduction is that, in our setup, tours are expected to take place during weekdays (i.e., immediately after a weekend) and therefore the overall number of games played during weekends is reduced.

Overall, the main managerial takeout from this analysis is that the schedule has a major impact both directly and indirectly on different business aspects. Besides the specific numbers and calculations presented in this section, more sophisticated tools mixing business, sports and fairness indicators could be beneficial to provide further insights regarding the benefits of using analytical tools for the different stakeholders involved in the decision making process.

5.5 A final experiment: scheduling a double RRT

For the seasons 2017-18 and 2018-19, our tournament format proposes a major change to the mix of games played by each team with respect to the double RRT implemented in practice. Therefore, in this section we conduct an additional experiment for these two particular seasons by adapting our approach to consider a single national stage with a double RRT. To generate the schedule, we resort to the TOUR-2 method by inserting a fixed tour window of size two (recall, four consecutive games) in each round. The results obtained are reported in Table 8, where the columns report the same metrics as in the previous cases. Between parenthesis, we include the relative difference with respect to LNB-R.

Season	dist (%)	br (%)	co-c (%)	profit (%)
2017-18	448.8 (-8.4%)	502 (16.2%)	7592 (165%)	3.6 (35.1%)
2018-19	417.7 (-6.5%)	498 (12.9%)	7560 (141%)	2.2 (39.0%)

Table 8: Results for the TOUR-2 variant adapted for a double RRT. Numbers between parenthesis represent the relative difference with respect to LNB-R for the corresponding season.

The results are aligned with the previous cases. The hybrid approach TOUR-2 reduces the distance traveled and improves the expected profit compared to LNB-R. Note, however, that since the teams are playing more games against teams belonging to the other conference (2 in this setup vs 1 in the previous experiments), the improvements are smaller compared to the previous case. These results are particularly interesting. The TOUR-2 approach reduces the total distance only with two fixed tour windows of four matches, improving the expected profit by increasing the share of games played during weekends. Overall, these results show that a tradeoff between these aspects may be beneficial regarding business oriented metrics.

6 Conclusions

In this paper, we study the impact of an alternative league structure for the LNB, which has recently adopted a new format by implementing a touring system to incorporate some preferences of the teams while reducing the total traveled distance. From a managerial perspective, our findings suggests that focusing only on the distance minimization can overlook other relevant aspects related to the business, such as the revenue obtained by the fan attendance to the stadiums. In terms of methodology, we revisit some well known techniques from the literature that are enhanced by incorporating explicitly a metric to guide the design of the schedule according to the distribution of the match importance. We further develop a new framework that integrates the use of tours as proposed by Durán et al. [2019] to the time-constrained schedule, aiming to capture the effect of the reduction on the distance traveled while maintaining the other objectives. Based on extensive computational experiments, we show that our approach is in general very effective, reducing distance traveled and generating higher revenue compared to the implemented LNB schedule.

As future research, we see several promising extensions of our work. Extending this type of study to other leagues, possibly considering other league formats and sports scheduling models, is of course a very interesting direction. In terms of the ILP formulations, exploring the different alternatives to incorporate the preferred tours to the TOUR-k approach while minimizing the distance appears as a very challenging problem, both in terms of modelling as well as algorithmically. Another interesting extension would be the development of more sophisticated tools to evaluate the impact of a schedule in a broader sense, possibly simulating outcomes of the games, attendance to the stadiums and other relevant business elements.

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References

I. Anderson. Balancing carry-over effects in tournaments. *Chapman and Hall CRC Research Notes in Mathematics*, pages 1–16, 1999.

J. Armstrong and R. J. Willis. Scheduling the cricket world cup-a case study. *The Journal of the Operational Research Society*, 44(11):1067–1072, 1993.

N. Ascheuer, M. Fischetti, and M. Grötschel. A polyhedral study of the asymmetric traveling salesman problem with time windows. *Networks*, 36(2):69–79, 2000.

T. Atan and B. Çavdaroğlu. Minimization of rest mismatches in round robin tournaments. *Computers & Operations Research*, 99:78–89, 2018.

