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# The Strategic Politics of Formula 1 Racing: Insights from Game Theory and Social Choice

DISSERTATION

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by

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## DEDICATION

Dedicated to my parents and my sister.

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## ABSTRACT OF THE DISSERTATION

The Strategic Politics of Formula 1 Racing:
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Brian Kaiser

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Marek Kaminski, Chair

This dissertation consists of three chapters demonstrating novel applications of social choice and game theory concepts to Formula 1 racing. Chapter 1 explores the history of the sport, focusing on early connections to national politics in Europe, strategic manipulation of rules as the sport grew, and politics within the sport, including collective action and negotiations between competitors and various stakeholders. Also addressed is the evolution of scoring rules in the sport, what inspired early scoring systems, and the overall trajectory of historical changes to scoring. Chapter 2 looks at various strategic dilemmas faced by competitors and other parties involved in Formula 1. Particular attention is paid to cases in which an action, on the surface, appears counterintuitive. Hidden incentives are revealed, then used to explain the strategic thinking behind what is observed. Cases are classified according to their salient features, and parallels are drawn to other sports. Chapter 3 is dedicated to scoring in Formula 1. Scoring in the sport uses a variation of Borda count, and parallels traditional elections. Drivers are the equivalent of candidates and races play the role of voters, with the season-long championship being the election. Within this context I identify several examples of voting paradoxes and other concepts from social choice theory. Collectively, these three chapters examine a global,

influential sport from multiple angles, including the political influence of the sport, politics within the sport, and the scoring of the sport as it relates to elections.

# INTRODUCTION

For more than two and a half millennia sports have been a part of politics and politics have been a part of sports. During the ancient Olympic Games a truce was called every four years for the sake of peaceful travel and competition. City-states used the games to display dominance over one another, and star athletes were even occasionally bribed to change their allegiance. These traditions have continued in the modern era, with the USA and USSR battling in the Olympics, and China and the USA engaging in Ping Pong Diplomacy. FIFA (Fédération Internationale de Football Association) has been accused of accepting bribes from would-be World Cup host nations, and NFL (National Football League) team owners have been accused of colluding to keep player Colin Kaepernick out of the league as a result of his pregame political activism. Sports and politics are deeply intertwined.

Formula 1 racing, in many ways, is the ultimate political sport. The early days of Grand Prix racing were the space race before there was a space race, with countries competing to demonstrate their technological superiority. In its current form, it is the only sport in the world in which multi-national corporations participate as players. It is also the only sporting league that holds competitions on five continents each year. Internally the sport has experienced a coup d'état, espionage, and twice been interrupted by war. It also has a scoring system that mirrors elections. For these reasons it has made for a fertile and interesting dissertation subject.

The first chapter covers the history of the sport, with special attention given to scoring and governance. Section one covers the origins of the sport in the late 19$^{th}$ century and the evolution of the format over several decades. What began as novelty events for independent enthusiasts quickly evolved into highly organized competitions for national pride. Technology was driven forward by two world wars, along with the commercial growth of the automobile industry. Section two deals with the scoring system used in the sport, beginning with the

primitive attempts at aggregating individual race performances to determine an annual champion, and the decision whether to honor drivers or car makers (a decision still debated today). Historical changes to scoring are documented, tracking overall trends, and the motivation behind some changes is explored.

Section three of the first chapter deals with a series of events known as the FISA-FOCA war, which was a battle for political and commercial control of the sport. Smaller, independent teams organized themselves to promote their interests. On the other side was the sport's governing body, race hosts, and the large teams backed by automobile manufacturers. The conflict lasted throughout the 1970s and early 1980s, and involved successful and unsuccessful attempts at collective action, sanctions, credible and non-credible threats, and ever-shifting coalitions.

The second chapter uses game theoretic analysis to model strategic behavior within the sport. Three main types of strategic dilemmas are identified: non-racing, coalitional, and intertemporal. Non-racing dilemmas cover issues such financing and race scheduling, and involve the largest group of players. Coalitional dilemmas deal primarily with drivers and team composition. How drivers choose their teams, how teams choose drivers, and how well driving pairings work are all addressed in this section. Intertemporal dilemmas largely arise from the scoring system used. A new champion is named each year, creating repeated games, and each season consists of multiple races, which are subgames. This leads to multiple time horizons that competitors must consider when planning strategy. The overall theme of the chapter is that some behaviors in the sport seem counterintuitive, but when formally analyzed a hidden game is revealed, and the behavior is shown to be very strategic and rational.

The third chapter studies the scoring system used in Formula 1 and identifies several paradoxes that have occurred. In some seasons the Condorcet winner was not named champion, in some the plurality winner was not named champion, and in one season a top cycle occurred. A season is identified that violates the concept of Independence of the Alternative Set, because the absence or presence of the third-place driver could switch the drivers in first and second places. Finally, historical seasons are recreated under every point system that has been used in the sport, and in 10 of the 57 seasons examined different point systems lead to different champions.

Collectively, the three chapters explore the politics of the sport and analyze the sport itself with the tools of political science. In doing so, two objectives are achieved. First, light is shed on the inner workings of a multi-billion dollar, politically influential, global sport. Whether we are discussing competitive strategy or the governance of the sport, Formula 1 is an extremely opaque world to outsiders, but analysis with the proper tools can create a clearer picture. Second, the data available from several decades of Formula 1 racing has allowed for the identification of several paradoxes. The conversion of individual rankings into an aggregate ranking occurs often, but rarely are full individual rankings documented. Because of this, real world paradoxes are not easy to find, and the research presented here provides some insights into how common they are.

# CHAPTER 1

# Political History of Formula 1 Racing


**ABSTRACT**

This chapter documents the history of Formula 1 racing, with an emphasis on politics in the sport and the evolution of scoring and rules. Shifting political priorities within the sport mirror geopolitical changes, as the focus on national pride in the early 20th century has given way to economic interests in the 21st. Changes to the scoring system in the sport, and the motives and controversies accompanying those changes, parallel debates in the field of social choice. As in politics, changes to scoring in F1 have been used as a tool to reward or incentivize various behaviors by changing the strategic landscape.

## 1.1. Origins

Formula 1 racing can trace its roots back to the late 19th century. Near the turn of the century enthusiasts and car builders began engaging in motoring competitions of various formats in France. The first decade consisted mostly of city-to-city races that could last multiple days. Vehicle repairs were made by racers and their onboard mechanics, and the emphasis was as much on reliability as speed. The spirit of competition led to rapid development of faster and more reliable engines. For the most part these were rather ad hoc affairs until the Gordon Bennett Cup took place in 1900 (Næss 2020). This was an organized competition pitting the automotive sporting clubs of six countries against one another. France, Belgium, Great Britain, Germany, Italy and the United States would each send three cars to race from Paris to Lyon. The nation with the winning car would host the following year's event. Up until this point technology was so primitive and rapidly evolving there were no limitations on car design. In 1901 The Gordon Bennett introduced the first vehicle regulations, or "Formula", by imposing a weight limit. This is the origin of the term "Formula" in Formula 1 and has also been applied to other classes of racing, such as Formula 2.

As defending champions, the Automobile Club de France (ACF) were obliged to host the 1906 Gordon Bennett, but they declined and instead created a new event. The race took place in Le Mans, France, and they called it "The Grand Prix", a term still used for F1 races today. In addition to the introduction of the name, this race is notable for two reasons. First, it was not a point-to-point race. The race consisted of 12 laps around a 65-mile circuit (Llurba 2016). The Grand Prix was not the first race to use the circuit concept, but it did solidify this as the preferred format going forward. Second, the formation of this event represents the first clear example of the manipulation of rules and regulations to favor a particular competitor. In the Gordon Bennett

three cars were entered by each nation. The new Grand Prix would be a competition between manufacturers rather than countries. France had a thriving auto industry with many manufacturers, which meant that this change would give them more cars in the field, creating an advantage in terms of representation. Even though France wouldn't be the winner, they dramatically increased the odds that the winner would be French, which is exactly what happened (Donaldson 2002).

1908 saw further refinement of regulations with the introduction of two classes of racing. The largest and most powerful cars in one class, and the smaller "voiturette" competed in their own class. French manufacturers had experienced a run of poor performance both in racing and in commercial sales, and diminished enthusiasm lead them to cease hosting the Grand Prix. In the following years voiturette racing was the main attraction until Grand Prix racing resumed from 1912-1914. After this brief return, racing would again stop until 1921 due to the outbreak of war, but technology continued to progress as auto manufacturers transitioned to building military hardware. When racing resumed, the knowledge gained during the war led to increasing speeds on track, and additional design regulations were introduced with an eye toward safety and levelling competition.

Up until this point races had been stand-alone events, with no concept of a season or championship. From 1925-1927 the AIACR (Association Internationale des Automobile Clubs Reconnus) awarded the World Championship for Manufacturers, and for the first time introduced the concept of a season-long winner. The AIACR, formed in 1904, was an association of national automotive clubs, and is the direct predecessor of the modern FIA (Fédération Internationale de l'Automobile), which is the governing body of Formula 1 (Hutton 2004). The championship considered performance in Grand Prix races, with competitors

required to compete in a minimum number of events to be eligible. One point was awarded for finishing in first place, two for second, three for third, four points for all other finishers, five points for entering but not finishing a race, and six points for not starting a race (Table 1.1). Manufacturers were awarded points according to their single best placed car in each race, with points from each race tallied for a season-long total. Then a so-called "Minimum Point System" was used, and the manufacturer with the lowest point total for the season was champion. From 1928-1930 not enough eligible races were held to have a legitimate championship.

**Table 1.1.** Minimum Point Systems

| **Scoring System** | **Points by Race Result** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | Finished Race | [75-100)% Race Distance | [50-75)% Race Distance | [25-50)% Race Distance | <25% Race Distance | Did Not Start |
| **World Manufacturers' Championship (1925-1927)** | 1 | 2 | 3 | 4 | 5 | 5 | 5 | 5 | 6 |
| **European Drivers' Championship (1931-1938)** | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 |

In 1931 the AIACR introduced the European Drivers' Championship. This time the focus was on drivers rather than manufacturers. The championship used a minimum point system similar to the previous one, with small changes. First through third place finishers in each race still earned from one to three points, respectively. If a driver completed more than 75% of a race, they earned four points, 50-75% meant five points, 25-50% meant six, less than 25% earned seven points, and failing to start a race incurred eight points (see Table 1.1). The

driver with the lowest total for the season was champion. The championship was awarded each year through 1938, but by 1939 things came to an end due to war.

Ahead of the 1939 European Drivers' Championship some dissatisfaction was voiced regarding the scoring system in use, particularly its level of complexity. The Belgian delegation to the AIACR undertook a project to research a potential new scoring system. The proposal was referred to as the "Maximum Point System," which was in fact a weighted Borda count[1]. Those finishing in positions one through five would receive 10, 6, 5, 4, and 3 points respectively. All others that started a race would receive one point (see Table 1.2). This proposal, combined with the outbreak of war, led to a strange outcome for the championship (Armstrong 2002).

**Table 1.2.** Proposed Maximum Point System for 1939 European Drivers' Championship

| **Scoring System** | **Points by Race Result** | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | Started Race | Did Not Start |
| **Proposed European Drivers' Championship (1939)** | 10 | 6 | 5 | 4 | 3 | 1 | 0 |

[1] Borda count is a scoring system in which alternatives or competitors are ranked from highest (best) to lowest (worst). The lowest ranked alternative is given 1 point (or 0 points in some versions), the next lowest 2 points, and so on. The highest ranked alternative will receive *n* points (or *n*-1 points in some versions), where *n* is equal to the number of alternatives or competitors. With 5 alternatives, the highest ranked will receive 5 points. The points received by each alternative are then totaled. The alternative with the highest total wins. In addition to this simple Borda count there are other variants. These include Weighted Borda count (sometimes referred to as weighting) where the differences in points received from one position to the next can vary, typically to the benefit of higher ranked alternatives, and Truncated Borda count (sometimes referred to as truncation), in which points are only awarded down to a certain rank with all others receiving 0 points.

As it turns out this scoring change was not formally presented until after the season had already begun. Even after three races, of a planned five, no official decision had been made. Teams and sporting journals were calculating championship leaders based on different systems, often using the one that most benefited them or their preferred driver. Following the cancellation of the Italian Grand Prix, the season was reduced to just four races, with the finale to take place in Switzerland. Going into the race Müller, a driver for Auto Union (later to become Audi), was the leader under both scoring systems. However, without knowing which system would be applied to determine the championship, he did not know what he needed to accomplish in the race to emerge victorious. Under the Maximum Point System he needed to finish in second place to guarantee the championship. Under the Minimum Point System he simply needed to complete half of the race distance. The flip side of this equation is that Lang and Caracciola, both drivers for Mercedes-Benz, had a much better chance of winning the championship under the Maximum Point System, which largely explains why the Mercedes-Benz team had been pushing for its adoption.

In the end Müller finished the Swiss GP in fourth place, with Lang winning (Etzrodt 2011). This meant that Müller was champion under the Minimum Point System and Lang under the Maximum Point System (Table 1.3). This is more than an interesting observation because even after the last race of the season the AIACR had not yet made its final decision on the system to be used. The plan was to settle the matter, and by extension name a champion, at their annual meeting in Paris in October, but the outbreak of war meant that the meeting never took place. This was the most extreme case of interested parties having the opportunity to shape rules to their advantage, because it wasn't a just matter of changing the odds of victory, it was a matter of determining the winner conclusively in the course of rulemaking. Officially no champion was

ever named for 1939 (The F1 History Wiki n.d.), which is unfortunate because a debate over scoring after competition was concluded would have been interesting from an academic point of view.

**Table 1.3.** Comparison of 1939 European Drivers' Championship under Minimum and Maximum Point Systems

| Driver (Team) | Points by Race under Maximum Point System | | | | Total |
|---|---|---|---|---|---|
| | Belgian GP | French GP | German GP | Swiss GP | |
| Lang (M-B) | 10 | 1 | 1 | 10 | 22 |
| Müller (A.U.) | 1 | 10 | 6 | 4 | 21 |
| Caracciola (M-B) | 1 | 1 | 10 | 6 | 18 |
| **Driver (Team)** | **Points by Race under Minimum Point System** | | | | **Total** |
| | **Belgian GP** | **French GP** | **German GP** | **Swiss GP** | |
| Müller (A.U.) | 5 | 1 | 2 | 4 | 12 |
| Lang (M-B) | 1 | 5 | 7 | 1 | 14 |
| Caracciola (M-B) | 6 | 7 | 1 | 2 | 16 |

A.U.: Auto Union; M-B: Mercedes-Benz

It didn't take long for racing to resume after the end of the war. In 1945 the AIACR was restructured as the modern FIA (Fédération Internationale de l'Automobile). In 1946 they undertook a project to organize and simplify a complex system of racing divisions largely overseen at the domestic level. The FIA created three divisions of racing that would be the international standards. Formula A, Formula B, and Formula C, with A being the highest division. Soon this evolved to Formulas 1, 2, and 3. Regulations were designed around existing pre-war cars because this allowed racing to begin without delay. There is debate as to whether the first official Formula 1 race was held in 1946 or 1947, but at this point Grand Prix races were still individual events with no season-long championship.

## 1.2. Evolution of Scoring

In 1949 the FIM (Fédération Internationale de Motocyclisme) held its first championship, naming winners for drivers as well as constructors. This played a role in the FIA decision to form their own championship. The inaugural Formula 1 World Championship for Drivers was held in 1950. Though there were up to 22 grand prix held that year, the championship only officially recognized six races in Europe plus the Indianapolis 500 in the United States, which was included primarily as a means to justify the term "World Championship" (Smith 2016). In total the European races involved 30 teams and 47 drivers, with each team fielding between one and five cars per race. Participation by most competitors was inconsistent and sporadic. These aspects likely played a role in the choice of scoring system for the championship.

For the championship a weighted, truncated, selective Borda count system was used. The first through fifth finishers in each race earned 8, 6, 4, 3, and 2 points, respectively. An additional 1 point was also awarded to the driver with the single fastest lap in the race. This amounted to a second, parallel Borda count, in which every individual lap time from the entire race was ranked, and points truncated down to 1 point for the driver with the single fastest lap. Of the seven qualifying races, only the best four performances from each driver were combined for their championship total, a method that can be called a selective Borda count. The driver with the highest total was the winner. Although the point allocation was slightly different, this system looks very similar to both the system proposed in 1939, and, especially with regard to the extra point for fastest lap, the system used by the FIM. All three systems are compared in Table 1.4.

**Table 1.4.** Comparison of 1950 Formula 1 World Championship for Drivers point system and predecessors

| Scoring System | Points by Race Result | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | Started Race | Did Not Start | Fastest Lap |
| **Proposed European Drivers' Championship (1939)** | 10 | 6 | 5 | 4 | 3 | 1 | 0 | 0 |
| **FIM (1949)** | 10 | 8 | 7 | 6 | 5 | 0 | 0 | 1 |
| **Formula 1 World Championship for Drivers (1950)** | 8 | 6 | 4 | 3 | 2 | 0 | 0 | 1 |

FIM stands for Fédération Internationale de Motocyclisme

There are clear indications where the inspiration for the original F1 points system came from, but there were also practical reasons for choosing it. With so many teams and drivers, each with varying levels of commitment to the series, it would not have been practical to use a standard Borda count allocating points for the entire field. For example, 34 cars raced in the 1953 German Grand Prix (Masefield 2014). Only awarding points to the top five finishers seems a reasonable solution. The weighting of the points systems feels natural as improving from second place to first seems to justify a larger point bonus than moving from third to second, and so on. The selective aspect of scoring also made sense given that no driver completed every race of the season. Further, a selective scoring system encouraged drivers to compete their hardest in each race, since their worst few performances would be thrown out. The intention was for fans to watch exciting competition rather than drivers conservatively accumulating points all season

long. The extra point for fastest lap would have had the same effect. The number of races counted toward the championship was increased from four to five the following year, but no other major revisions were implemented for the first eight years of the sport.

