1. Measuring competitive balance in Formula One racing

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1. INTRODUCTION

The Fédération Internationale de l'Automobile (FIA) Formula One World Championship (hereafter F1) represents, in business terms, one of the biggest sport events in the world. Its 2017 total revenue is estimated to be approximately US\$1.8 billion (Sylt 2018b), making it economically the ninth most important sports industry. At the top of the biggest sporting events is the US National Football League (NFL) with approximately US\$13.68 billion league revenue (Statista 2019) and Major League Baseball with approximately US\$9.46 billion league revenue (Statista 2018). In revenue generated per event, F1 exceeds its competitors by far, with US\$229 million, compared with US\$24 million for the NFL (Sylt and Reid 2008, pp. 13, 21). Formula One achieved an operating profit in 2013 of more than US\$530 million against a turnover of about US\$1.7 billion (Sylt 2014). Its commercial rights holder is now the Liberty Media Group, which acquired F1 for a total enterprise value of US\$8.0 billion (Nimmervoll 2016; Liberty Media Group 2019).

In 2015, the annual budgets of the participating teams varied between US\$83 million (Manor) and US\$467.4 million (Mercedes) (Walthert 2015). Sponsorship of teams amounted to more than US\$1.5 billion (Reid 2015). Since 2016, Heineken (races and trackside advertising; US\$200 million) is one of the biggest single sponsors in motorsport history (Smith 2018). In 2018, teams earned total prize money of US\$921 million (Sylt 2018a). With an estimated salary of US\$42 million plus personal sponsorship and endorsements of approximately US\$9million, title defender Lewis Hamilton (Mercedes) was one of the highest paid drivers on the 2018 grid (Badenhausen 2018).

During the past two decades, an ostensible lack of competitive balance among participating teams has continuously been one of the biggest issues for the governance of F1. It reached a peak with the domination of Ferrari and Michael Schumacher, winning six and five consecutive world

championships (1999–2004 and 2000–2004, respectively),¹ and continues to the present day, with the dominance of Mercedes winning all constructors' championships between 2014 and 2018, and Lewis Hamilton who lost only one world driver championship during the same period – to his teammate Nico Rosberg (in 2016).

Since March 2013, only three teams have won an F1 Grand Prix; none of the other teams even came close to winning a single race during that time. As a consequence of this perceived competitive imbalance, numerous changes to the regulatory framework have been introduced in order to improve competitive balance. Even more proposals have been put forward and are controversially discussed. The changes and proposals encompass virtually every dimension of F1, from the points system to technical aspects.

Against this background, it seems amazing that only a few scholarly articles analyze the business and economics of F1. Solitander and Solitander (2010) present a case study on sharing and the thievery of intellectual property in F1, in particular focusing on the 2007 spying scandals involving the leading teams Ferrari, McLaren and Renault. From a technological-managerial perspective, Jenkins and Floyd (2001) traces technological trajectories from 1967 to 1982 in order to identify the evolutionary forces generating dominant designs. Potter (2011) analyzes driver reactions to safety measures, in particular whether more risky driving styles are incentivized. An operations-research paper by Bekker and Lotz (2009) simulates race-strategy choices for three 2005 F1 races. Jenkins (2010) provides a qualitative-historical analysis of the influence of technological discontinuities on competitive performance and advantage. For the period between 1950 and 2006, he finds that incumbent firms often fail to adapt to the impact of external shocks. The exceptions, firms (teams) whose competitive superiority survived a number of successive discontinuities, are explained with a resource-based management view.

Addressing competition issues in F1, Cygan (2007) and Budzinski (2012) discuss the antitrust implications of the FIA case from the late 1990s (the European Commission alleged an abuse of dominance by F1's governing body, the FIA). Budzinski and Müller-Kock (2018) analyze antitrust allegations relating to the financial system and revenue distribution model of F1. They find indications of both an abuse of market power by the commercial rights holder and a collusive equilibrium between the governing bodies and the leading teams. On a more general level, Mourao (2017) discusses costs and revenues in F1. He also presents survivor models for the constructors' and drivers' championships, and attempts to identify success factors for winning in F1 (Mourao 2017, 2018). Along similar

lines, Stadelmann and Eichenberger (2008), Philipps (2014) and Bell et al. (2016) try to identify the best driver in F1 history by attempting to isolate the impact from the driver on success and separate it from other important influence factors, such as the competitiveness of the race car. Gutiérrez and Lozano (2014) use the data envelopment analysis (DEA) method to discuss the relative efficiencies of F1 team budgets. Depken et al. (2018) analyze family connections as a success factor in F1.

