STRATEGY AND PARADOXES OF BORDA COUNT IN FORMULA 1 RACING

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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 article 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 building strategies by teams around particular scoring systems is a legitimate aspect of the sport.*

Key words: *social preferences, Borda count, voting paradoxes, social choice, Formula 1.*

STRATEGIE KIEROWCÓW I PARADOKSY METODY BORDY W WYŚCIGACH FORMUŁY 1

Streszczenie: *Zdobycie mistrzostwa świata to najważniejsze osiągnięcie w Formule 1, a wielokrotny tytuł umieszcza kierowcę w panteonie tego sportu. W artykule zadałem pytanie czy metoda punktacji przy wyborze mistrza może być uznana za ostateczną i jak niestabilne mogą być wyniki, gdy parametry metody zostaną nieznacznie zmienione. Przeanalizowałem przypadki wyścigów, w których wystąpiły paradoksy oraz zrekonstruowałem wyniki historyczne przy użyciu alternatywnych systemów punktacji. Twierdzę, że metoda Bordy jest pożądanym systemem do oceniania w Formule 1, a budowanie strategii przez zespoły w odpowiedzi na własności aktualnego systemu punktującego jest w pełni uzasadnionym aspektem strategicznym sportu.*

Słowa kluczowe: *preferencje, metoda Bordy, paradoksy głosowania, teoria wyboru społecznego, Formuła 1.*

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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 impact that F1's continued existence has had on the world, having the right scoring system in place should probably warrant at least passing interest from those concerned with environmental issues, developing economies, or social justice.

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 R&D 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.

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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 paper 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.

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 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 complete statistics" 2017). Each expert effectively casts a vote by ranking the 40 players they believe to be the

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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 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 (FIS Rule Book 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

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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

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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 paper were the institution of double points for the final race of the season in 2014, followed by its abandonment the following year.

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.

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

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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 2) are shown the head-to-head performances of the 3 drivers broken down by race (round) for the entire season.

Table 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

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	

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	

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Round	Raikkonen	Alonso
14	x	
15	x	
16	x	
17	x	
Final	**11**	**6**

Round	Alonso	Hamilton
14	x	
15		x
16	x	
17	x	
Final	**10**	**7**

Round	Hamilton	Raikkonen
14		x
15	x	
16		x
17		x
Final	**10**	**7**

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). Though a Condorcet winner existed in 2008, the scoring in use at the time failed to select them as champion.

Table 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

Note: 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 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

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be favored by manufacturers looking to develop reliable road-going technologies. The first case encourages risk-taking strategies more than the second does.

Table 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

Note: Winner under each points system highlighted in grey. All races from season scored under all systems (no selective aspect applied).

* Under 1950-1959 system Massa is champion due to ties going to driver with more victories (6 for Massa 5 for Hamilton).

2003: Truncation & 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. 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.

Table 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	

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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
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	

Note: 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 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	

Note: 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.

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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 5a and 5b), which likely cost the team millions of dollars in championship payouts (Budzinski and Müller-Kock 2018) 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.

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 2013, 2015; see also Young 1997, and for empirical examples 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

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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 6a shows the results for the season as they actually happened. Table 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 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	

Note: 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 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	

Note: 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.

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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.

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 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.

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

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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.

Table 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

Note: 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.

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

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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.

4. 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,

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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.

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