In the pre-war era championships had been held for both drivers and constructors at different times, but for the first eight years of modern F1 only a drivers' champion was named. In 1958 the International Cup for F1 Manufacturers was introduced alongside the World Championship of Drivers. Each team was awarded points according to its best placed car in each race, using the same point allocation as the drivers' championship. Selective scoring was maintained for both championships, with the best five or six results being counted from the eight to twelve races held each year. The number of races fluctuated from season to season.

In 1967 the selective aspect of scoring was modified. Since 1958 nearly half of the worst performances for drivers and teams were dropped each year when calculating the championships. This meant that theoretically the championship could be decided just past halfway through the season. Two changes were implemented to make for better competition. First, the number of races that did not count for each team and driver was reduced to two. For example, if a season had twelve races, the best ten would be counted. Second, the season would be split into first and second halves. Meaning the best five results from the first six races would be counted, and the best five results from the last six races would be counted. This made it more difficult for a competitor to build up an insurmountable lead early in the season.

The next major scoring changes came in 1979, and they were a result of the FISA-FOCA war discussed in the next section. Up until this point, for the constructors' championship only the best placed car from each team in each race was counted. Also, the two lowest scoring races for each team were dropped from their total score. Beginning in 1979, all races would be

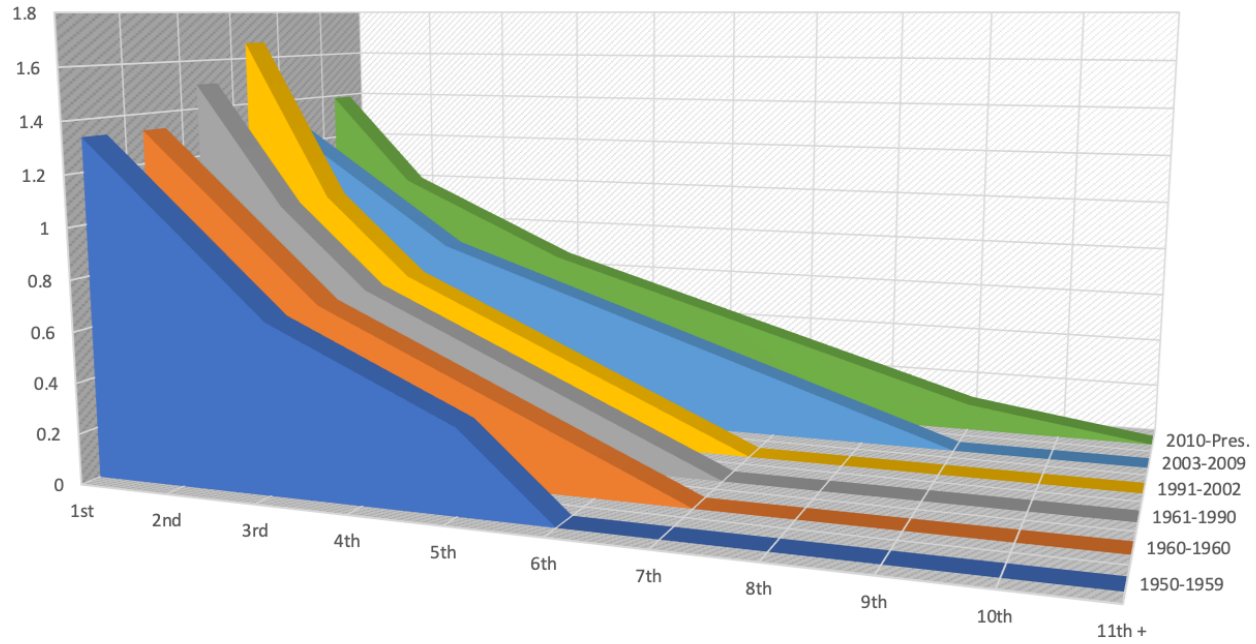
counted toward the constructors' championship (but not the drivers' championship). Furthermore, the points scored by every car a team fielded would contribute to their points total, though teams rarely had more than two cars on track. Prior to this, if a season had twelve races and two cars, only their best 10 out of 24 results (single best car in 10 out of 12 races, with 2 cars x 12 races = 24 race entries) would have counted. After the change, all 24 race entries counted. The result was a greater emphasis on consistency, and a need for teams to commitment to contesting the full season.

While the constructors' championship had begun scoring more races the drivers' championship was scoring fewer, only counting roughly two-thirds of races for each driver toward the season total. In 1991 the selective scoring aspect was finally dropped from the drivers' championship, partially in response to the outcome of the 1988 season. Had all races been counted, Prost would have won the championship, but because 5 of 16 races did not count for each driver, Senna was champion. There was nothing illegitimate about this result, but it felt counterintuitive, or at least confusing, to fans. From this point on all races would be counted toward both championships. One other change was made for 1991, with an additional point being awarded for first place. In 1989 Prost won the championship, but Senna won two more races than him. Although the 1991 scoring changes would not have altered the 1989 outcome, it did place more value on race wins.

Apart from the selective aspect of scoring, the points system used has evolved in two major ways. The number of points scoring positions in each race has grown progressively over time. For the first ten years points were only awarded for first through fifth place in each race. In 1960 a point was added for sixth place. Beginning in 2003 seventh and eighth place were awarded points. Finally, from 2010 onward the top ten finishers in each race all earn points.

Going forward, there has been discussion of removing the truncation aspect of scoring altogether and assigning points for all drivers (Rencken and Collantine 2018). Part of the motivation for this is to make battles near the back of the field meaningful, to add excitement for fans.

**Figure 1.1.** Historical points systems used in Formula 1




Finishing positions are shown along horizontal axis. The vertical axis shows points per position, as a proportion of second place. Each points system is scaled by setting second place within that system equal to 1 point and representing points for all other positions relative to second place. The current scoring system is the one farthest toward the back.

The other major trend over the last seventy years involves the value placed on a win, and this evolution has ebbed and flowed rather than progressing monotonically. Figure 1.1 shows the six points systems that have been used in F1. The graph shows the full distribution of points under each system, but each has been scaled by setting the value of second place equal to one, allowing for direct comparison of certain features of each system. All other places are shown as a percentage of the value of second place. This allows us to compare the value of a win relative

to a second-place finish. This has gone from 1.33 (1950-1960) up to 1.5 (1961-1990) and then 1.67 (1991-2002), and down to 1.25 (2003-2009), finally settling at 1.39 (2010-pres.). Table 1.5 summarizes the Borda count modifications used throughout the history of the sport.

**Table 1.5.** Modifications applied to Borda count in Formula 1 scoring

| Modification | Variations and Implementations |
|---|---|
| Truncation | • Number of point-scoring positions has changed over time |
| Weighting | • Weighting of each position relative to others has changed over time |
| Selective scoring | • Selective scoring has been applied to entire seasons, and subsets of races within seasons, at different times |
| Simultaneous systems | • Simultaneous Drivers' and Constructors' Championships<br>• Fastest lap on top of race results |

Left column lists fundamental modifications to basic Borda count. Right column represents variations and implementations seen within each modification. Multiple modifications are typically combined within a single scoring system.

## 1.3. Governance of Formula 1

For its first few decades F1 was populated largely by wealthy enthusiasts, for whom monetary gains from the sport came second to their passion. Governance of the sport was relatively uncomplicated. By the 1970s the commercial value of the sport was growing, as were the costs of operating teams. This led to power struggles over commercial rights, revenue sharing, and sporting regulations. This battle, which spanned the late 1970s and early 1980s, is known as the FISA-FOCA war, and the fallout from it shaped the sport into what it is today.

Several stakeholders were involved in this game, each with different interests and different levels of influence. The FISA, further explained in the following paragraph, was the

governing body of the sport. The FOCA, also explained below, was an organization representing the financial interests of the smaller, independent teams. Teams came in two general types – large factory teams representing auto manufacturers, and small independent teams. Organizers arranged and hosted races at different circuits around the world. Drivers, each of which was contracted to a specific team. Sponsors, whether working with Formula 1 as a whole or individual teams, also had an interest in the outcome of the war. Finally, fans had skin in the game, but their only means of influence was choosing whether or not to consume the Formula 1 product.

The previously mentioned AIACR was the first governing body in the sport. This was an association of national motoring clubs founded in 1904. The sporting wing of the AIACR, which dealt directly with Grand Prix racing, was the CSI (Commission Sportive Internationale), founded in 1922. When the AIACR was restructured as the FIA in 1945, the CSI continued to oversee international motor racing. It was until 1978 that the CSI was reorganized as the FISA (Federation International du Sport Automobile), which set regulations for motor racing divisions and controlled commercial rights. The man that would later be in charge of the FISA would be Jean-Marie Balestre, but until 1978 the CSI still existed.

While there were some "factory" teams in the sport (Renault, Ferrari, Alfa Romeo), many competitors were what was known as "garagistes", or garage teams. These were primarily independent, British-based organizations working with small budgets. These teams had little influence over shaping regulations or revenue allocation. In 1964 the F1CA was formed (Formula 1 Constructors Association) as a unified front for negotiating better financial terms and other matters important to teams. Several years later the F1CA was renamed the FOCA (hereafter the organization will be referred to as the FOCA) because "F1CA" closely resembled a

vulgarity in the Italian language. By 1972 Bernie Ecclestone, a former used car salesman, had gained the support of other teams and managed to assert control over the FOCA. His closest ally was Max Mosely, a British barrister and member of the FOCA. This set the stage for the FISA-FOCA war. Ecclestone, Mosely, and the independent teams of the FOCA on one side, and the FIA, the FISA (previously the CSI), Balestre, and eventually the factory teams on the other.

All of the interested parties depended on one another to make F1 what it was. Races couldn't be held without a venue, and there were a limited number of circuits in the world that were suited to the cars, so the involvement of hosts (or organizers) was vital. A race is not a race without a sufficient number of competitors participating, so without teams the sport wouldn't exist. Finally, even if a race were held, it wasn't a real Formula 1 race unless the FIA said it was, and that is what attracted fans, and more importantly, their money. The FISA-FOCA was essentially a test of how critical each group was to the sport, played out through a series of threats, alliances, work strikes, and negotiations.

By the early 1970s the FOCA's power was growing. The FOCA teams were unified enough to begin throwing their weight around in the form of strikes and hard-nosed negotiations. At Monaco in 1971 teams brought a combined 23 cars to race, but the organizers limited the field to 18 cars. This was dictated by an obscure calculation in the regulations, with no other rationale or further justification behind it. The FOCA organized a strike among teams, and declared that no cars would even practice for the race unless they were all allowed to race. The Monaco organizers in turn threatened to impound the cars and sue each team. The FOCA knew that the fans were growing angry because no cars were on track for them to watch, so they called the organizers' bluff. The organizers eventually agreed to allow all cars to race, but claimed that the FIA official capable of signing such an agreement was not currently present, and the teams

should begin practice based on a handshake agreement. The FOCA knew that once teams and drivers began to practice, their unified front would begin to break down, so they stood their ground and continued the strike. Very quickly the FIA official appeared and signed the contract, allowing all 23 cars to compete (Mosley 2015).

In 1975 the FOCA was negotiating with organizers ahead of the Canadian GP over the financial package for teams. It was expensive for independent teams to travel across the Atlantic, and teams felt they were not being compensated fairly. The FOCA gave an ultimatum – more money would be paid or no teams would show up for the race, forcing its cancellation. The organizers did not respond by the deadline given, and the FOCA made a public announcement that the race was cancelled. The organizers immediately contacted them and said they would agree to the terms. However, to gain a stronger position in future negotiations with other organizers, the FOCA stuck to their word and the race never took place. Going forward organizers knew that threats made by the FOCA were credible. The FOCA's growing power made organizers nervous, and made the FIA (the rightful authority over Formula 1) feel threatened, so there was a sense that something had to be done to reign the FOCA in.

Race organizers made the first attempt to push back against the FOCA. The FOCA's strength came from the unity of its members, and organizers formed the short-lived GPI (Grand Prix International) to push back. The GPI strategy was to approach teams individually and offer them lucrative deals to leave the FOCA and participate in races (Diepraam 2007). The thinking was that if GPI could get a few teams to abandon the FOCA, the FOCA would no longer have the strength to make threats and carry out effective strikes against organizers. A coalition with all of the independent teams in it was stable because none of them stood to benefit in the long-term from defection. If the organizers could entice just a few of the teams to leave the coalition,

however, it may have been possible to create a chain reaction and establish non-cooperation among teams as a new equilibrium. This plan did not work because everyone knew they were playing a repeated game, and the benefits teams received from the FOCA were excludable. If a team were to abandon the FOCA for a one-time payout, they would not reap the rewards of any FOCA-negotiated contracts any longer, and they knew that once the FOCA ceased to exist, teams would be weak, and organizers could dictate terms.

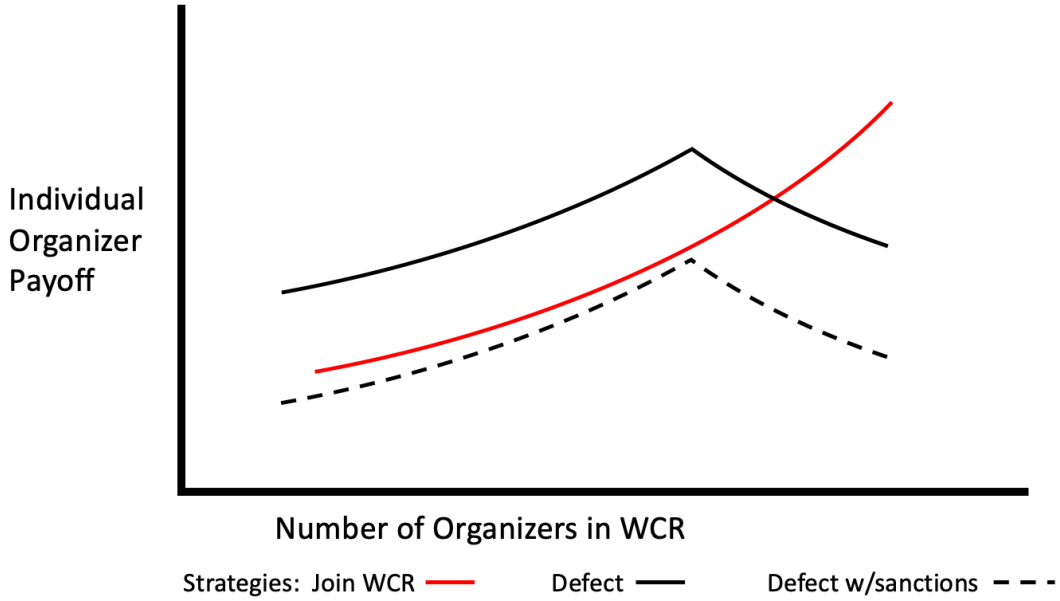
Next, race organizers turned to the CSI (predecessor to the FISA, sporting wing of the FIA) for help. The CSI's interests aligned with the race organizers because the CSI did not like the control the FOCA was exercising over Formula 1. The tactic used this time was to open Grand Prix races up to cars from lower divisions. Teams could boycott races, and they could legally block their famous drivers from competing, but the FIA could still sanction official Formula 1 races and change the rules to allow cars from lower divisions. Formula 2 cars, for example, look and sound very similar to Formula 1 cars, so fans would still enjoy the show. This meant the FIA/CSI could immediately stage Formula 1 races, with full fields of competitors, without having to negotiate with the FOCA any longer. This might have worked, were it not for the fact that the FOCA publicly pointed out the hypocrisy of such a move by the FIA. The FIA had been making a push for increased safety in Formula 1 racing in the 1970s, with new technical requirements for cars. The cars they were planning to allow from lower divisions did not meet these requirements, and the FOCA pointing this out embarrassed the FIA, forcing them to abandon their plans (Diepraam 2007).

The next salvo from race organizers came in the form of WCR (World Championship Racing). They appear to have learned the power of collective action from the FOCA, and sought to do the same themselves. If they could negotiate collectively with the FOCA, they would have

a much stronger bargaining position. WCR knew that its members, unlike the FOCA members, would face real temptation to defect. If any member were to abandon the cause and negotiate independently with the FOCA, they would be the only venue hosting a Formula 1 race, which would be a very lucrative situation indeed. To address this WCR arranged for externally imposed sanctions to incentivize loyalty of its members. Each member agreed to pledging a $100,000 bond with a third party, which would be forfeit should they negotiate with the FOCA independently (Figure 1.2). It was a good plan except for the fact that not every WCR member followed through with their bond, and many abandoned WCR to sign contracts with the FOCA (Diepraam 2007). Another attack on the FOCA had failed.

In 1978 Jean-Marie Balestre was appointed head of the CSI, and immediately began making changes. First, he replaced the CSI with the FISA, which did not amount to much beyond a name change. Second, scoring for the constructors' championship was changed. Now all races would be scored, rather than selectively dropping each team's worst races. What this amounted to was a greater penalty for teams missing a race because of a strike. This was taken a step further in 1981, when teams would be forced to sign up for the full season rather than a series of stand-alone events. This demanded an even higher level of commitment from teams and made resistance all the more difficult for the FOCA.