Touching the field of competitive balance in F1 motor racing, Mastromarco and Runkel (2009) as well as Judde et al. (2013) analyze the impact of rule changes on competitive balance in F1 racing. Kipker (2003) and Krauskopf et al. (2010) explore the effect of competitive balance, among others, on television ratings. While these papers model competitive balance by means of simplistic measures (for example, standard deviation or Gini coefficient based on championship tables), Schreyer and Torgler (2018) enhance these studies by employing more sophisticated methods and introducing additional control variables, finding a positive effect of competitive balance on viewers' demand.

This scarcity of economic literature on one of the most important sports events in the world is in line with a more general negligence of competitive balance issues in non-team sports. Another motorsports-related competitive balance paper is Berkowitz et al. (2011), which analyzes competitive balance in the North American National Association for Stock Car Auto Racing (NASCAR) touring car series, applying an adjusted-churn method as well as Herfindahl-Hirschman Index (HHI) indices. Outcome uncertainty in cycling is discussed by van Reeth (2013), whereas Du Bois and Heyndels (2007), del Corral (2009), Konjer et al. (2017) and Koning (2009) address competitive balance in tennis, with the latter also discussing speed skating. Shmanske (2007) analyses competitive balance in the golf PGA tour.

Since non-team sports differ from typical team sports, the analysis of competitive balance in non-team sports requires an adaptation and evolution of competitive-balance measuring methods. Furthermore, non-team sports differ considerably from each other and, therefore, methods often have to be adapted to the unique features of the sport in question. Here, round-based sports, such as tennis, have to be distinguished from pure head-to-head races, such as marathon running, professional cycling or motorsports. This may also explain the comparatively few contributions to this field.

The aim of this study is to contribute to closing two gaps in the existing literature: It contributes, first, to the (sports) economic analysis of the F1 business and, second, to the literature on competitive balance in non-team sports. Finally, operationalizing measures of competitive balance in

motorsport racing could be important for further research in this area. Formula One seems to be a particularly well-suited field in which to analyze the effects of competitive balance on fan demand,² especially with a view to distinguishing between the effects of competitive balance and a domestic/local hero preference.

2. COMPETITIVE BALANCE IN NON-LEAGUE SPORTS

2.1 The FIA Formula One World Championship

The FIA Formula One World Championship comprises a series of single race events (Grand Prix; GP) taking place on permanent race circuits and temporary city street circuits all around the world.³ In these races, 20 drivers from ten teams (constructors⁴) compete for points awarded for two different world championships: (1) the World Drivers' Championship (WDC) and (2) the World Constructors' Championship (WCC). In 2019, 25 points were awarded for the winning driver and for the winning team, 18 for the second placed, then 15, 12, 10, 8, 6, 4, 2, 1 for the finishers down to the tenth place. Both drivers of each team can score individually for themselves in the drivers' championship and for their team in the constructors' championship. The title 'world championship' is then awarded at the end of the season to the driver and to the team with the most points. Unlike other motor racing series, each team is required to build its own monoposto race car (the chassis), whereas engines from (currently four) different suppliers can be fitted. Technical and sporting regulations have been subject to frequent changes since the inaugural F1 season in 1950 (for an overview, see Mastromarco and Runkel 2009). This includes several changes to the points system, the race distance, the number of races, and the number of participating teams and drivers.