J. C. Bean and J. R. Birge. Reducing travelling costs and player fatigue in the national basketball association. *Interfaces*, 10(3):98–102, 1980.

F. Bonomo, A. Cardemil, G. Durán, J. Marenco, and D. Sabán. An application of the traveling tournament problem: the argentine volleyball league. *Interfaces*, 42(3):245–259, 2012.

D. Briskorn. Combinatorial properties of strength groups in round robin tournaments. *European Journal of Operational Research*, 192(3):744–754, 2009.

D. Briskorn and A. Drexl. IP models for round robin tournaments. *Computers and Operations Research*, 36(3): 837–852, 2009a.

D. Briskorn and A. Drexl. A branch-and-price algorithm for scheduling sport leagues. *Journal of the Operational Research Society*, 60(1):84–93, 2009b.

D. Briskorn and S. Knust. Constructing fair sports league schedules with regard to strength groups. *Discrete Applied Mathematics*, 158(2):123–135, 2010.

D. Butler, R. Butler, and E. Mullane. Changing competition design and spectator turnout: Evidence from the league of ireland. *The Economic and Social Review*, 52(3, Autumn):333–353, 2021.

J. Cain and O. William. The computer-assisted heuristic approach used to schedule the major league baseball clubs. *Optimal strategies in sports*, 5:32 – 41, 1977.

M. Cardone. La devaluación llegó a la liga nacional de básquet. *Perfil, Published on 30th March 2019 Available on https://442.perfil.com/2019-03-30-666188-la-devaluacion-llego-a-la-liga-nacional-basquet/ (Consulted: 25th January 2020)*, 2020.

B. Çavdaroğlu and T. Atan. Determining matchdays in sports league schedules to minimize rest differences. *Operations Research Letters*, 48(3):209–216, 2020.

L. Csató. Optimal tournament design: lessons from the men's handball champions league. *Journal of Sports Economics*, 21(8):848–868, 2020.

D. De Werra. Geography, games and graphs. *Discrete Applied Mathematics*, 2(4):327–337, 1980.

F. Della Croce, R. Tadei, and P. Asioli. Scheduling a round robin tennis tournament under courts and players availability constraints. *Annals of Operations Research*, 92:349–361, 1999.

G. Durán. Sports scheduling and other topics in sports analytics: a survey with special reference to latin america. *TOP*, 29(1):125–155, 2021.

G. Durán, M. Guajardo, J. Miranda, D. Sauré, S. Souyris, A. Weintraub, and R. Wolf. Scheduling the chilean soccer league by integer programming. *Interfaces*, 37(6):539–552, 2007.

G. Durán, M. Guajardo, and D. Sauré. Scheduling the south american qualifiers to the 2018 FIFA world cup by integer programming. *Eur. J. Oper. Res.*, 262(3):1109–1115, 2017.

G. Durán, S. Durán, J. Marenco, F. Mascialino, and P. A. Rey. Scheduling Argentina's professional basketball leagues: A variation on the Travelling Tournament Problem. *European Journal of Operational Research*, 275 (3):1126–1138, 2019. ISSN 03772217.

K. Easton, G. Nemhauser, and M. Trick. The traveling tournament problem description and benchmarks. In *International Conference on Principles and Practice of Constraint Programming*, pages 580–584. Springer, 2001.

J. A. Ferland and C. Fleurent. Computer aided scheduling for a sport league. *INFOR: Information Systems and Operational Research*, 29(1):14–25, 1991.

D. Goossens and F. Spieksma. Scheduling the belgian soccer league. *Interfaces*, 39(2):109–118, 2009.

D. Goossens, X. Yi, and D. Van Bulck. Fairness trade-offs in sports timetabling. In *Science Meets Sports: When Statistics Are More Than Numbers*, pages 213–244. Cambridge Scholars Publishing, 2020.

D. R. Goossens and F. C. Spieksma. The carryover effect does not influence football results. *Journal of Sports Economics*, 13(3):288–305, 2012.