**Figure 1.2.** WCR collective action problem with sanctions




Shown is the approximate payoff scheme faced by each organizer. Joining WCR meant forgoing race revenue until the FOCA agreed to terms, which decreased payoffs. As the number of WCR members grew, negotiating power would increase, leading to a higher likelihood of favorable financial packages, thus the upward sloping curve. Defection would mean that an organizer was available to host races, and as the number of organizers decreased, their ability to negotiate favorably with the FOCA. However, once WCR reached a critical mass the FOCA would have to deal with them, at which point the FOCA would likely stop dealing with non-WCR organizers, or at least offer them worse terms. Sanctions served the purpose of lowering the payoffs for defection as WCR attempted to reach this critical mass

Meanwhile, a technological battle was beginning to take shape, and this would soon play a part in the war for control of F1. The manufacturer teams were developing turbo technology, which involved forcing additional air into the internal combustion engine to create more power. The independent garagiste teams did not have the resources to develop this technology, and it was too new to be purchased off the shelf, so to speak. Instead of making their cars go faster in a straight line, the smaller teams focused on having them slow down less around turns by using what is known as ground effects. They began shaping the underside of their cars to create negative air pressure at speed, sucking the cars to the ground and generating better traction around corners. This was important politically because the FISA controlled sporting regulations,

and they could use the technological battle as a tool against the FOCA. By outlawing the ground effects used by the FOCA teams, the FISA could weaken the organization. What's more, though the FISA existed solely to oversee motor racing, it was only one part of the FIA. The FIA dealt with all things automotive, including road vehicles, which were produced by the very same companies that were developing turbo technology in F1. Through shaping the rules of F1, the FISA could attack their opponents and keep the FIA's allies happy at the same time. The FISA began pursuing a ban on the ground effects used by the FOCA teams, but this did not take immediate effect.

As the chess match continued both pawns and kings were brought into play. By 1980 the FISA continued to extend its reach, and instituted a regulation requiring drivers to appear at press briefings. The FOCA instructed drivers in their camp not to attend, and they were subsequently fined. The drivers either did not pay their fines, or the fines were paid by sponsors. Unsatisfied, the FISA threatened to revoke their Super Licenses (required to drive in a Formula 1 race). The battle over driver fines came to a head at the 1980 Spanish GP when the FISA instructed the organizers not to allow drivers with unpaid fines – representing most of the field - to race. At this point Juan Carlos I, King of Spain, stepped in and ordered that the race continue as planned. The race was held but was deemed a "pirate" race by the FISA and was not counted toward the championship. The conflict had become so heated that even sponsors, such as Goodyear and Philip Morris urged a quick resolution.[2]

[2] Though it may not have been deliberate, the actions taken during this period had the effect of introducing new actors, with new sets of interests, into an expanding conflict. Both Schattschneider (1960) and Lipsky (1968) predicted that this would be most likely to benefit the party challenging the status quo, in this case the FOCA. As we will see this was eventually the case, as the conflict began affecting a growing number of FISA allies, leading to pressure to find a solution.

The next move made by the FOCA teams was to attempt to form their own rival racing series (the doomed World Professional Drivers Championship). The FOCA had ongoing contracts between teams and organizers – contracts that did not involve the FISA. The FOCA assumed that these contracts gave them the right to continue with their own series, and recourse if organizers did not comply. Enough organizers were willing to go along with the FOCA coalition to create a viable rival racing series, and a few individual "pirate" races were actually run, including the 1981 South African Grand Prix (Jones 2012). The endeavor ultimately failed, however, when Balestre and the FISA threatened to impose sanctions on any organizer working with the new rival FOCA series. Organizers were able to keep their racing circuits profitable by hosting a number of smaller FISA races throughout the year, and losing all of them at once would ruin the organizers financially. It soon became clear that an entire rival series was not viable, but the FOCA continued to fight.

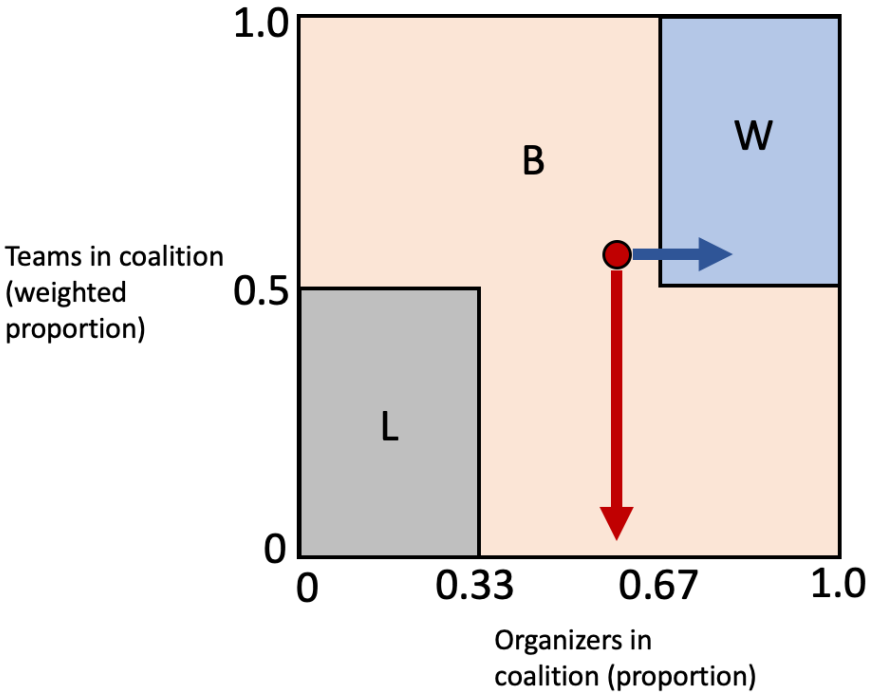
The FISA threats did not work against all organizers. The organizers of the 1981 Long Beach Grand Prix decided to honor the existing contract they had with FOCA and host a race that allowed the FOCA teams to use cars with ground effects. The FISA had outlawed this and said the race would be unofficial if it was held under such rules. The threat did not work, and the organizers went ahead with the race anyway (*United Press International* 1981). It appeared as though the race would be held as a pirate race, until something unexpected happened and caught the FISA completely off guard.

Though the power struggle between the FISA and the FOCA had ebbed and flowed over the years, the coalitions had remained relatively stable. The FOCA, the garagiste teams, and most of the drivers were on one side. The FISA, the manufacturer teams, and race organizers were on the other side. The ground effects controversy, and the threat of a rival series, had

caused some organizers to leave the FISA camp and side with the FOCA. By the 1981 Long Beach Grand Prix the FISA appeared to have turned the tide, and was attempting to consolidate its position by forcing organizers to rejoin their camp. This was where they were focusing their attention, assuming the rest of their coalition was unbreakable. After all, the manufacturers were benefiting from the technical regulations being championed by the FISA. To the FISA's surprise, the manufacturers announced they would race in Long Beach. The motivation to abandon the FISA (and the FIA) was the same that had aligned them in the first place. The manufacturer teams were, first and foremost, businesses. The American race was too important, from a marketing standpoint, for them not to take part. The FISA was paying attention to the wrong part of their coalition, and allowed it to be broken (Figure 1.3).

Balestre and the FISA relented and began to negotiate with the FOCA in good faith over control of the commercial rights for Formula 1. The resulting contract is known as the Concorde Agreement, named for the Place de Concorde in Paris – the location where it was signed at the headquarters if the FIA. Some of the highlights were that the FOCA was granted permission to sell television rights for all races, and teams received a higher portion of the revenue from these rights. Teams agreed to commit to full seasons rather than one race at a time, but also had some control over which races were added to the calendar. Teams also would have control over future technical changes to the sport, but the FIA (through the FISA) was still the governing body. Teams would also have better representation within the FIA. However, not all teams were granted equal representation. For example, even in the present era, Ferrari has outsized representation within the FIA, and official veto power over proposed technical changes to Formula 1 (Hall 2020). Other teams have varying degrees of influence, though none as strong or as official as that of Ferrari.

**Figure 1.3.** FISA coalition battle at 1981 Long Beach Grand Prix




The graph plots the FISA coalition's approximate power along two axes. The horizontal axis is the proportion of race organizers in the FISA coalition. With a sufficient number of FISA-loyal race organizers (here arbitrarily designated at 2/3 of all organizers), there would not be enough left for the FOCA to create a rival series, creating a winning coalition for the FISA. On the other hand, with fewer than 1/3 of organizers in their camp, the FISA would not be able to continue the championship, leaving them with a losing coalition. Anything in between would prolong the battle. In addition, there was a battle over teams loyal to each organization. Fans come to watch teams, and a coalition with many organizers but few teams does not make for a successful race series. Teams each had unequal influence, with manufacturers, specifically Ferrari, adding the most value to any coalition, and the British garagiste teams adding the least, though with many more garagiste teams in existence. The red dot represents an approximation of the FISA coalition before the Long Beach GP. The blue arrow represents the FISA's attempt to coerce the Long Beach GP into joining their coalition. The red arrow represents the unexpected result of the manufacturer's leaving the FISA coalition. L – Losing coalition; B – Blocking coalition (can't win, but can avoid losing); W – Winning coalition.

Today, Formula 1 generates some of the highest revenues of any sport in the world at over 2 billion USD annually (Liberty Media Corp n.d.). The FIA is an international governing body rivaled only by the IOC (International Olympic Committee) and FIFA (Fédération Internationale de Football Association) in its reach and influence. As an organization, Formula 1 appears to be somewhat democratic in the modern era, but the politics of how this came about

are anything but. Threats, coercion, power struggles, favors, and financial influence drove the politics that grew this European gentleman's hobby to the global juggernaut that exists today.

# CHAPTER 2

## Unorthodox strategies and hidden incentives in Formula 1 racing


### ABSTRACT

This chapter reconstructs strategic dilemmas found in Formula 1 racing and models them with varying degrees of formality. Formula 1 has one of the largest financial footprints of any sport, with direct economic ties to dozens of nations and fans in many more. Elements of traditional political public choices, such as strategizing, collective action, and con games, exist in F1 as well, and I argue that it can be considered political in nature. The analysis in this chapter pays special attention to strategic dilemmas in which seemingly irrational actions are revealed to be payoff-maximizing in light of hidden motives. The purpose of the present study is to provide a better understanding of this influential, global sport, while at the same time highlighting the non-obvious and counterintuitive strategies developed within a highly competitive environment.

## 2.1. Introduction

Who first studied strategy in sports is unknown. Perhaps it was the loser of the first ever sporting match, hoping to gain an advantage the next time around. Modern sports are particularly well-suited for formal strategic analysis because they have clearly defined rules and objectives and are played frequently enough to provide rich data. Formula 1 racing is no different, yet the strategic aspects of the sport have received surprisingly little academic attention. This chapter seeks to fill that void by highlighting hidden motives that exist within the sport and modelling the strategic dilemmas they bring about.

It is tempting to dismiss sports as mere entertainment, but to do so would be a mistake. The largest professional sports leagues have annual budgets equal to those of small nations. They also have spillover effects in retail, hospitality, and other industries. Beyond economics, sports also impact politics. The trend to acknowledge the role of sports in international relations has gained momentum in recent years (Levermore and Budd 2004). Even the United Nations has used sports as a means to promote several of its missions (Jackson and Haigh 2008). Success, and even participation, in international sporting events historically has been leveraged as a political tool, the most famous examples being the 1980 and 1984 Olympic boycotts by the United States and the Soviet Union, respectively (Guttmann 1988). Sports likewise can be used for the purpose of political healing, as was the case with the South African Springboks during the 1995 Rugby World Cup (Steenveld and Strelitz 1998). Hosting major international sporting events is a way for nations to shape their international images, as exemplified by South Korea with the 2002 (Lee et al. 2005) and Germany during the 2006 FIFA World Cups (Grix and Houlihan 2014).

Sports are a popular subject for the application of economic tools. Cheng and Coughlin (2017) use Shapley-Shubik and Banzhaf power indices to analyze the contributions of individual figure skaters during team competitions, providing a new way to quantify individual player value in a team setting. Demmink (2010) takes an economic approach to placing a value on stolen base attempts in baseball, adding to the rich literature in that sport. Horrace, Jung, and Sanders (2020) use basketball as a platform for developing new methods of measuring the effects of team chemistry and competitive rivalry. Hammond (2007) has identified examples in running competitions of a scoring system violating social choice principles and creating vote cycles. The role of scoring systems in determining competitive outcomes in NCAA (National Collegiate Athletic Association) cross-country running (Boudreau et al. 2018) and opportunities for strategic manipulation of scoring in team tennis matches (Sanders, Ehrlich, and Boudreau 2017) also have been studied. McCormick and Tollison (2010) even provide an economic explanation for the regional differences in how golf course layouts accommodate female players. The current research adds to that tradition by analyzing strategies, deception, coalitional behavior and other maneuvering in a competitive setting that mirrors important political public choices.

Among all sports, one may think that various forms of racing involve minimal strategy, with "go faster" always being the dominant strategy. Yet, even here, work has been done on the determination of optimal race pacing (Díaz, Fernández-Ozcorta, and Santos-Concejero 2018), as well as pacing execution (Santos-Lozano et al. 2014; Takai 1998) in various running disciplines. Even the will to win causing champion runners to ignore optimal effort-minimizing strategies in early qualifying rounds of competition has been examined (Hanley and Hettinga 2018). In swimming, we have literature on pacing (Oliveira et al. 2019) and pacing variations across race distances (Veiga et al. 2019). Within cycling, pacing has been explored from theoretical

(Sundström, Carlsson, and Tinnsten 2014) and empirical (Koning, Bobbert, and Foster 1999) perspectives. Cycling has the added strategic element of drafting, whereby one rider reduces wind resistance by following another closely and, of course, the strategic implications of that strategy have been studied as well (Olds 1998). Little, if any, similar research exists for Formula 1.

Formula 1, along with the IOC (International Olympic Committee) and FIFA (Fédération Internationale de Football Association), is one of the few sporting organizations that has a truly global reach. So it makes sense that some aspects of the sport have been studied. Scoring, including historical analysis (Kaiser 2019) and alternative systems (Langen and Krauskopf 2010), has been examined. Factors influencing competitive balance (Judde, Booth, and Brooks 2013; Mastromarco and Runkel 2009), as well as the role competitive balance plays in viewer interest (Krauskopf, Langen, and Bünger 2010; Schreyer and Torgler 2018) also have been studied. The Peltzman effect, which theorizes that increases in safety regulations will lead to more reckless behavior among drivers, has been observed in Formula 1 (Potter 2011), as well as in NASCAR racing (Pope and Tollison 2010).

Some of the behaviors we see in Formula 1, even those of competitors, can appear irrational, reckless, or otherwise confusing. Yet the sport is a competitive world full of intelligent people who have had plenty of time to refine strategies, making us wonder whether there is a method to their madness. As with political public choices, a number of ways to take advantage of rules to achieve desirable outcomes are available. What follows is a strategic analysis of counterintuitive behaviors and unexpected dilemmas found in F1.

The research at hand describes and analyzes decisions faced by various players and attempts to understand their motives and actions. Cases will be presented as strategic dilemmas

with varying degrees of formalization. A few of the cases are opportunities that theoretically could be exploited, but most are derived from actual events that have taken place. In each example, I will lay out what could be called a naïve view of the game being played and then I will introduce a hidden motive or incentive that sheds light on the strategic actions we observe.

The approach of juxtaposing two perceptions of the same game has been used by Kaminski (2003; 2004) to explore strategic prisoner behavior and con games in Polish prisons. It is a modeling technique that allows us to analyze strategic interactions from different points of view, bringing to light different perceptions of events. The topics covered by Kaminski include initiation rituals that new inmates may not understand, linguistic banter that actually serves to reduce violence, and the self-injury and illness-faking that serve as a means of achieving early release or transfer. The present chapter conducts a similar survey of hidden games within Formula 1.

Section 2 looks at the fundamental features of Formula 1 and defines relevant players. That section also includes a brief rundown of what, to the uninitiated, would appear to be the obvious strategic choices that teams and drivers should make. Sections 3-5 identify and analyze cases from Formula 1, defining three broad categories of hidden games in that sport. The categories are intertemporal dilemmas, coalitional dilemmas and general non-racing dilemmas. Section 6 concludes.

## 2.2. The rules of the game

Strategy in any setting is shaped by the rules governing interaction and competition; Formula 1 is no exception. To make sense of the cases that follow we will first get the lay of the strategic landscape. In its current iteration the sport consists of ten teams fielding two cars each.

The number of teams is allowed to fluctuate within a small margin. The number of cars per team is presently set at two, but historically that number has varied dramatically. Typically, each team will have two drivers under contract, each assigned to a specific car for the duration of the season.

A season consists of approximately 20 races. Two championships are awarded each year – one for the winning driver and one for the winning team. Points are awarded at each race using a truncated, weighted Borda count. The same type of scoring is present in a number of sports settings, including Major League Baseball's Most Valuable Player (MVP) voting (Sanders et al. 2021). As of the 2020 season, points are awarded at each race to the top ten finishing drivers, and their teams, according to the following allocation: (25, 18, 15, 12, 10, 8, 6, 4, 2, 1). The points are totaled at the end of the season to determine final championship rankings. In the past, other variations of the scoring system have been used.