Formula One's sporting authority is the FIA, which is formed by and consists of national motor sports clubs and associations. The FIA governs and controls all sporting regulations of F1 through its World Motorsports Council (WMSC), in which stakeholders, such as the constructors, also have a number of seats. Contrary to typical team sports, constructors neither own nor lend or rent the race circuits, whose owners constitute a separate group of stakeholders (and, thus, there are no formal 'home races' in F1). The commercial rights have been transferred on a long-term contract to the Formula One Group (FOG), who takes responsibility for all commercial activities of F1.⁵

2.2 Dimensions of Competitive Balance in Formula One Motor Racing

The concept of competitive balance relates to the relative strengths of the teams and individuals competing in a sporting contest. If all the participating teams and drivers (in the case of motor racing) are of equal competitive strength, then competitive balance is maximal. The more a team or driver is superior to its or his or her competitors, the lower is competitive balance. Sports economic interest in competitive balance traces back to the uncertainty-of-outcome hypothesis (Rottenberg 1956; Neale 1964), stating that fans want to see a close fight for the win. An increasing outcome uncertainty is then conjectured to increase demand for watching sports (live or via broadcasts). Outcome uncertainty relates to competitive balance, since a high degree of competitive balance should, on average, increase outcome uncertainty, whereas a greatly superior competitor will dominate the sport and make contest results *ex ante* expectable. Thus, a better competitive balance should *ceteris paribus* increase demand. However, competitive balance is only one of many factors influencing demand, and factors such as home team or local hero preferences, own-price and cross-price elasticities, media presence and superstar phenomena may overcompensate the effect of increasing or decreasing competitive balance. As a consequence, the empirical evidence on the influence of competitive balance on demand is mixed (Coates et al. 2014). Notwithstanding, too much competitive imbalance is likely to hurt the business of any sports.⁶

When comparing F1 with typical team sports, some differences are immediately striking. First, instead of having games of team pairs each match day, the 20 drivers from ten teams race head to head in each GP. Secondly, points for two different championships (drivers' and constructors') are awarded in each GP. Thirdly, the competitiveness in both championships depends on both the ability of one teams' drivers (drivers' competitiveness) and the technical package (chassis, engines, tires and so on; technical competitiveness). The latter implies that competitive imbalance can be owing to differences in driving talent but also (and perhaps even more so) to differences in the technical competences of the respective team.

Three dimensions of competitive balance can be distinguished in relation to both championships (Berkowitz et al. 2011, p. 255):

- (a) within-race competitive balance, i.e. outcome uncertainty regarding a single GP,
- (b) within-season competitive balance, i.e. outcome uncertainty regarding the evolution of the points standings, and
- (c) inter-season competitive balance, i.e. outcome uncertainty regarding the series of champions in the course of time.

Within-race competitive balance is an important dimension for F1 fans. On the one hand, it can refer to the fight for the victory of the top positions only. For instance, television broadcasts of F1 races usually focus predominantly on the top contenders. Potential measures for within-race balance include the margin of victory or the number of lead changes (Berkowitz et al. 2011, pp. 257–8). On the other hand, within-race competitive balance can refer to the overall race, that is, including what happens further down the grid. The difference between starting and finishing position of a driver can serve as an estimation method here (Berkowitz et al. 2011, p. 258).

For within-season competitive balance, that is, the unfolding of a season, the most obvious measure would probably be a concentration measure such as the HHI. In order to measure the development of the concentration of performance points over the course of a season, Berkowitz et al. (2011, p. 259) calculate a points-based HHI before each race.

While both within-race and within-season competitive balance can be viewed as constituting similar phenomena for the drivers' and for the constructors' championship, this differs as regards inter-season competitive balance. The WCC resembles closely a league in team sports in that it is predominantly the same teams that compete in different seasons over longer periods. There is some change, particularly in the very long run, but the same is true for team sports (trade of franchises, enhancement or shrinking of leagues, relegation and promotion in open leagues, and so on). However, looking at inter-season competitive balance of the WDC is connected to the problem of overlapping driver careers. The number of seasons each driver competes in F1 differs and is naturally limited. Moreover, individual careers overlap. Thus, any defined interval of seasons would comprise some drivers' careers in full and others merely in parts of differing lengths, thereby blurring the explanatory power of the respective measure. This considerably aggravates the measuring of inter-season balance in the drivers' championship.

3. COMPETITIVE BALANCE IN FORMULA ONE MOTOR RACING: EMPIRICAL EVIDENCE

3.1 Within-Race Competitive Balance

Berkowitz et al. (2011, p. 257) give some examples on how within-race competitive balance could be measured. First, the margin of victory could be used. As this measure only gauges the difference between the first- and second-placed driver, and does not reveal any information about the competitive balance of the remainder of the drivers, it is disregarded for this specific analysis.