D. R. Goossens, J. Beliën, and F. C. Spieksma. Comparing league formats with respect to match importance in belgian football. *Annals of Operations Research*, 194(1):223–240, 2012.

T. Januario, S. Urrutia, and D. de Werra. Sports scheduling search space connectivity: A riffle shuffle driven approach. *Discret. Appl. Math.*, 211:113–120, 2016.

G. Kendall. Scheduling English football fixtures over holiday periods. *Journal of the Operational Research Society*, 59(6):743–755, 2008. ISSN 14769360.

G. Kendall, S. Knust, C. C. Ribeiro, and S. Urrutia. Scheduling in sports: An annotated bibliography. *Computers and Operations Research*, 37(1):1–19, 2010a. ISSN 03050548.

G. Kendall, S. Knust, C. C. Ribeiro, and S. Urrutia. Scheduling in sports: An annotated bibliography. *Computers & Operations Research*, 37(1):1–19, 2010b.

M. Kidd. A tabu-search for minimising the carry-over efects value of a round-robin tournament. *ORiON*, 26(2), 2010.

E. Lambrechts, A. M. Ficker, D. R. Goossens, and F. C. Spieksma. Round-robin tournaments generated by the circle method have maximum carry-over. *Mathematical Programming*, 172(1):277–302, 2018.

G. L. Nemhauser and M. A. Trick. Scheduling A major college basketball conference. *Oper. Res.*, 46(1):1–8, 1998.

T. F. Noronha, C. C. Ribeiro, G. Duran, S. Souyris, and A. Weintraub. A branch-and-cut algorithm for scheduling the highly-constrained chilean soccer tournament. In *International Conference on the Practice and Theory of Automated Timetabling*, pages 174–186. Springer, 2006.

T. Pawlowski and G. Nalbantis. Competition format, championship uncertainty and stadium attendance in european football – a small league perspective. *Applied Economics*, 47(38):4128–4139, 2015.

M. Siemann and M. Walter. A Polyhedral Study for the Cubic Formulation of the Unconstrained Traveling Tournament Problem. *arXiv e-prints*, art. arXiv:2011.09135, Nov. 2020.

W. Suksompong. Scheduling asynchronous round-robin tournaments. *Operations Research Letters*, 44(1): 96–100, 2016.

D. Van Bulck, D. Goossens, J. Schönberger, and M. Guajardo. Robinx: A three-field classification and unified data format for round-robin sports timetabling. *European Journal of Operational Research*, 280(2):568–580, 2020.

T. Wallrafen, G. Nalbantis, and T. Pawlowski. Competition and fan substitution between professional sports leagues. *Review of Industrial Organization*, pages 1–23, 2022.

M. B. Wright. Scheduling fixtures for basketball new zealand. *Computers & Operations Research*, 33(7):1875–1893, 2006.

A Example of teams location for the 2018-19 season

Figure 2: Geographic location of the teams of the 2018-19 season

B Stadium capacities

Team	Stadium Capacity
9 de Julio (RT)	1000
Argentino (J)	1500
Atenas	3424
Boca Juniors	2000
Comunicaciones	3500
Echagüe	2306
Estudiantes (C)	1610
Ferrocarril Oeste	4500 before the 2017-18 season, 3500 since
Gimnasia (CR)	2276 before the 2017-18 season, 1453 since
Hispano Americano	3000
Instituto (C)	2000
La Unión	4500
Lanús	3000
Libertad	4000
Obras	3000
Olimpico (LB)	3964 before the 2017-18 season, 3400 since
Peñarol	8000
Quilmes	3000 before the 2016-17 season, 8000 since
Quimsa	5200 before the 2017-18 season, 5000 since
Regatas (C)	4000 before the 2017-18 season, 3400 since
Salta Basket	10000
San Lorenzo	4500 for 2015-16, 2000 for 2016-17, 2200 for 2017-18 and 2018-19
San Martín (C)	3000 before 2017-18, 2500 since
Sionista	2100
Unión Progresista	1750
Weber Bahía	3950

Table 9: Stadium Capacity per Team