Small changes are made to the rules every season, with major overhauls coming regularly but less frequently. The changes focus primarily on car design but can cover other issues such as the scoring system, limitations on vehicle testing, jurisdiction of racing officials, and safety regulations. Other regulations include a maximum number of times certain components or parts can be replaced throughout the course of a season. Teams often play a role in negotiating the changes, and they are known in advance by all parties.

The sport is very expensive and securing sources of revenue is critical to its operation. Each year teams receive payouts as part of the championship, based partly on how they performed over the previous season and partly on other factors. Teams also bring in money through sponsorship deals, and some are subsidized by parent companies. Formula 1 itself (the governing body) makes money through sponsorships, selling TV rights, and fees charged to the

venues that host races, all of which creates a rich landscape with multiple parties driven by complex and often conflicting sets of incentives.

A naïve view of the sport would lead us to believe that the dominant strategy for competitors should be transparent and rather straightforward. To do well in a championship, teams and drivers must place as high as possible in each race. To do well in an individual race, one needs to reach the finish line as soon as possible. Teams should hire the two fastest drivers available to them. Drivers should seek to join the team with the fastest car. It seems as though it should all be very obvious. However, for competitors in the sport things are not always as simple as they might look to an outsider.

### 2.3. Intertemporal dilemmas

Competitors in F1 must balance multiple time horizons continuously. Championships and payouts are determined by performance across entire seasons. Yet points are earned in individual races. Intertemporal dilemmas exist when the ideal strategy for a given time horizon is not ideal for another, such as when a single event represents a small part of a larger, or repeated, interaction. Behaviors that don't seem to make sense in a one-shot game are more easily understood when put in proper context. The same dynamic is paralleled in other sporting and political settings, wherein a competitor must conduct a smaller battle with an eye toward the larger campaign.

### 2.3.1. Senna-Prost

In 1989, Prost and Senna were teammates at McLaren. The Japanese Grand Prix was the second to last race of the season and, heading into it, Prost was leading the championship over Senna by 16 points, with no other drivers left in the hunt. Near the end of the race Senna attempted to pass Prost for the lead. Prost did not yield and give Senna room, leading to a crash that caused Prost to immediately retire from the race. Senna went on to finish the race in first place but was disqualified later on a technicality. Only Prost himself knows what his true intentions were, but some commentators have made the assertion that he failed to make any effort to prevent the crash from taking place. Why would a driver ever choose to allow a collision that ends his/her race and results in scoring zero points? Before getting to the answer, we need some context. In that era, first through sixth places in each race were awarded 9, 6, 4, 3, 2 and 1 point, respectively. Additionally, championships applied a selective scoring system under which only the best 11 out of 16 performances for each driver were counted. If Senna were to win the last two races of the 1989 season, and Prost failed to score points in either, Senna would have won the championship. If Senna failed to win either race, or if Prost scored three or more points over the final two races, Prost would be champion.

During races drivers must often decide whether to take evasive action or commit to a driving line that may lead to a collision. If they take no evasive action, they face the possibility of a crash involving themselves or an opponent. Often the expected payoff for taking no evasive action is such that drivers avoid collisions (Figure 2.1a). In the case at hand, Prost's expected payoff from a collision was altered slightly (Figure 2.1b). In the event that both drivers crashed and ended their races, he would immediately become champion. Prost had no way of knowing what the outcome would be, but he certainly had less incentive than usual to avoid a collision.

Though Senna's race win and subsequent disqualification add another layer of complexity to the story, Prost did end up securing the championship that day (DeGroot 2014).

**Figure 2.1a.** Typical driver facing possible collision

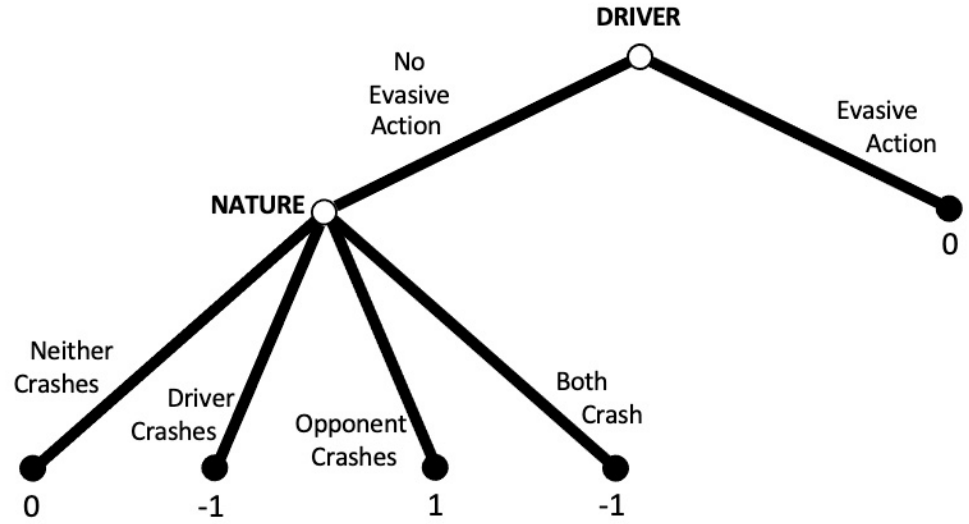



**Figure 2.1b.** Prost facing possible collision (1989 Japanese Grand Prix)

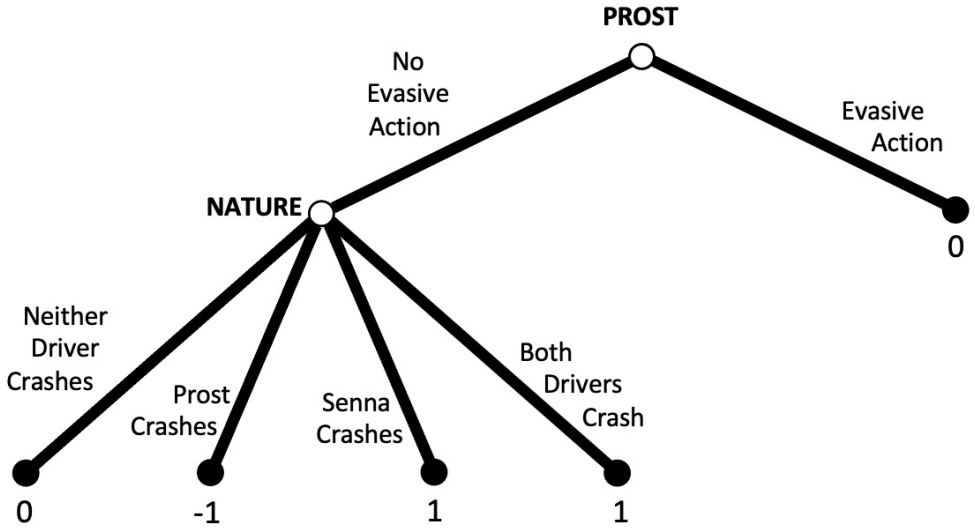



Figure 2.1a shows the typical scenario of a driver faced with an impending collision. He can choose to take evasive action and maintain the status quo, leading to a payoff of 0 (for simplicity, overtaking and reversals of on-track positions have been omitted from the model). The driver also can choose to take no evasive action, and accept a lottery over four possible outcomes, determined by a move by nature. We assume equal probabilities of 25% for each outcome, leading to an expected utility of -0.25. Here, taking evasive action is preferable. Figure 2.1b shows Prost's case, with the node "Both drivers crash" providing a positive payoff, changing the expected utility to +0.25, which is higher than the payoff for taking evasive action. A "crash", in this case, means elimination from the race or falling back significantly in the field.

The story had another twist one year later, at the same event, between the same two drivers. Senna still drove for McLaren and Prost had switched to the Ferrari team. With two races to go in the season, Senna was leading the championship by nine points, but it was still possible for Prost to overtake him and win the championship. In the first corner of the first lap, the two crashed, ending both of their races. With neither driver scoring points in Japan, it became mathematically impossible for Prost to win the championship in the last race (only the best 11 races were counted for each driver, so even if Prost scored 9 points with a victory in the final race, he would have dropped 2 points from a race earlier in the season). Again, speculation was widespread that the beneficiary of the crash, in this case Senna, had allowed it to happen for strategic reasons.

### 2.3.2. Hamilton's delay of game

In 2016, Rosberg and Hamilton were teammates at Mercedes. The last race of the season was in Abu Dhabi. After roughly 40 laps out of a 55-lap race, Hamilton was leading with Rosberg in second place. Hamilton suddenly began to slow his pace dramatically (Weaver 2016). When the team requested that he speed up, he ignored them. Not only was Hamilton giving Rosberg the opportunity to pass him and take away the race victory, but several other competitors were closing in on him as well. Hamilton essentially had a victory in hand, which earns maximum points toward the championship, so why would he deliberately give others a chance to take that away from him? It turns out that Hamilton was quite strategic, and pretty good at arithmetic too.

Heading into the race, Rosberg was ahead of Hamilton in the championship by 12 points. The scoring system in use that season awarded points for positions one through ten as follows: (25, 18, 15, 12, 10, 8, 6, 4, 2, 1). Hamilton needed to outscore Rosberg by 12 points or more, and there were a number of different ways in which that could be done. If Rosberg finished in 7th (6 points), Hamilton needed to finish in 2nd or better (18+ points). If Rosberg finished in 4th, 5th or 6th (12, 10, or 8 points), Hamilton needed to win the race (25 points). However, with Rosberg in second (18 points), Hamilton had no way of earning enough points to win the championship. Hamilton realized that the only thing he could do was try to cause Rosberg to earn fewer points. Hamilton may or may not be helped by a potential crash but, given that the status quo meant he could not win the championship, he had little to lose from a crash.

Hamilton's reason for slowing down was to allow other drivers to catch Rosberg and potentially pass him, reducing the points Rosberg would earn and giving Hamilton a chance to win the championship. The brilliance of that strategy was Hamilton's anticipation of Rosberg's reaction. Hamilton slowed his pace to the point that Rosberg probably could easily have passed him, but Rosberg made little effort to do so. If Rosberg were to drive aggressively, and possibly crash, he may have created a window for Hamilton to take the championship from him. Alas, Hamilton's plan was likely doomed to failure. Had anyone overtaken Rosberg for second place, they would have pursued Hamilton, forcing him to speed up. At that point, Rosberg could have followed comfortably in third place, which would have earned him enough points to win the championship. In the end, Rosberg chose to stay behind Hamilton and allowed other drivers to close in on him. Rosberg finished the race in second place and became the Drivers' Champion for 2016.

### 2.3.3. Cutting losses

Each winter off-season, teams develop cars according to new regulations. Teams continue to develop the car as the season progresses, hoping to gain or maintain an advantage over the competition. Following the 2019 Italian Grand Prix, the Renault and McLaren teams were battling for fourth place in the Constructor's Championship. McLaren had watched as their lead over Renault shrunk from 43 points to 18 points. Strangely, McLaren was open about its plan to slow development of its car, and even stop development entirely within a few races. For a team whose position in the championship was under threat, that plan seemed to be the wrong strategy. The probability was very high that they would drop from fourth to fifth in the championship, potentially losing millions of dollars in the process. (Figure 2.2a).

**Figure 2.2a.** Naïve Interpretation of cutting losses

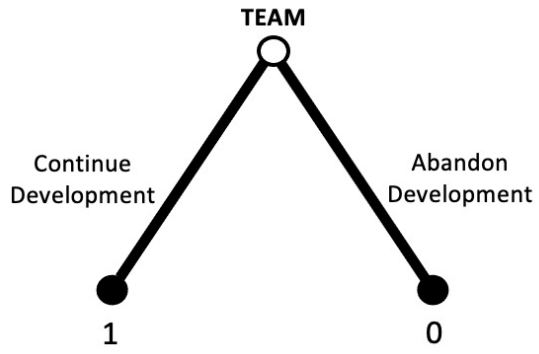
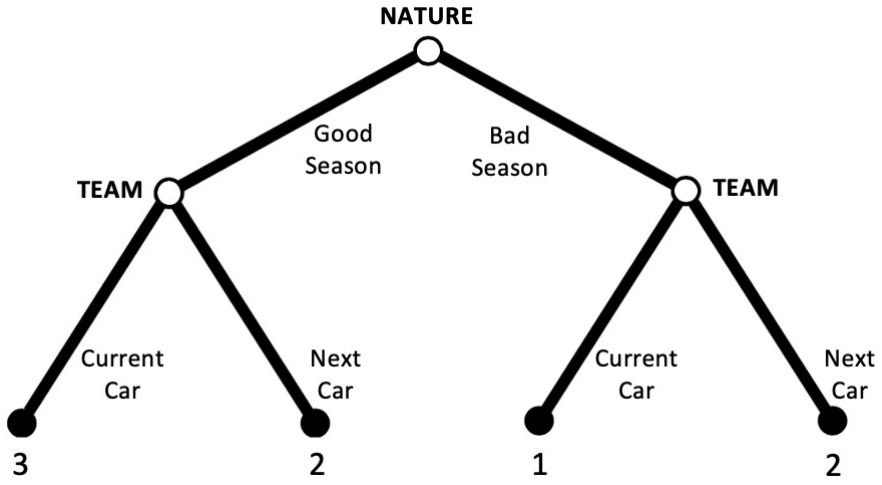


**Figure 2.2b.** Informed interpretation of cutting losses




In the naïve version of the dilemma, the obvious solution is to continue improving the current car because doing so can only lead to a better payoff. In the informed version, we see that a good future season, even if discounted to the present, typically is worth more than a bad current season.

To make sense of McLaren's strategy, we need to first understand the player implementing it. McLaren is the second oldest and third most successful team in Formula 1. A fourth-place finish in the championship was not particularly noteworthy. For them, only championships matter, and they think long-term, meaning that the perceived loss of dropping from fourth to fifth in the current season was small. However, McLaren wasn't giving up, it was thinking ahead.

Teams work with finite resources, and the scarcest of all is human capital. If a team is doing well in a season, they will want their staff to use their time to continue developing the car until the final race. Then they all switch to working on the next season's car as soon as the current season concludes. However, if a team is not doing well in the current season (as, by its own standards, McLaren was not in 2019), it can make sense to stop dedicating staff hours to a lost cause and turn their attention to the next season. Some aspects of cars remain the same from

season to season, meaning that development in the present can pay future dividends. However, frequent regulation changes limit the amount of carry-over each year. More important, if a team determines that its current concept has a fundamental flaw, they may need to redesign everything from the ground up for the following season. Starting the following year's car early means that it will be developed further by the beginning of the next season, giving the team a leg up on the competition. Figure 2.2b shows the calculations teams face when deciding if they should cut their losses in the current season to ensure success in the following one. That is a case of investing resources where they are likely to yield the greatest returns.

### 2.3.4. Conserving resources

At the 2019 Russian Grand Prix, Robert Kubica was driving for the Williams team. Just over halfway through the 55-lap race, Kubica retired the car and deliberately ended his race, even though the car appeared to be running perfectly fine. The Williams team was in last place in the championship, and Kubica was in second to last place in the race. The team was in desperate need of points, so passing up any opportunity to score did not seem to make much sense. It turns out that the Williams team was thinking ahead to future races and trying to maximize its payoff over the full season.

Kubica's teammate had experienced a mechanical malfunction on the previous lap, and the ensuing crash had done extensive damage to the car's aerodynamics. The team was afraid that Kubica's car, which fundamentally was identical, could experience the same fate, and they decided not to risk it (*ESPN.com* 2019). They knew that if Kubica did not finish in tenth place or better he would not score points. So, finishing the race in eleventh or worse earned no better

payoff than simply retiring the car. What is more important, the Williams team was thinking ahead to the next few races, which all were going to be on different continents from their UK factory, introducing logistical challenges. Adding more wear and tear on parts by finishing the race would bring them closer to the point of failure. When parts fail on the other side of the world from the team's factory, replacing them is challenging. The team made the strategic decision to save miles on the car so that they would be in a stronger position over the next few races. Maximizing their payoff across multiple races dictated an action that was the opposite of what they would have done in a stand-alone event.

### 2.3.5. Intertemporal dilemmas in other sports

Intertemporal dilemmas exist in other settings beyond F1. In many team sports, new players enter a league through a draft. A common approach used to determine the order in which teams make draft picks is to give the earliest picks to the teams that have performed the worst over the previous season. That ordering of draft picks creates an incentive for teams to do what is known as tanking. We normally would expect teams always to compete to win every contest. However, if a team determines that a championship is out of reach in the present season, they have an incentive to deliberately begin losing games so that they earn a better draft pick the following season. With no knowledge of that draft pick motivation, it would be hard to make sense of teams deliberately losing games. That is not just a theoretical issue. It occurs frequently and has been studied extensively across multiple sports (Balsdon, Fong and, Thayer 2007; Borland, Chicu, and Macdonald 2009; Price et al. 2010; Taylor and Trogdon 2002; Walters and Williams 2012).

Another, very bizarre example of an intertemporal dilemma comes about because of the way FIFA's world rankings are calculated in soccer. Cases exist when winning a match at one point in time is detrimental to a team in future tournaments. FIFA's world rankings are calculated using two formulas. First, the value of an individual match is determined as follows:

$$P = M \text{ x } I \text{ x } T \text{ x } C,$$

where $M$ is the outcome (3 for a win, 0 for a loss, 1 for a tie, 1 for a shootout loss and 2 for a shootout win), $I$ is the importance of the match (ranging from 1 for a friendly match to 4 for a World Cup match), $T$ is the strength of one's opponent (using the formula 200 – r, where r is the opponent's rank), and $C$ is the opponent's federation, or regional association (ranging from roughly 0.85 to 1.0). A team's ranking is determined by its weighted average $P$ value over the previous four years, in the following way:

$$R = P_{-1} + 0.5P_{-2} + 0.3P_{-3} + 0.2P_{-4},$$

where $P_{-1}$ represents the previous year, $P_{-2}$ the year prior to that, and so on. The raw $P_{-i}$ value for a given year is the average of all matches played within that 12-month period. Cases exist in which a team plays a low-ranked opponent in a friendly (non-tournament) match, and even with a decisive victory the winner's world ranking will drop owing to the low value of that match reducing the total value of $P_{-1}$. The phenomenon has been explored in detail by Kaminski (2012). If a team is focused on rankings and future tournament seedings, it may be a better strategy to forgo certain matches even when victory is relatively assured.