Second, the number of lead changes can be used as an indicator of competitive balance. Figure 1.1 displays the development of lead changes in F1 races for all official races since 1950.⁷ The left-hand side of the figure plots the number of lead changes for each race, while the right-hand side shows season averages. The x -axes on the figure is displaying the individual F1 GP from the first GP in 1950. However, the label of the x -axes indicates the first race of each decade instead of the pure race number, in order to increase readability. In addition, here and in the following figures, the grey line indicates the measure of competitive balance, while the solid black line depicts a linear trend and the dashed black line a smoothed trend calculated by means of a locally weighted regression (LLR).

Even if the left-hand side of Figure 1.1 might seem a little confusing at first glance, the two trend lines are particularly interesting. A clear positive linear trend can be observed. Furthermore, the smoothed LLR trend first declined and reached its minimum around the 1980 season. From this minimum, the smoothed trend indicates an increased number of lead changes during the races with a notable drop after 2010. A similar story can be derived from the right-hand side. Here, the smoothed trend follows a comparable pattern and the minimum of the average lead changes can be observed around the mid-1980s. Following this minimum, a strong increase in the smoothed trend can be attested, implying also an improvement in competitive balance, while a notable drop can be identified after 2010. Note that the number of lead changes is particularly influenced by certain aspects of the sporting regulations (for instance, introduction versus bans of within-race re-fueling and mandatory pit-stops for tire changes). Nonetheless, one shortcoming of the number of lead changes as a measure of competitive balance should not be concealed here. As already criticized by Berkowitz et al. (2011, p.258), this measure does not reflect how much passing occurred throughout the entire field until the end of the race. Unfortunately, this data is, to our best knowledge, not available for F1.

Calculating the Gini coefficient for the results of the qualifying could be a competitive balance measure which takes the balance throughout the entire field into account. Figure 1.2 highlights the development of the Gini coefficients based on the distribution of qualifying lap times for each race since 1950, whereas the pole position qualifying lap time is normalized to a value of 100 percent and the time gaps of the remaining drivers are specified as three digit percentage value of the qualifying time (for example, 104.693 percent).

The Gini coefficients reveal some variance between the races, especially during the starting period of the F1 championship. Also a clear negative linear trend can be seen. The smoothed trend confirms the development

Figure 1.1 Lead changes in F1 races as a measure of competitive balance

Figure 1.2 Gini coefficient based on qualifying times (percentage)

towards a more balanced competition towards the actual seasons, while there is a slight trend in the opposite direction after 2010.

Finally, Berkowitz et al. (2011, p.258) suggest that a measure of competitive balance within a race should reflect the differences between the starting and finishing positions throughout the entire field. They adopted the adjusted churn index developed by Mizak et al. (2007). Instead of this measure, we employ the Spearman rank correlation coefficient to measure the changes between the starting grid and the final result (Figure 1.3). The ranking of the race results is based on finishing times, and laps behind if relevant. For retired drivers the completed race distance is used to rank the drivers. To begin with, a clear positive (long-term) linear trend can be observed, while the smoothed trend decreases at first, reaching the minimum around the mid-1980s. Following the minimum, the LLR trend increases. This implies a growing congruence between the grid positions and the final positions and, thus, a decreasing competitive balance.

3.2 Within-Season Competitive Balance

As in team-sport leagues, within-season competitive balance can be measured by means of the final standings of the sporting competition. So

Figure 1.3 Spearman's rank correlation coefficient between grid and final race position

far, several measures are employed in the literature. The methods used are, for example, the HHI, the Gini coefficient, standard deviation, coefficient of variation, or the ratio of actual and ideal standard deviation (RSD). The RSD has its legitimacy for team-sports leagues considering different schedule lengths. In this context, however, such a correction mechanism is not necessary. Therefore, we employ a standard measure of concentration in this section. The Gini coefficient is calculated, analogously to team-sport leagues, on the basis of the final standing of each F1 season for both the WDC and the WCC.

When calculating this indicator, some peculiarities have to be taken into consideration. In contrast to team-sport leagues, where normally all teams have accumulated at least some points in the final league standing, in F1 only a fraction of the drivers and teams have scored points at the end of the season. This leads to the decision whether the Gini coefficient should be calculated on the basis of the point distribution of the drivers and teams which have accumulated points or on the basis of the point distribution of all enlisted drivers and teams. The inclusion of drivers and teams with zero points in the calculation of the index could have a serious impact.

The left-hand side of Figure 1.4 shows the development of competitive

Figure 1.4 Competitive balance based on different point distributions

balance according to the Gini coefficients on the basis of the point distribution of all drivers and teams that have earned at least one point in the final season standing. The grey line indicates the individual values of the Gini coefficients for all 69 seasons since 1950,⁸ while the solid black line is a linear trend and the dashed black line a smoothed trend calculated by means of an LLR. For both championships, mid-range values of the Gini coefficient can be observed. A clear positive trend is visible, indicating a reduction in competitive balance over time. This positive LLR trend can also be confirmed until the early 1990s.

Inspecting the development of competitive balance according to the Gini coefficients on the basis of the point distribution of all drivers and teams including zero values, which is displayed for both championships in the right-hand side of Figure 1.4, reveal a different picture. First, the absolute values of the Gini coefficients are considerably higher than in the other case. Second, the overall trend is negative which can be translated into an improvement of competitive balance in both championships over time.

The results depend strongly on the decision to include or not include the zero-point participants, therefore it is necessary to be careful when using measures of the competitive balance in motorsports in general or F1 in particular. Since sport fans might be mindful of more than just the top-ranked participants, we recommend using the distribution including zero-value observations.

When analyzing competitive balance on the basis of the point distribution, it must be considered that FIA has changed the points system several time since 1950. For the first ten seasons the drivers finishing first to fifth were awarded with points (8-6-4-3-2). From 1960 to 1990 the first six drivers gained championship points (9-6-4-3-2-1).⁹ Following the 1990 season, the reward for winning was raised to ten points, while the remaining scheme remained unchanged. Starting with the 2003 season, the previous scheme was replaced by a new scheme, now awarding 10-8-6-5-4-3-2-1 points to the first eight positions. The rule change came at the end of the 2002 season which was dominated by Michael Schumacher who secured the WDC after 11 of 17 races. Since this was viewed negatively from business considerations (especially television quotas for the final races), a main motivation behind the new points scheme was to delay the WDC win of a dominating driver by awarding a smaller points advantage from winning (compared with the second-placed driver). Thus, the change of the points system was motivated by competitive balance concerns. Furthermore, the increase in range of awarded positions from the top six to the top eight was expected to lead to more engaged racing in the respective positions. In order to increase the incentives for the leading drivers of a GP, the point scheme was changed to 25-18-15-12-10-8-6-4-2-1 in 2010.

One possible solution regarding the inconsistencies of the point scheme might be the development and implementation of a consistent point scheme according to the final race results. We chose a simple scheme rewarding 10-9-8-7-6-5-4-3-2-1 points to the drivers finishing within the first ten positions. A downside of such an adjustment is that the points system in force at a given time represents an important incentive structure for drivers and teams, and therefore probably influences the race results. That is, the results might have been different if they had been run under this consistent point scheme.¹⁰

Figure 1.5 displays the development of competitive balance for the two different point schemes, where the calculations include drivers with zero points accumulated at the end of the season. The left-hand side contains the FIA points-based Gini coefficient, while the right-hand side shows the consistent point scheme-based Gini coefficients. At first glance, the index sequences seem to be similar. For all four panels of Figure 1.5, a clear negative trend, implying an increase in competitive balance, can be attested. Moreover, the smoothed trend does not deviate strongly from the linear trend in both cases. At least at the end of the observation period, a different pattern of the smoothed trend could be seen. Looking at the outcomes based on the current FIA scheme, the LLR trend is generally following the linear trend over the whole observation period reasonably closely, while the LLR trend deviates positively from the linear trend at the end of the observation period when using the consistent point scheme.