## 2.4. Coalitional dilemmas

Despite the focus on individual drivers, Formula 1 functions largely as a team sport. Teams must choose which two drivers to sign and drivers must decide which teams to join. Teams must weigh the success of the team against the performance of each driver, and at times those priorities can conflict with one another. A driver may have to choose if and when to put their own interests ahead of the team's, mirroring the politics of coalition formation and collective action problems.

Coalitional dilemmas can exist any time team harmony plays a role in success. Opportunities for the formation of coalitions often arise that seem strange on the surface, but that benefit players in unexpected ways. One might think that individuals should join the strongest teams they can, teams should recruit the most talented members available, and everyone should support one another to maximize the odds of success. Considerations of team dynamics may help us understand why many successful teams and drivers implement entirely different strategies.

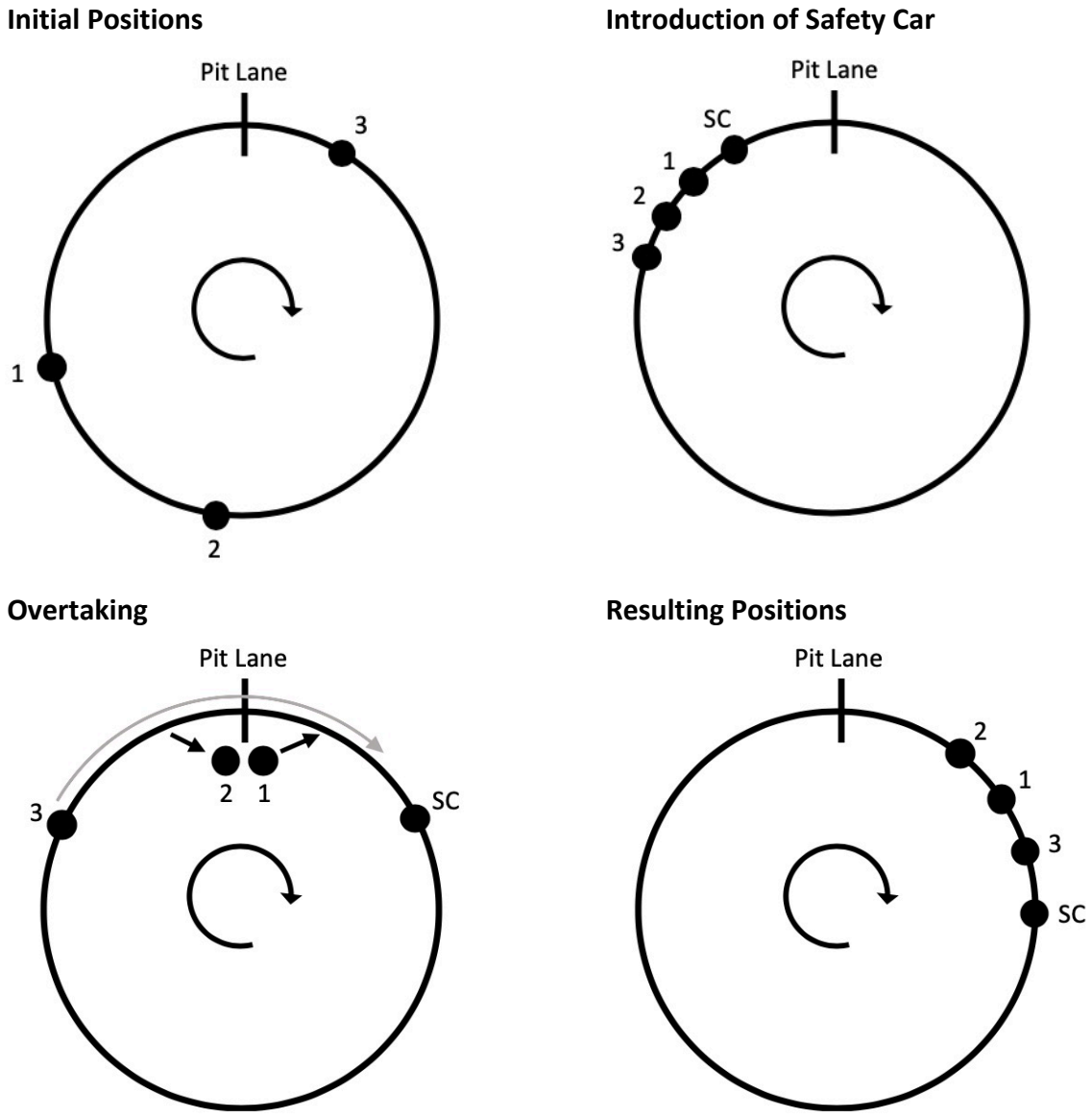
### 2.4.1. Sacrifice shunt

On lap 14 of the 2008 Singapore Grand Prix Nelson Piquet, Jr. lost control of his car and crashed into a wall, ending his race. The crash meant that Piquet would not be able to score points for himself or for his team, Renault. It also meant that the car would require costly repairs. Piquet stated that the cause of the crash was the hard tires that had been put on his car. Strangely, he changed his story less than one year later. When Piquet left the Renault team in

2009, he announced that he had been ordered to crash in Singapore the previous year (Lewis 2018). As outlandish as this claim seemed, it eventually led to a suspended sentence for the Renault team, along with banishment from the sport for some of the team's top management.

Why would a team order one of its drivers to crash deliberately, especially in light of the need to conserve resources? In the just-described case, it was to help the team's other driver win the race, which was worth the cost of a damaged car. The team's lead driver, Alonso, had experienced mechanical problems in qualifying and started the race near the back of the grid. Alonso's first pit stop was earlier than other drivers, and two laps later Piquet crashed. The purpose of Piquet's crash was to bring the safety car onto the track, which slows drivers down, giving drivers trailing the leader a chance to close the gap and catch up. Drivers also use safety cars as opportunities to make pit stops because reduced speed means that fewer cars will pass them while they are in the pits. Pit stops require a certain amount of time, called a delta. If the pit stop delta is equivalent to roughly one-third the time of a typical lap, every other car will cover one-third of a lap while a driver is in the pits. With a safety car on the track, speeds are reduced (for simplicity we will say by one-half), so other cars cover only half the distance they normally would while a driver is in the pits. Instead of losing one-third of a lap in track position, under a safety car a driver only loses one-sixth of a lap during a pit stop. The Renault team used that knowledge to tempt other teams into making pit stops by bringing out the safety car. Since Alonso had just made a pit stop, he did not need to make another, so he stayed on track. Everyone else that made pit stops re-entered the track behind him, leaving Alonso in better position after the safety car left the track (see Figure 2.3). Alonso ended up winning the race because of that choice. While Alonso himself was cleared of any wrongdoing, it was concluded that the team had planned the strategy to aid in his victory.

**Figure 2.3.** Alonso overtaking opponents




The diagram shows the stages of a pit stop overtake under safety car. Initially, cars are spaced out on the track. With the safety can present, gaps between cars are reduced as cars gather behind the safety car. As cars 1 and 2 make pit stops car 3 stays on the track and passes them. When cars 1 and 2 return to the track they are behind car 3.

While the Singapore scandal was an egregious use of team orders, many other cases can be found. A much more common occurrence is a team ordering one driver to allow another to pass so that the lead driver can maximize points. That happened with Ferrari at Austria in 2002 (Schumacher passing Barrichello), McLaren at Australia in 1998 (Hakkinen passing Coulthard), and with BMW at Canada in 2008 (Kubica passing Heidfeld).

As an aside, the Virtual Safety Car is a relatively modern innovation in F1. Under a normal safety car, drivers are allowed to close gaps and group up right behind the safety car (as long as they are no more than one lap behind the leader), meaning that large leads over trailing drivers are wiped out. Under a Virtual Safety Car, all drivers are forced to maintain a constant speed, which keeps gaps between positions constant. That difference has changed how pit stop strategy is handled by teams.

### 2.4.2. Stable stable

When building a driver lineup, the simple assumption would be that teams want the two best drivers available. However, many teams avoid that strategy and have one aggressive lead driver paired with a talented but slightly more agreeable second driver. The reason is because having two hyper-competitive drivers on the same team can potentially lead to problems.

Some teams have tried that in the past and a common outcome is as follows: overwhelming success in the short-term, followed by hostility and a rapid implosion of the team. As teammates for McLaren, Senna won the championship in 1988 and Prost in 1989. However, competition between teammates quickly led to open hostility, including the crash in Japan described in the Prost-Senna dilemma. After just two years together, the relationship became

unsalvageable, and Prost left the team following 1989. McLaren again attempted to pair two dominant drivers in 2007, with Alonso and Hamilton. That duo lasted only one year, as Alonso departed the team the following season. The rivalry came to a head in Hungary when Alonso interfered with Hamilton's qualifying run. The drivers tied for second place in the championship, and although the team earned the most championship points that season, it was disqualified for spying on Ferrari (which was exposed partly because of the drivers' conflict). In 2016, Mercedes partnered Hamilton with Rosberg. The team won nearly every race that season, but competition between drivers became too much when neither would flinch on the first lap of the Spanish Grand Prix, leading to a crash (Benson 2016). The team threatened both drivers with punitive action should it happen again, and Rosberg retired from the sport after winning the championship that year.

On-track encounters can be seen as microcosms of teammates' relationships. Drivers play chicken constantly with one other. If one driver yields, the other comes out ahead. If neither yields, a crash is likely. Some drivers refuse to be beaten, no matter the cost. Others are more measured and undertake strong efforts to avoid crashes. Through repeated interactions, drivers tend to learn about one another, and pairs can develop dynamics between them. Teams must weigh internal harmony against external competitiveness when building a driver lineup. Overly passive teammates would avoid crashing with each other but likely would be dominated by other teams. Overly aggressive teammates develop conflicts and often crash with one another, as described above. The solution adopted by many teams is to have a clearly defined lead driver. Both drivers can be aggressive against competitors but encounters between teammates follow the script laid out by the team. For that reason, teams with a top driver often will not sign another top driver even when they are available.

### 2.4.3. Pay drivers

Heading into the 2016 season, the Renault team had Maldonado under contract as one of its drivers. Suddenly, Maldonado was released and replaced by Magnussen (Duncan 2016). It was the off-season, so Maldonado's current performance was not an issue. He had not been involved in any sort of scandal or offended the team. Maldonado was released because the bill for his position with the team had not been paid. It was not a matter of the team failing to pay Maldonado – it was Maldonado failing to pay the team. Maldonado was what is known as a "pay driver", meaning that someone (in this case, the Venezuelan state-owned oil and gas company PDVSA) provides sponsorship money in exchange for the driver having a place on the team.

While most drivers bring some form of sponsorship money with them to a team, the term "pay driver" typically refers to a driver that would not remain in the sport without sponsorship money, as was the case with Maldonado. From a team's perspective, it is a matter of tradeoffs. Pay drivers are typically competent and even somewhat talented, but usually are not the most skilled in the sport. Teams that accept pay drivers have estimated that the additional funds can be used to produce a car that is fast enough to make up for the less talented driver. However, if one pay driver is good, would two be even better? Most teams choose to sign only one pay driver because the other, more experienced and skilled driver can provide knowledgeable feedback to engineers and showcase what the team is capable of. With two pay drivers, the cars are unlikely to achieve their full potential and if the drivers leave the team or the money dries up, the team is left with a poor performance history that can make finding new sponsors and quality drivers difficult.

### 2.4.4. Choosing a team

Red Bull had been one of the top teams throughout the 2010s and remained highly competitive heading into the 2019 season. When Ricciardo announced that he was leaving the team for 2019, many observers struggled to make sense of it. Why would a driver want to leave Red Bull, a top team, for Renault, a middle of the pack team? Many rumors have circulated as to the reasoning behind the move. An increase in salary, a desire to lift Renault out of mediocrity, and discomfort with Red Bull's pending switch to Honda engines have all been cited. Another theory has been floated that involves a dilemma faced by many drivers. At Red Bull, Ricciardo was at best treated as equal to teammate Verstappen, and at worst was being relegated to a supporting role. At Renault he would be paired with the talented Hulkenberg, but most commentators assumed he would be the team's lead driver.

Not many drivers in F1 have much choice regarding the team they join. If an opportunity is open, they take it. A few drivers, like Ricciardo, are sought after and have some control over where they sign. Such drivers also tend to have the most competitive mindsets. Why would a competitive driver choose to join a team that leaves them less likely to score points and win a championship? For some, the thought of driving a competitive car and placing well in the championship, but still receiving less internal support than their teammate, is unbearable. Even worse is the prospect of being asked to sacrifice for a teammate. Figures 2.4a and 2.4b highlight the dilemma. Drivers usually know what their place will be in a team up front. Faced with a choice between leading a lower-ranked team and being in a supporting role on a better team, drivers with different dispositions will make different choices.

**Figure 2.4a.** Choosing a team without driver ego

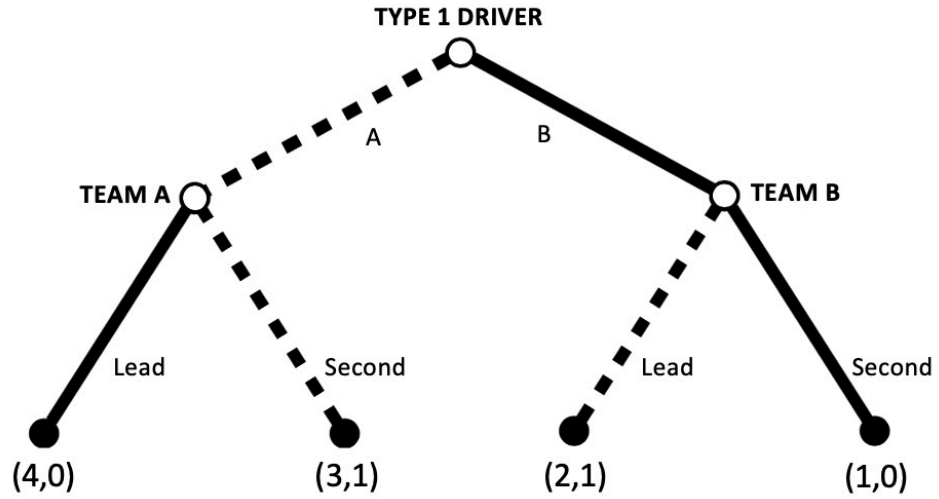
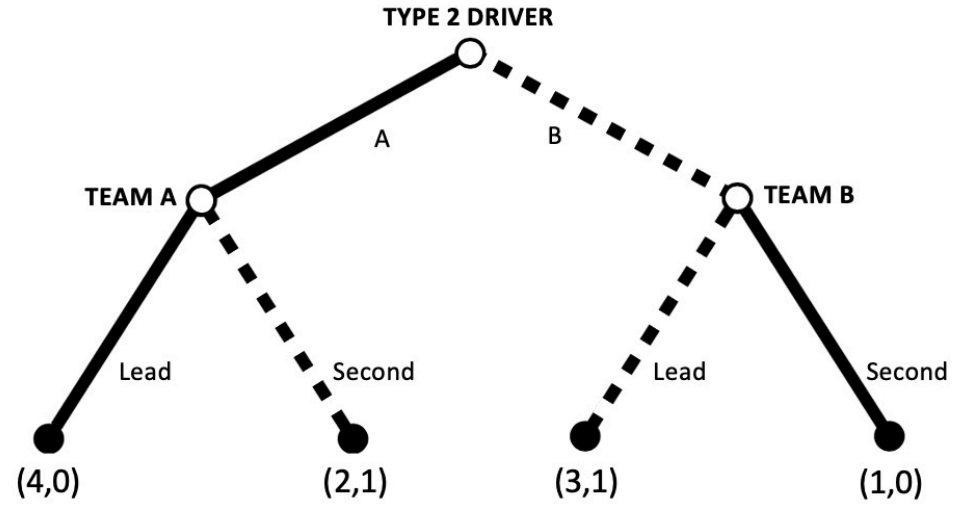



**Figure 2.4b.** Choosing a team with driver ego




Team A prefers to assign a new driver to a supporting role. Team B prefers to make a new driver the team lead. Type 1 Driver values objective race results, Type 2 Driver prioritizes status within their own team.

### 2.4.5. Coalitional dilemmas in other sports

In cycling, road racing crowns individual riders as champions, even though it is ultimately a team sport. Teams have members that are known as domestiques (Bailey 2014; Mignot 2016). They are riders whose primary function is to support their team's lead rider in a

variety of ways, including riding in front of the lead rider to create a wind break and reduce resistance for the lead rider. Domestiques are talented and often specialize in a particular aspect of racing, such as climbing in hilly sections, or sprints. Some domestiques are well-rounded enough to be lead cyclists themselves, but they are willing to provide support instead. The challenge in building a successful team is finding domestiques who are talented enough to be helpful, but also humble enough to allow someone else to take the glory.

Many players of American football at the collegiate level are hoping to be recruited to the NFL (National Football League). Choosing which college to attend is a critically important strategic decision for those young athletes. A simple assumption is that athletes always prefer to join the best team possible, because doing so gives them the best opportunity to win and be recognized. However, top teams have no shortage of talent and the odds of a young recruit seeing much playing time, thereby drawing the attention of professional scouts, can be lower on traditional powerhouse teams. Players take into consideration their potential playing time (Dumond, Lynch, and Platania 2008; Mirabile and Witte 2017), and some players make the strategic decision to join lesser teams so that they are assured more playing time and higher visibility in the hope of making it to the professional level.

## 2.5. Non-racing dilemmas

Many strategic games are played in Formula 1 beyond the intertemporal and coalitional dilemmas faced by teams. Driver safety and race revenue are prime examples. Teams must manage budgets, cultivate sponsor relationships, and plan high-level strategy for their futures. In one sense, the present discussion is a catch-all category, but it does the important work of

highlighting the fact that decision-making extends beyond the field of play. In any competitive environment, a number of peripheral strategic dilemmas exist, including externalities generated by competition, the influence of special interest groups, decisions regarding resource allocation, and much more.

### 2.5.1. Track specialist

Is it possible that the best strategy for some teams is to put less effort into certain races? Each race in a season is held on a different track with unique characteristics. On certain tracks there is more emphasis on cornering, requiring more aerodynamic downforce (like airplane wings, except pushing down instead of lifting up) to help tires maintain traction with the racing surface. On other tracks there is more emphasis on higher speed, requiring less downforce because having less downforce allows a car to slip through the air easier. The common approach is for teams to develop multiple "aero packages" to suit different tracks, which can be very expensive. Top teams expect to compete for wins in every race and with their large budgets that is not a problem. Smaller teams must be more judicious when it comes to how they allocate their resources. Typically, they aim to be well-rounded and end up with relatively consistent results somewhere in the middle or back of the field. They could opt to become specialists and improve their odds of better results on certain tracks while focusing less on others.

Becoming a specialist is a viable strategy only because of the scoring system adopted by F1. F1 uses a weighted, truncated Borda count system, meaning that finishing below a certain position ($10^{th}$ place under the current system) earns no points. Therefore, if a team would expect its typical finishing position to earn no points, specializing and earning points in at least one race

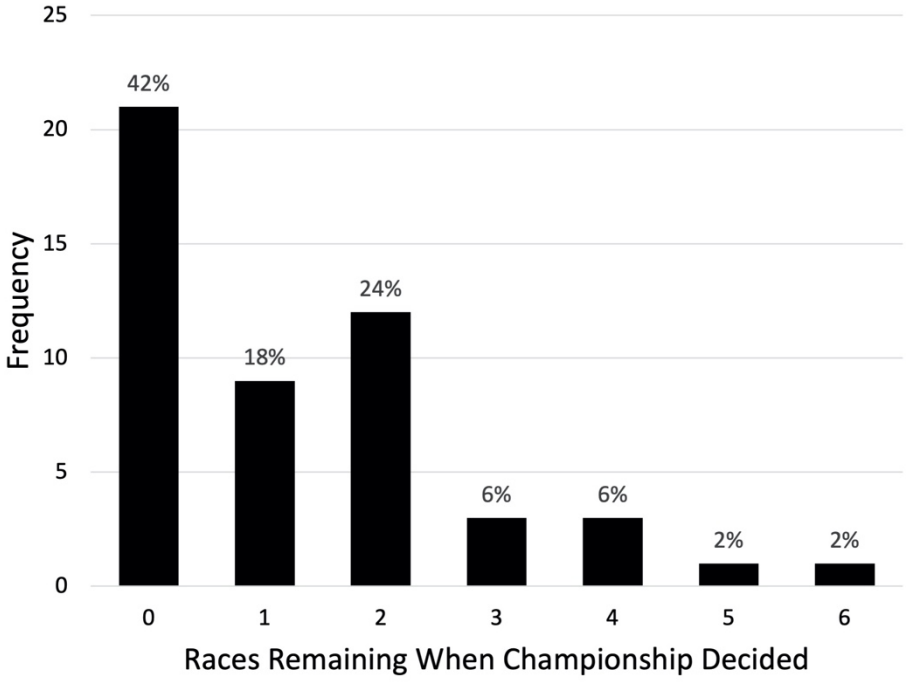
represents a net gain in points. Even if a team would expect its typical finishing position to earn just a few points in each race, gains may still be had from specialization. If we assume that specialization leads to better results in some races and worse results in others, both in equal proportion, the net gains should be positive. That is because the increase in points earned for each successive move up in the order in a given race is greater than or equal to the reduction in points from an equivalent move down the order in another race. For example, under the current system, moving up from 4$^{th}$ to 3$^{rd}$ earns an additional three points, while moving down from 4$^{th}$ to 5th means a loss of two points. Specializing and earning one 3$^{rd}$ place finish and one 5$^{th}$ place earns more points than being consistent and earning two 4$^{th}$ places.

### 2.5.2. Host scheduling game

Hosts pay the Formula 1 organization significant fees for the right to host races. Some hosts are able to make a profit from hosting a race, while others are hoping to attract tourism and foreign investment to their nations. In both cases, visibility and public interest in the race is desirable for the host. Many factors determine the calendar of races. Seasons and weather in different regions must be considered and organizers make some effort to cluster races together in the same geographic region to reduce travel costs and make logistics easier. Within those constraints, certain slots on the calendar should be more attractive to hosts because they draw more publicity, such as the opening race of the season. The crowning of the Driver's Champion is often the key moment each season and the race in which it occurs always attracts considerable attention. With that in mind, one would think that the most desirable race to host would be the final race.

The final race of the season is always significant in its own right, but the scoring system used in F1 means that the last race does not necessarily decide the championship. In fact, less than half of all championships are decided in the final race of the season (Collantine 2019). If we assume that the later races are more likely to decide the championship, and that public interest steadily increases for each successive race, then drastically falls off after the championship is decided, we can build a decision-making model for the ideal calendar slot for maximizing the attention a race receives. The challenge is, however, that hosts never know exactly how early the championship will be decided (Figure 2.5).

**Figure 2.5.** Championship-deciding race




The chart shows how many races were remaining in the season when the Drivers' Championship was decided (ranging from 0, for the last race of the season, to 6), and the frequency of each case. The percentage of all cases that each value represents is also shown.

One more element must be considered in the host scheduling game, and that is anticipation. Hosting the decisive race is the most desirable scenario and will bring a level of significance to the track. In terms of viewership, however, the mere prospect of the title being decided by a given race is enough to attract a large audience. A window of two to three races typically exists during which the championship could be decided. Any race in that window should be expected to draw a large audience.

### 2.5.3. Lemons to lemonade

The following strategic scenario is theoretical, and there is no definitive evidence that it has occurred in an actual race. All scoring systems used throughout the history of F1 have been some form of Borda count with truncation, meaning that drivers finishing below a certain position in a race receive no points. Until a race is concluded, every driver maintains at least a small chance of scoring points, and that typically is a team's primary focus. However, in some cases a driver and team may realize that their odds of scoring points are close to zero in a particular race. Once a team reaches that conclusion, they may cease playing one game and begin playing another. The second game is financial in nature and is based on revenue and costs.

Continuing to race offers essentially no possible return in terms of points, but it does pose a risk of damaging the car or adding wear and tear to its components, both of which are costly. Also to be considered is sponsor satisfaction. Sponsors pay to have their brands displayed on the car, and they value screen time during television broadcasts. Finishing the race at the back of the pack typically provides very little sponsor visibility. Retiring the car may lead to a small amount of airtime, but also may project an undesirable image for brands. A third option could be for the

team to select a safe corner and have the driver deliberately spin the car off the track (Figures 2.6a and 2.6b). Cars that are not near the leader rarely receive television coverage, but almost every incident such as a car spinning off the track receives at least some screen time. In the event that a team knows they can't succeed in competition, such behavior could be a way to satisfy sponsors by essentially making a spectacle and drawing attention to themselves. However, if the maneuver were obvious or particularly egregious, or if it were executed too frequently, regulators would certainly crack down on it.

**Figure 2.6a.** Naïve interpretation of deliberate spin

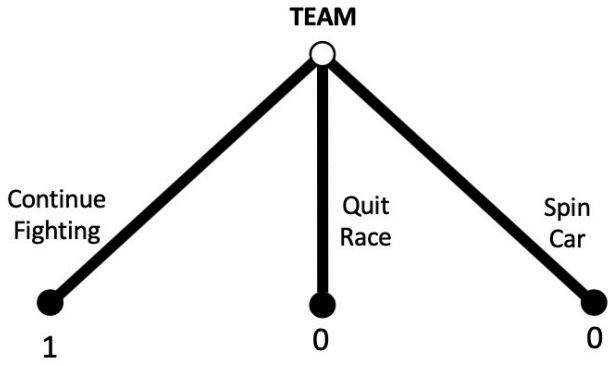
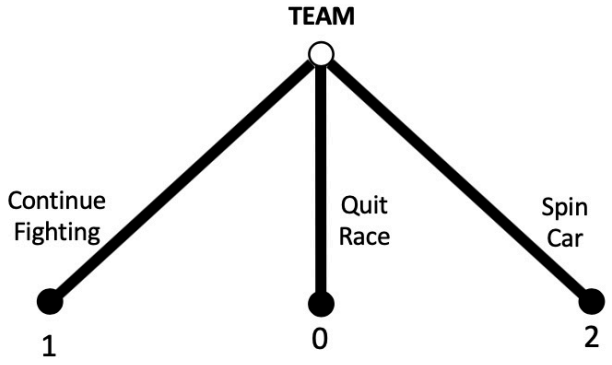



**Figure 2.6b.** Informed interpretation of deliberate spin




The naïve game is what we see if we only consider scoring points. Any non-zero probability of scoring points is worth more than a guarantee of no points under that view. The informed game incorporates consideration of finances and sponsor satisfaction.

### 2.5.4. Design conformity

In 2015, Honda returned to F1 as an engine supplier for the first time in a decade. The regulations and technology had changed dramatically in that time and Honda's engineers were designing from scratch. Other teams had been working with the current regulations for a year, so evidence existed about what designs worked the best. Honda was faced with a decision. Should it copy a proven concept, or try to come up with something completely new?

If Honda were to copy other teams, Honda would be assured of being on a viable path, but however hard the engineers worked they would be a full year behind the competition in terms of development. On the other hand, if Honda gambled on its own original design, it would either come up with something superior, or risk pouring money and time into a dead-end. In conjunction with McLaren, Honda made the choice to develop something unique. It did not pay off. After a few years of poor performance, Honda and McLaren parted ways and Honda abandoned its unique concept in favor of something more similar to other engine suppliers (Somerfield 2017). Teams constantly are faced with the choice between playing catch up with a proven design or attempting to leapfrog the competition with something novel.

### 2.5.5. Non-racing style dilemmas in other sports

A classic example of non-racing style dilemma is match-fixing, and the most famous case is the "Black Sox" of baseball's 1919 World Series. In the annual championship, it would be hard to imagine players having any incentive other than to play their best. However, gamblers had made arrangements with several players to deliberately lose the series. The poor performance of the Chicago White Sox during the series had been inexplicable until the scandal

came to light. Such a scandal is not as rare as one might think. It takes place across a range of sports, including tennis, boxing, sumo wrestling, snooker, cricket, soccer, horse racing, and others (Carpenter 2012; McNamee 2013).

Organizers and officials also face dilemmas within the governance of sports. In gymnastics, points are awarded according to the difficulty of the maneuvers being attempted as well as the quality of execution. One would assume that the most difficult moves would earn the most points, and any other methodology would be confusing and hard to justify. However, just such a thing does happen. Gymnastics is a potentially dangerous sport and the most difficult moves come with greater risk. Concerns exist that gymnasts, coaches, and even countries may have an incentive to push gymnasts beyond their limits to gain notoriety, leading to injury or worse. Awarding fewer points than expected for the riskiest moves is an attempt by the governing body to weaken those incentives ( Fédération Internationale de Gymnastique 2019; Sands 2000).

## 2.6. Conclusion

Sports offer fertile ground for strategic analysis and Formula 1 in particular involves strategic decisions at multiple levels. This chapter has attempted to analyze how strategy is implemented and optimized by those involved in the sport. Hidden motives and counterintuitive strategies have been highlighted, both in an attempt to unpack some of the unconventional behaviors observed, as well as to demonstrate ways in which a competitor can take advantage of the rules of the game in ways that are not immediately apparent.

In many strategic interactions, competitors must evaluate a vast number of possible moves available to both themselves and their opponents. To make such analysis manageable, we often exclude from consideration moves that don't make obvious, direct progress toward a goal. While at times we must do that out of necessity, the approach does have shortcomings. This research has demonstrated that non-obvious, hidden strategies are frequently adopted, can be very effective, and should not be ignored by analysts or competitors. In doing so, this research also has provided a better understanding of an influential, international sporting organization that faces all of the strategic dilemmas and opportunities for manipulation that exist in traditional political public choices.

# CHAPTER 3

## Strategy and paradoxes of Borda count in formula 1 racing


**ABSTRACT**

Winning a championship is the highest achievement in Formula 1, and multiple titles can earn one a place in the pantheon of the sport. In this chapter I explore whether the scoring method for selecting a champion can be considered definitive, and how unstable results might be when the method's parameters are slightly changed. I have employed case studies of paradoxes and historical recreations of seasons using alternative scoring systems. Finally, I argue that the Borda count is desirable system for scoring in Formula 1, and that teams building strategies around particular scoring systems is a legitimate aspect of the sport.

## 3.1. Introduction

November 1988: Ayrton Senna becomes Formula 1 Drivers' Champion for the first time. He had amassed 90 points over the course of the season, beating rival and teammate Alain Prost by 3 points. This season was central to Senna's legacy because he had gone head-to-head with Prost, one of the greats in the history of the sport, in equal machinery, and prevailed. Some have drawn the significance of the achievement into question, however, due to an oddity in the scoring system used in Formula 1 at the time. Of the 16 races that season, only the 11 best results for each driver were counted toward their championship totals. Had all 16 races been counted, Prost would have won the championship with 105 points to Senna's 94. Yet even these results are dependent on how points were allocated for each race. If we look at how the two faired only against each other, forgetting all other competitors, Senna prevailed 9 times (including 8 race victories) to Prost's 7 (including 7 race victories). Arguing that one driver deserved the championship over the other seems a precarious matter. This season presents the perfect case study in the paradoxes and debates surrounding scoring in Formula 1.

Formula 1 is widely considered the highest level of auto racing in the world. As a sport it ultimately exists as a form of entertainment. Though the championship outcome affects those involved with the sport, it would appear that it is of little consequence to anyone else. However, if the scoring system in use leaves fans unsatisfied they may lose interest and the sport could lose relevance or even cease to exist. Considering the financial and political reach of the sport, it should warrant at least passing interest.

The technology used in F1 rivals that of the aerospace industry (Wright 1982), and much of it eventually reaches road-going vehicles. Major auto manufacturers are willing to spend vast sums of money funding race teams because the sport serves as an research and development

platform to drive the development of new technologies (Aversa, Furnari, and Haefliger 2015). Braking technology (including early experimentation with Anti-lock Braking Systems) has been dramatically advanced by F1, improving road safety. Crumple zones and survival cells found in road cars are due in large part to F1 (Toma 2016). The sport has also led to major improvements in the efficiency of internal combustion engines as well as energy recovery systems that are now used in road-going hybrid vehicles (Boretti 2010). Sporting regulations are constantly updated, presenting teams with new challenges that push the limits of efficiency technology, which results in better gas mileage for the millions of vehicles driven by the public. Formula 1 pit-stop techniques have even been used to improve patient transfers following surgeries (Catchpole et al. 2007).

In the earliest days of Grand Prix motor racing (the predecessor to Formula 1) there was an element of national pride involved, as it was an opportunity for teams to demonstrate the technological prowess of their home countries. Teams sported color schemes representing their nations, with red for Italian teams, blue for French, green for British, and silver for German teams. Today globalization is on full display in the sport and national identity plays much less of a role within teams. However, the sport does still play a role in international politics. Much like the Olympics or the FIFA World Cup, a Formula 1 race puts the host nation in the spotlight. Obviously, there is much less significance attached to hosting a single annual race, but there is a different kind of attention that comes with it. Competitors with names like Ferrari, and sponsors like Rolex and Moët bestow upon the host nation an image of stability and sophistication. This is often used as a means to court foreign investment and attract tourists. A well-known example of Formula 1 successfully driving tourism being Singapore (Henderson et al. 2010).

Granting a country the right to host a race is seen as a form of endorsement of a government and its policies. As such, F1 plays a role in the politics of the countries it works with, for better or for worse. An example of F1 using its position to influence politics came when the South African Grand Prix was cancelled after 1985 due to apartheid. On the other hand, some observers criticized the 2012 Bahrain Grand Prix taking place because it was viewed as allowing the government to present an image of stability despite civil unrest related to the Arab Spring (Avraham 2015).

Though it is a sport meant to entertain fans, F1 does have an impact on world affairs, with the potential to do significant good. To remain viable it is important that the sport appear fair, competitive, and entertaining. Many of these aspects have been previously studied. Ways of encouraging competition have been explored (Judde, Booth, and Brooks 2013; Mastromarco and Runkel 2009) as has the role of competitive balance in attracting fans (Krauskopf, Langen, and Bünger 2010; Schreyer and Torgler 2018).

Few papers have examined the role scoring can have on competitiveness and how different systems can influence the championship. Langen and Krauskopf (2010) use simulated data to look at how various aspects of the sport are sensitive to changes in scoring. Haigh (2009) recreated the 1950 season using modern scoring and identified an interesting paradox. This chapter conducts historical analysis and explores the role points have played in determining the championships in Formula 1. Section 2 explains scoring in the sport and details the history and evolution of the systems used. Section 3 looks at various paradoxes and odd results that have occurred, highlighting five particular seasons. Section 3 goes on to simulate every season from 1961 through 2017 using all points systems from the history of the sport and explores how

frequently points can alter the outcome of a season. Section 4 concludes with brief statements regarding strategy and the role scoring plays in the sport.

### 3.2. Formula 1 Points Systems

Formula 1 uses a variant of the scoring system known as Borda count. When the Borda count is applied to elections, each voter ranks a set of alternatives or candidates from most preferred to least. The lowest ranked alternative is given 1 point (or 0 points in an alternative version), the next lowest 2 points, and so on. The highest ranked alternative will receive $n$ points (or $n$-1 points in an alternative version), where $n$ is equal to the number of candidates involved in the election. With 5 candidates, the highest ranked will receive 5 points. The points given out by each voter are then added together, creating a total score for each candidate. The candidate with the highest total wins. In addition to this Classic Borda count there are other variants of the Borda procedure. These include Weighted Borda count (sometimes referred to as weighting) where the differences in points received from one position to the next can vary, typically to the benefit of higher ranked alternatives, Truncated Borda count (sometimes referred to as truncation), in which points are only awarded down to a certain rank with all others receiving 0 points, and Selective Borda count (sometimes referred to as a selective aspect), in which only a subset of races are considered when calculating a competitor's aggregate total (typically the ones in which the candidate scored the highest). All or any subset of the three modifications described above may be applied.

In F1 racing we have races instead of voters, competitors instead of candidates, and a season-long championship instead of an election. Otherwise, the math is similar. Drivers finish each race in a particular order, and points are awarded according to position. The points from all

races are added together, and the driver (or team) with the highest total for the season is crowned champion. To date the sport has used six different allocation schemes to award points to drivers (see Table 3.1).

Borda count is a concept familiar to the sporting world, being used in a variety of settings where a series of individual rankings need to be aggregated into an overall ranking. An obvious and appropriate application of Truncated Borda to sport is the creation of a ranking for association football (soccer) players created from the personal rankings provided by a panel of experts (*The Guardian* 2017) Each expert effectively casts a vote by ranking the 40 players they believe to be the best in the world. 40 points are awarded to their top choice, 39 for second, and so one. The points from each expert are added together, and a top ranked player is elected.

**Table 3.1.** Historical Drivers' Championship point allocations

| Years in Use | Points by Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1950-1959 | 8 | 6 | 4 | 3 | 2 | - | - | - | - | - |
| 1960 | 8 | 6 | 4 | 3 | 2 | 1 | - | - | - | - |
| 1961-1990 | 9 | 6 | 4 | 3 | 2 | 1 | - | - | - | - |
| 1991-2002 | 10 | 6 | 4 | 3 | 2 | 1 | - | - | - | - |
| 2003-2009 | 10 | 8 | 6 | 5 | 4 | 3 | 2 | 1 | - | - |
| 2010-Present | 25 | 18 | 15 | 12 | 10 | 8 | 6 | 4 | 2 | 1 |

Like F1, there are other sports that use some variant of the Borda count to select a champion for the season. The FIS Ski Jumping calendar consists of 25-30 competitions annually. The top 30 finishers in each event are awarded points, and the points from all events are tallied to determine rankings at the end of the season. However, there are more than 30

jumpers competing on a given weekend, so not everyone will be awarded points in each round. Those not in the top 30 receive 0 points. First place receives 100 points, second 80, and third 60. The margin of change from one position to the next decreases as we move down through the rankings. Positions 28-30 are awarded 3, 2, and 1 point respectively. Thus, the variant of Borda applied to FIS Ski Jumping is both Weighted and Truncated.

As with ski jumping, Formula 1 uses a type of Weighted Truncated Borda count. The 2018 season involved 10 teams with 2 drivers each (20 cars in total) competing in 21 rounds of racing. In each round only the top 10 finishers earn points according to the following allocation: (25, 18, 15, 12, 10, 8, 6, 4, 2, 1). Points from all rounds are added together to determine final rankings. The Drivers' Champion is the driver that has accumulated the most points throughout the season. The Constructors' Champion (awarded to a team) is determined by adding together the points earned by both of a team's cars throughout the season. If a substitute driver is used for certain races, the points earned by the car still count toward the team's total.

Interestingly, FIS ski jumping also has the Nations Cup team competition, but it is conducted slightly differently than in F1 (International Ski Federation 2018). In ski jumping there are both individual and team competitions. In an individual competition, all points scored by jumpers from the same country are added to their national team's total. In a team competition, the performances of all team members are combined to establish a raw team score, and points are then awarded to the top eight teams, with 400 for first place, then 350, 300, and so on. In F1, points are awarded according to individual performances, and in a subsequent step these points are combined into a team total. Additionally, in F1 the results of each race are applied to both the Drivers' and Constructors' Championships while in ski jumping team competitions don't award individual points in the individual World Cup. Though both of these sports use Weighted

Truncated Borda count systems for team competitions, we can see that the details of how systems are applied can vary greatly. In fact, the system used in F1 itself has gone through several changes over the years, and in the beginning did not even include a team competition.

The first year that Formula 1 crowned a Drivers' Champion was 1950, but the concept of a Constructors' Championship did not yet exist. A variant of Selective Borda was used, in which, out of 7 races that season, only the best 4 performances for each driver were scored. In other words, the 3 worst performances for each driver were thrown out when determining the champion. Some other quirks existed in scoring for roughly the first decade of the championship. The driver with the single fastest lap during a race was awarded an additional point for that race. If multiple drivers tied for fastest lap, that single point would be divided among them, in some cases up to 7 ways. Also, in the early years of the sport drivers could share or switch cars with other drivers. Points for the race were again split between the drivers involved. By the early 1960s many such oddities had been removed, but the use of Selective Borda remained for several decades. The weighting and truncation of points has been modified several times over the years, and further changes can be expected in the future.

Through 1957 scoring remained largely unchanged. The weighting of points stayed consistent, and the selective aspect of scoring counted roughly the best half of each driver's performances toward the championship totals. In 1958 a second championship for the best constructor (or team/car builder) was introduced. The same Selective Weighted Truncated Borda count system was used, with the additional stipulation that only the highest finishing car from each team in a given race was considered.

In 1961 an additional point was added to first place for the Drivers' Championship, and the same change was applied to the Constructors' Championship in 1962. Beginning in 1967 the

selective aspect of scoring was changed. Through 1978, for both the Drivers' and Constructors' Championships, the single worst performance from the first half of the season and the single worst performance from the second half of the season were dropped for each competitor, and all others were counted.

From 1979 all cars from all teams were counted toward the Constructors' Championship. For the Drivers' Championship a change was made to the selective aspect of the system. For 1979 and 1980, for the first half of the season the better half of a driver's performances were counted, and the same went for the second half of the season. From 1981-1990 the number of races counted for drivers was fixed at 11. From 1991 onward Selective Borda count was no longer used, and all races were counted for both championships. The final changes as of the writing of this chapter were the institution of double points for the final race of the season in 2014, followed by its abandonment the following year.

### 3.3. Can the Championship Be Considered Definitive?

A single race produces a clear, straightforward ranking based on the order in which drivers cross the finish line. Aggregating multiple races into a season-long ranking presents a greater challenge. Is one 1st place finish and one 3rd place finish worth more than two 2nd place finishes? If so, how much more? Borda count provides one way of resolving this dilemma, and the weighting and truncation attributes used in Formula 1 are not particularly controversial. But with so much money at stake for teams and sponsors, and with drivers' legacies built in how many championships they have won, it seems relevant that we ask if the results produced by the scoring system can be considered definitive.

It seems straightforward that altering the weighting and truncation of a scoring system can alter the outcome (Saari 1984). Ordeshook (1986) and others have demonstrated that many voting systems, including Borda count, can produce so-called paradoxes, wherein we are given outcomes that seem counterintuitive in various ways. Such paradoxes can exist in other sports, including FIFA rankings, as shown by Kaminski (2012). Below are some of the more striking paradoxes and scoring oddities that have occurred throughout the history of F1.

### 3.3.1. 2007: Top Cycle

The Borda count method is named after French mathematician Jean-Charles de Borda, even though the system had been used in various forms much earlier. A contemporary of Borda, the Marquis de Condorcet, is the namesake of another voting system, the Condorcet method. Under the Condorcet method, the Condorcet winner is the alternative that is preferred by a majority of voters in pairwise comparisons against all other alternatives. A previous study has examined how the Condorcet method might be applied to F1 (Mello et al. 2015). The challenge faced by the Condorcet method is that a Condorcet winner does not always exist. We can be left with what is known as a Condorcet paradox, or a cycle. This concept is most easily illustrated with the game rock-paper-scissors. Scissors defeats paper, paper defeats rock, rock defeats scissors, and so on, leaving us with a cycle encompassing all three alternatives. This can be expressed as follows:

**sPpPrPs**

where **aPb** denotes that **a** is preferred to **b**, or **a** defeats **b**, in a pairwise comparison.

Part of the appeal of the Borda count method is that, apart from occasional ties, it is decisive. The 2007 F1 season ended with a top cycle (the top 3 finishers were in a cycle amongst themselves, but each of the top 3 defeated all other drivers), yet the Weighted Truncated Borda count method was able to determine a winner. This was the closest season in the history of the sport, with Raikkonen ending up with 110 points and Hamilton and Alonso earning 109 points each. Over the course of the season Raikkonen defeated Alonso 11 races to 6, Alonso defeated Hamilton 10 races to 7, and Hamilton defeated Raikkonen 10 races to 7, producing the following cycle:

**rPaPhPr**

Not only was there a top cycle, but it was quite balanced, with only a slightly larger margin between Raikkonen and Alonso than in the other 2 pairs. Raikkonen ended up champion for the season, and this result is surprisingly stable. As we will see later on, Raikkonen remains the winner under every scoring system F1 has used. This is likely due to the fact that he won 6 races to Alonso's 4 and Hamilton's 4 that season. Below (Table 3.2) are shown the head-to-head performances of the 3 drivers broken down by race (round) for the entire season.

**Table 3.2.** Pairwise comparisons for Raikkonen, Alonso, and Hamilton for 2007

| Round | Raikkonen | Alonso |
|---|---|---|
| 1 | x | |
| 2 | | x |
| 3 | x | |
| 4 | | x |
| 5 | | x |
| 6 | x | |
| 7 | | x |
| 8 | x | |
| 9 | x | |
| 10 | | x |
| 11 | x | |
| 12 | x | |
| 13 | | x |
| 14 | x | |
| 15 | x | |
| 16 | x | |
| 17 | x | |
| Final | 11 | 6 |

| Round | Alonso | Hamilton |
|---|---|---|
| 1 | x | |
| 2 | x | |
| 3 | | x |
| 4 | | x |
| 5 | x | |
| 6 | | x |
| 7 | | x |
| 8 | | x |
| 9 | x | |
| 10 | x | |
| 11 | | x |
| 12 | x | |
| 13 | x | |
| 14 | x | |
| 15 | | x |
| 16 | x | |
| 17 | x | |
| Final | 10 | 7 |

| Round | Hamilton | Raikkonen |
|---|---|---|
| 1 | | x |
| 2 | x | |
| 3 | x | |
| 4 | x | |
| 5 | x | |
| 6 | x | |
| 7 | x | |
| 8 | | x |
| 9 | | x |
| 10 | x | |
| 11 | x | |
| 12 | | x |
| 13 | x | |
| 14 | | x |
| 15 | x | |
| 16 | | x |
| 17 | | x |
| Final | 10 | 7 |

### 3.3.2. 2008: Failure to Choose the Condorcet Winner

As we saw with the 2007 season a Condorcet winner does not always exist. When one does exist, it would be reasonable to assume that they should be crowned champion. Some have used this as a criterion by which to judge voting methods. Whether this is truly relevant in racing is debatable. However, it is still interesting and noteworthy that a Condorcet winner may lose the championship to an opponent that they have defeated head-to-head in the majority of races in a season. Such was the case in 2008. Hamilton was crowned champion after the final race of the season with 98 points to Massa's 97. Yet Massa had prevailed over Hamilton in 10 out of 18 races, and over every other driver that season by a margin at least as wide (Table 3.3). Though a Condorcet winner existed in 2008, the scoring in use at the time failed to select them as champion.

**Table 3.3.** Pairwise comparisons of Felipe Massa vs. all other drivers for 2008 season

| Driver | HAM | RAI | KUB | ALO | HEI | KOV | VET | TRU | GLO | WEB | PIQ | ROS | BAR | NAK | COU | BOU | BUT | FIS | SUT | SAT | DAV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Massa vs. | 10-8 | 12-6 | 10-7 | 11-7 | 11-7 | 12-6 | 13-3 | 13-4 | 12-4 | 14-3 | 13-4 | 13-5 | 14-3 | 13-5 | 13-4 | 14-3 | 14-3 | 15-2 | 16-0 | 16-1 | 16-1 |

Head-to-head results displayed with Massa on the left and opponent on the right. Opposing drivers are denoted by the first 3 letters of their surnames.

Unlike 2007, the results of 2008 are particularly sensitive to the scoring system used (Table 3.4). Under every point allocation system used prior to 2003 Massa would have won the championship. Only under the system used from 2003 to 2009 and the current system does Hamilton win the championship. We can say that each driver had a particular type of season (accounting for season-long consistency, number of victories, etc.), and that different points systems reward different types of seasons. With this in mind, we have to wonder to what degree teams attempt to shape race strategy around points systems, and to what degree points systems can be used to influence the behavior of teams and drivers. For example, heavily incentivizing victories may lead to more exciting races for fans, but incentivizing consistency may be favored by manufacturers looking to develop reliable road-going technologies. The first case encourages risk-taking strategies more than the second does.

**Table 3.4.** 2008 season results for Hamilton and Massa using all points systems

| Point System | 1950-1959 | 1960 | 1961-1990 | 1991-2002 | 2003-2009 | 2010-Pres. |
|---|---|---|---|---|---|---|
| Hamilton | 70 | 70 | 75 | 80 | 98 | 243 |
| Massa | 70* | 71 | 77 | 83 | 97 | 240 |

Winner under each points system highlighted in grey. All races from season scored under all systems (no selective aspect applied). *Under 1950-1959 system Mass is champion due to ties going to driver with more victories (6 for Mass 5 for Hamilton).

### 3.3.3. 2003: Truncation and Weighting Change the Outcome

Jordan Grand Prix was a Formula 1 team competing from 1991 through 2004, though the name was retained for the 2005 season after the team was taken over by new owners. After

struggling for their first few years in the sport, the team managed to never finish lower than 6th in the Constructors' Championship from 1994 through 2002, reaching their peak with a 3rd place finish in 1999. This was very impressive for a small, independent team that was relatively new to the sport and worked with a modest budget (Budzinski and Müller-Kock 2018). After finishing 9th in the championship in 2003 and 2004 the team was not able to recover and was acquired and renamed by the Midland Group. The downfall of Jordan Grand Prix is a complicated story, involving changing sporting regulations (the rules governing car design) and loss of sponsorship revenue, but it is interesting to note that this all coincided with a change in the points system implemented in 2003.

Through a strange series of events Jordan managed to win the 2003 Brazilian Grand Prix. For mid-field teams wins are rare and extremely valuable. With the 1991-2002 points system, under which Jordan had faired so well, this single race victory would have meant that the team finished the season 5th in the Constructors' Championship. For the 2003 season 2 points were added for each position from 2nd through 6th, and 7th and 8th become point-scoring positions. These subtle changes meant that Jordan dropped from 5th down to 9th for the championship (See Tables 3.5a and 3.5b), which likely cost the team in the range of $10m USD in championship payouts and probably several times that amount in sponsorship dollars. Taking such a financial hit would only exacerbate their problems, making them less competitive the following season, leading to a snowball effect (Cobbs et al. 2017). Though the team were facing several other challenges at the time, the scoring changes for 2003 most certainly played a part in the team's demise.

**Table 3.5a.** Actual points scored for 2003 season

| Team | Car No. | Rd 1 | Rd 2 | Rd 3 | Rd 4 | Rd 5 | Rd 6 | Rd 7 | Rd 8 | Rd 9 | Rd 10 | Rd 11 | Rd 12 | Rd 13 | Rd 14 | Rd 15 | Rd 16 | Driver Totals | Team Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ferrari | 1 | 5 | 3 | 0 | 10 | 10 | 10 | 6 | 10 | 4 | 6 | 5 | 2 | 1 | 10 | 10 | 1 | 93 | 158 |
| | 2 | 0 | 8 | 0 | 6 | 6 | 6 | 1 | 4 | 6 | 2 | 10 | 0 | 0 | 6 | 0 | 10 | 65 | |
| Williams | 3 | 8 | 0 | 0 | 2 | 5 | 0 | 10 | 6 | 8 | 8 | 8 | 10 | 6 | 8 | 3 | 0 | 82 | 144 |
| | 4 | 1 | 5 | 2 | 5 | 4 | 3 | 5 | 8 | 10 | 10 | 0 | 0 | 5 | 4 | 0 | 0 | 62 | |
| McLaren | 5 | 10 | 0 | 5 | 4 | 0 | 4 | 2 | 0 | 0 | 4 | 4 | 8 | 4 | 0 | 0 | 6 | 51 | 142 |
| | 6 | 6 | 10 | 8 | 8 | 0 | 8 | 8 | 3 | 0 | 5 | 6 | 0 | 8 | 5 | 8 | 8 | 91 | |
| Renault | 7 | 4 | 4 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 3 | 6 | 2 | 0 | 5 | 4 | 33 | 88 |
| | 8 | 2 | 6 | 6 | 3 | 8 | 0 | 4 | 5 | 5 | 0 | 0 | 5 | 10 | 1 | 0 | 0 | 55 | |
| BAR-Honda | 16 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 9 | 26 |
| | 17 | 0 | 2 | 0 | 1 | 0 | 5 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 5 | 17 | |
| Sauber | 9 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 6 | 19 |
| | 10 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 13 | |
| Jaguar | 14 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 3 | 3 | 0 | 0 | 3 | 2 | 0 | 0 | 17 | 18 |
| | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | |
| Toyota | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 6 | 16 |
| | 21 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 2 | 10 | |
| Jordan | 11 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 12 | 13 |
| | 12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| Minardi | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

2003 points system (10, 8, 6, 5, 4, 3, 2, 1). For the Constructors' Championship cars earn points for the team regardless of the driver, so "Car No." is used rather than drivers' names.

**Table 3.5b.** 2003 season recreated using points system from 1991-2002

| Team | Car No. | Rd 1 | Rd 2 | Rd 3 | Rd 4 | Rd 5 | Rd 6 | Rd 7 | Rd 8 | Rd 9 | Rd 10 | Rd 11 | Rd 12 | Rd 13 | Rd 14 | Rd 15 | Rd 16 | Driver Totals | Team Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ferrari | 1 | 3 | 1 | 0 | 10 | 10 | 10 | 4 | 10 | 2 | 4 | 3 | 0 | 0 | 10 | 10 | 0 | 77 | 125 |
| | 2 | 0 | 6 | 0 | 4 | 4 | 4 | 0 | 2 | 4 | 0 | 10 | 0 | 0 | 4 | 0 | 10 | 48 | |
| Williams | 3 | 6 | 0 | 0 | 0 | 3 | 0 | 10 | 4 | 6 | 6 | 6 | 10 | 4 | 6 | 1 | 0 | 62 | 105 |
| | 4 | 0 | 3 | 0 | 3 | 2 | 1 | 3 | 6 | 10 | 10 | 0 | 0 | 3 | 2 | 0 | 0 | 43 | |
| McLaren | 5 | 10 | 0 | 3 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 6 | 2 | 0 | 0 | 4 | 33 | 100 |
| | 6 | 4 | 10 | 6 | 6 | 0 | 6 | 6 | 1 | 0 | 3 | 4 | 0 | 6 | 3 | 6 | 6 | 67 | |
| Renault | 7 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 3 | 2 | 15 | 51 |
| | 8 | 0 | 4 | 4 | 1 | 6 | 0 | 2 | 3 | 3 | 0 | 0 | 3 | 10 | 0 | 0 | 0 | 36 | |
| Jordan | 11 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 10 |
| | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| BAR-Honda | 16 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 9 |
| | 17 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 6 | |
| Sauber | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 9 |
| | 10 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 7 | |
| Toyota | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 4 |
| | 21 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | |
| Jaguar | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 3 |
| | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Minardi | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

1991-2002 points system (10, 6, 4, 3, 2, 1). For the Constructors' Championship cars earn points for the team regardless of the driver, so "Car No." is used rather than drivers' names.

### 3.3.4. 1976: Winner-Turns-Loser Paradox

As seen in the previous example changing the weighting and truncation of a point system can affect the outcome of a racing season or an election. Even if we keep the point system fixed there is another, even more surprising paradox that can occur. If one driver earns more points than another under a given system, it would seem that this should be a rather stable result, because the winning driver has performed in a way that is better suited to maximizing points under said system. Unlike the Condorcet method, Borda is concerned with more than just the relative orientation of every pair of drivers to each another. Borda count takes into account their rankings within a larger set of drivers, and placing 2 positions higher than an opponent creates a larger point differential than placing 1 position higher. This means that third parties can have an influence on how a pair of drivers fair against one another.

We say that a voting rule is *independent of the alternative set* (IAS) if, under it, the winner and another alternative would not switch positions with one another as the result of the addition or elimination of some other set of alternatives (Heckelman and Chen 2013; Heckelman 2015; Kaminski 2015). For example, if we have 3 alternatives (**a, b, c**) and they are ranked as follows:

**aPbPc**

if **c** is removed, the social preferences of **a** and **b** should remain unchanged, not to reverse to:

**bPa**

As counterintuitive as it seems, this sort of inversion can and does exist. In 1976 Hunt defeated Lauda 69 points to 68 in one of the most exciting seasons in F1 history. Plenty of controversy surrounded the season. Hunt's car was deemed illegal in one race, but the decision

was later overturned, and his points restored. Lauda was famously burned in a crash and missed several races. Lauda also voluntary retired from the final race of the season due to unsafe driving conditions, opening the window for Hunt to claim the championship. All of this has been discussed and analyzed at length, and a major motion picture was made about the season. What people rarely mention is the man that finished 3rd that season, Sheckter. Sheckter was not fighting for the title, so he is typically ignored. However, his presence actually shaped the outcome for Hunt and Lauda. Table 3.6a shows the results for the season as they actually happened. Table 3.6b shows what would have happened had Sheckter withdrawn prior to the start of the season (Again, ignoring the impact his on-track presence had on the performance of other drivers). As we see, Sheckter actually determined the champion in 1976. If he had not raced that season, Lauda would have won the championship with 72 points to Hunt's 70. This provides an illustration of how Borda count can violate IAS.

**Table 3.6a.** Actual results from 1976 season for Hunt, Lauda, and Sheckter

| ROUND | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Season |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hunt | Place | - | 2 | - | 1 | - | - | 5 | 1 | - | 1 | 4 | 1 | - | 1 | 1 | 3 | 69 |
| | Points | 0 | 6 | 0 | 9 | 0 | 0 | 2 | 9 | 0 | 9 | 3 | 9 | 0 | 9 | 9 | 4 | |
| Lauda | Place | 1 | 1 | 2 | 2 | 1 | 1 | 3 | - | 1 | - | - | - | 4 | 8 | 3 | - | 68 |
| | Points | 9 | 9 | 6 | 6 | 9 | 9 | 4 | 0 | 9 | 0 | 0 | 0 | 3 | 0 | 4 | 0 | |
| Sheckter | Place | 5 | 4 | - | - | 4 | 2 | 1 | 6 | 2 | 2 | - | 5 | 5 | 4 | 2 | - | 49 |
| | Points | 2 | 3 | 0 | 0 | 3 | 6 | 9 | 1 | 6 | 6 | 0 | 2 | 2 | 3 | 6 | 0 | |

Selective Borda count used in 1976. Seven best results from first eight races and seven best results from last eight races highlighted in grey for each driver.

**Table 3.6b.** Hypothetical 1976 season recreated for Hunt and Lauda, with Sheckter not present

| ROUND | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Season |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hunt | Place | - | 2 | - | 1 | - | - | 4 | 1 | - | 1 | 4 | 1 | - | 1 | 1 | 3 | 70 |
| | Points | 0 | 6 | 0 | 9 | 0 | 0 | 3 | 9 | 0 | 9 | 3 | 9 | 0 | 9 | 9 | 4 | |
| Lauda | Place | 1 | 1 | 2 | 2 | 1 | 1 | 2 | - | 1 | - | - | - | 4 | 7 | 2 | - | 72 |
| | Points | 9 | 9 | 6 | 6 | 9 | 9 | 6 | 0 | 9 | 0 | 0 | 0 | 3 | 0 | 6 | 0 | |

Selective Borda count used in 1976. Seven best results from first eight races and seven best results from last eight races highlighted in grey for each driver.

### 3.3.5. 1988: A Scoring Conundrum

This brings us back to 1988 and Senna vs. Prost. Under the rules in place at the time, Senna won the championship with 90 points to Prost's 87. Had the Borda count system in use not been selective, Prost would have won with 105 points over Senna's 94. Arguments can be made for both sides, and with no objective way of proving who deserved the championship more, it comes down to what type of performance the scoring system aims to reward.

Prost and Senna represent two distinct, and opposite driving styles. At his best, Senna was quicker than Prost. This fact is rarely disputed. But Senna was less consistent. Prost was reliable and was known for race management and maximizing points. Prost was often referred to as "The Professor" for this very reason. Both drivers failed to complete 2 races during the season, so this is a rare case in which comparing average finishing position makes sense. Prost's average finishing position was 1.5 while Senna's was 2.43. Prost was better on average than Senna. However, Senna won 8 races to Prost's 7. This illustrates a contentious issue in voting systems regarding what is rewarded by Borda count vs. majority rule and other systems. It seems inevitable that the rule-maker plays a role in shaping the outcome.

## 3.4. Historical Analysis

Though the seasons described above are certainly interesting, one has to wonder how influential scoring is on a larger scale. Does the points system in use frequently play a deciding factor in the championship, or is it rare that such an event occurs? Table 3.7 shows which drivers would have won the championship each year from 1961 through 2017 under each points system (Chris G. 2017). For this simulation all races were counted toward the championship in every season. Only the points awarded for finishing positions were changed. Rules such as only

counting a certain number of each driver's best results, or extra points for fastest race laps, were ignored. Simulations were not run for years 1950-1960 because regulations at the time allowed for multiple drivers to share a single car, and the points earned from it, within a race. This would make recreations of these early seasons very complicated, and essentially meaningless.

**Table 3.7.** Drivers' Champions for years 1961-2017 under alternative points systems

| | POINTS SYSTEM | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Actual | 1950-1959 | 1960 | 1961-1990 | 1991-2002 | 2003-2009 | 2010-Pres |
| 1964 | Surtees | G. Hill | G. Hill | G. Hill | G. Hill | G. Hill | G. Hill |
| 1965 | Clark | Clark | Clark | Clark | Clark | G. Hill | G. Hill |
| 1970 | Rindt | Rindt | Rindt | Rindt | Rindt | Rindt* Ickx | Rindt |
| 1976 | Hunt | Hunt* Lauda | Hunt* Lauda | Hunt | Hunt | Lauda | Lauda |
| 1981 | Piquet | Reutemann | Piquet* Reutemann | Piquet | Piquet | Piquet | Piquet |
| 1983 | Piquet | Piquet | Piquet | Piquet | Piquet | Piquet | Prost* Piquet |
| 1984† | Lauda | Lauda | Lauda | Lauda | Prost | Lauda | Prost |
| 1988 | Senna | Prost | Prost | Prost | Prost | Prost | Prost |
| 1994 | Schumacher | D. Hill | D. Hill | D. Hill | Schumacher | D. Hill | D. Hill |
| 1997 | Villeneuve | Villeneuve | Schumacher | Villeneuve | Villeneuve | Schumacher | Schumacher |
| 1999 | Häkkinen | Häkkinen | Häkkinen* Irvine | Häkkinen | Häkkinen | Irvine | Irvine |
| 2003 | Schumacher | Schumacher* Räikkönen | Schumacher* Räikkönen | Schumacher | Schumacher | Schumacher | Schumacher |
| 2008 | Hamilton | Massa* Hamilton | Massa | Massa | Massa | Hamilton | Hamilton |
| 2012 | Vettel | Alonso | Vettel | Vettel | Vettel | Vettel | Vettel |
| 2016 | N. Rosberg | N. Rosberg | N. Rosberg | N. Rosberg | Hamilton* N. Rosberg | N. Rosberg | N. Rosberg |

Names in the "Actual" column represent official champions and have not been changed. For all other reconstructions using alternative points systems the selective aspect of scoring was not applied (i.e. all races were scored for all season). * Denotes champion after tie-break. In even of tie championship goes to driver with most victories. † Denotes season with one or more races in which points awarded for each finishing position were reduced by half.

One season of note is 1964. Surtees won the championship that year, but under any other system Hill would have been champion. Particularly, using the actual points system from that year, and simply not having it be a selective system, Hill becomes champion. This is exactly the same thing that happened in 1988. What is surprising is that these are the only 2 seasons in which making the Borda count system selective seems to have had in impact. In every other season, the actual champion remains champion when the selective aspect is removed. The reason for this is surprisingly simple. Pre-1991 (the first year in which all races were counted) cars were very unreliable. The number of races that a driver did not finish was usually greater than the number of races that were excluded by making the system selective. Therefore, the races excluded for each driver most often were scored 0, and would have not added points to their total even if they had been counted.

Had 1964 not used a selective version of Borda count, Hill would have earned his third world championship. Several other drivers' legacies could have turned out differently had different scoring been in place throughout their careers. Schumacher, currently with the most championships at 7, only wins 6 under some systems. He maintains 7 under others, though twice he loses the 1994 championship while gaining the 1997 championship. Piquet, a triple world champion, sees both the 1981 and 1983 championships taken away under some systems. Damon Hill (son of Graham Hill mentioned above) wins the 1994 championship (making him a double world champion) under any other system than the one in place at the time. Massa wins the 2008 championship from Hamilton had almost any other system been used, but Hamilton gains 2016 under one system. Lauda gains the 1976 championship under more recent systems, but also loses 1984 under some. Prost is possibly the most impacted by scoring. Under any other system he wins 1988, under several systems he wins 1984, and under the system introduced in 2010 he

wins 1983. In fact, had the post-2010 system been in place throughout his career, Prost becomes a 7-time world champion (1983, 1984, 1985, 1986, 1988, 1989, 1993).

How frequently does scoring have any kind of impact? Of the 57 seasons studied, scoring produced some kind of variation in the championship in 12 seasons. 2 of the seasons affected (1964, 1988) were strictly the result of removing the selective aspect of scoring. In those cases, once all races were counted there was no variation across points systems. In 10 of 57 seasons there was at least one instance of the championship being altered simply by changing the weighting and/or truncation of the Borda count system used.

### 3.5. Conclusion

The preceding simulation has shown that a significant proportion of championships leave some room for debate. In some seasons the Drivers' Champion can be so dominant that a scoring system seems almost unnecessary because the winner is so apparent. But in the most competitive seasons, which are the most exciting for fans, the scoring system used can play a critical and decisive role.

It is an inherent feature of Borda count that it can produce paradoxes and occasional counterintuitive outcomes. This effect is only exaggerated when points are weighted and truncated. However, it still seems the most logical system to use for the sport. It can be argued that other systems such as Condorcet or the related Copeland method (Mello et al. 2005), or even a more refined and precise weighting system (Sitarz 2013) have desirable traits. However, a critical feature to consider when selecting a system is how well fans are able to understand it, and since Borda count relies on nothing more than simple arithmetic there is a certain appeal to it.

In the end, even though the results produced by Weighted Truncated Borda count may be unstable as we alter the weighting and truncation, the same scoring is applied to all teams in a given season, so it is hard to argue that it is unfair. Furthermore, all teams have equal opportunity to tailor their approaches to a given points system, so there is a strong argument to be made that this is a legitimate strategic aspect of the sport. We see similar features in several other sports. In [American] Football the decision to kick a field goal would be very different if it were worth more points or fewer points. Divers make choices based on how difficulty vs. execution are weighted, and this could change if weights were altered. In Association Football (soccer) teams in tournaments may choose a strategy to secure a tie (1 point for the tournament) rather than pursue a victory (3 points) and possibly risk a loss (0 points). Were any of these points changed, we might see more, or possibly less, exciting games.

No scoring system in Formula 1 can be considered correct in any objective sense. It comes down to choosing a system that creates desired effects. Doing this requires understanding the stakeholders in the sport, the incentives facing each of them, and creating a scoring system that shapes competition to the maximum benefit of the sport.

# CONCLUSION

This dissertation is a political analysis of a global sport in more than one sense. Sports can be used as a test bed for existing political and economic theories, or sports can be studied in their own right to provide insights that can be applied in other settings. Sports can also be analyzed because they, themselves, are politically influential and political in nature. The three preceding chapters on Formula 1, collectively, represent each of these approaches. The objective has been to make original contributions to the fields of social choice, applied game theory, and sports analysis.

Some of the most interesting findings in this study have to do with scoring and manipulation. Much like the longstanding political debates about which electoral rule best captures the will of the people, for over a century racing has involved battles over which scoring system names the rightful champion. What was surprising was to discover that in 1939 the debate was not merely theoretical. The season was run with no rule firmly in place, and ended with an actual paradox, producing a different champion by each of the rules under consideration. This was not the only time that the scoring system being used played a role in the championship. In 10 of the 57 seasons examined, using the points system from a different era could have changed the outcome. Finally, while I expected that competitors would optimize strategies to fit rules, I was surprised to discover how creative they are and how early it started. From France changing the rules of representation (switching from three cars per nation to three cars per auto manufacturer, of which France had many) to Hamilton trying to impede an opponent's ability to score points, tricks and manipulation seem to be baked into the sport.

Despite being the only sport in the world holding events on five continents each year (and historically a sixth), and having direct relationships with governments and multi-national corporations, Formula 1 receives notably little attention in academic literature. Though this

dissertation had contributed to the existing literature, there remain plenty of promising avenues for future research. The effect of Formula 1 races on the domestic politics of host nations and the sport's potential to drive clean automotive technology are obvious subjects on which more work can be done. Internal corruption and international representation in the sport's governing body are others. Though the sport does not make itself easily accessible to outsiders, the work done here shows that Formula 1 is fertile ground for original research.

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