It is not easy to decide whether to use the point scheme based on the current FIA rules or the consistent but artificial point scheme. The latter has the advantage of comparability, while the first reflects the situation the fans perceived during or at the end of the relevant season. Perhaps we can recommend using the artificial consistent point scheme while analyzing competitive balance for its own sake. Furthermore, if a measure of competitive balance should be used as a dependent variable in a regression to identify the reaction of consumers to changes in competitive balance, using the current FIA point scheme might be appropriate.

All examples showed so far in this section are based on the number of points each driver and team accumulated at the end of a given season. Since the difference in points awarded to the top positions of the final race result are fixed, accumulated points might not reflect perceived difference in the race level; for example, winning by just one-thousandth of a second is no different to winning by 30 seconds. A possible solution to overcome this shortcoming of the point-based championship table is to use the leading distance or leading laps accumulated by the different drivers and teams. Figure 1.6 contains the development of the Gini coefficients calculated on the basis of accumulated leading laps or distance at the end of each season.

Figure 1.5 Competitive balance based on different point schemes

Figure 1.6 Competitive balance based on leading laps and leading distance (drivers)

The left-hand side shows the Gini coefficient using leading laps, and the right-hand side similarly using leading distance in kilometers.

Looking at the left-hand side of Figure 1.6, which displays the Gini coefficient based on drivers with a non-zero number of leading laps and kilometers, respectively, the story seems to be a little different if compared with the Gini coefficient based on the accumulated points. Here, the long-term trend of the coefficient index is generally stable over the observation period. The smoothed trend reveals a minimum of the Gini coefficient and thus a maximum of competitive balance around the year 1980, while ending at almost the same level as at the beginning of the observation period. Regarding values of around 0.6, the competitions could be considered relatively imbalanced. If drivers without any leading laps or kilometers are also considered, F1 seems to be even more imbalanced, meaning that only very few drivers and teams are leading a GP over the course of a season. However, both the linear and the smoothed trend indicate a slightly negative development, that is, a small improvement of competitive balance, over the observation period. Figure 1.7 depicts the same indicators but for teams instead of drivers. Here, the results are very similar to those shown in Figure 1.6.

3.3 Inter-Season Competitive Balance

Static and dynamic inter-season competitive balance might not be of great interest from the perspective of program planners and advertising marketers since their interests are normally more short term. However, from the perspective of the championship organizer, it might be an important indicator for long-term rule changes to raise the attractiveness of the competition.

First, indicators of static inter-season competitive balance should be introduced. The measures are based on the distribution of the championship titles won by individual drivers and teams. Here, we again employed the Gini coefficient but other measures, such as the HHI or the standard deviation, could have been used, too. Table 1.1 displays the coefficients for the entire period from 1950 to 2018 and coefficients for each decade since the introduction of the F1 world championship. The first two rows of the table show the values for the WDC and the WCC. The subsequent rows contain comparable coefficients for popular team-sport leagues in Europe and North America.

Table 1.1 reveals that the WDC is, in many cases, more balanced than the WCC. Moreover, the WDC seems to be the most balanced competition among the listed championships. The F1 driver championship, especially the decades dominated by Juan Manuel Fangio (five titles between 1951 and 1957) and Michael Schumacher (five titles between 2000 and 2004), show high values for this competitive balance indicator. The competitive

Figure 1.7 Competitive balance based on leading laps and leading distance (teams)

Table 1.1 Competitive balance based on championship distribution (Gini coefficient)

	1950–2018	1950–59	1960–69	1970–79	1980–89	1990–99	2000–2009	2010–18
F1 drivers (WDC)	0.350	0.360	0.171	0.171	0.267	0.171	0.360	0.222
F1 teams (WCC)	0.503	–	0.233	0.300	0.133	0.350	0.400	0.056
Premier League	0.489	0.267	0.150	0.300	0.400	0.360	0.267	0.194
La Liga	0.591	0.250	0.467	0.350	0.300	0.333	0.250	0.370
Bundesliga	0.533	0.171	0.150	0.350	0.400	0.280	0.400	0.278
Serie A	0.569	0.250	0.240	0.333	0.300	0.350	0.311	0.444
MLB	0.495	0.400	0.171	0.160	0.089	0.241	0.089	0.241
NBA	0.538	0.300	0.400	0.150	0.350	0.400	0.320	0.241
NFL	0.409	0.240	0.333	0.233	0.233	0.233	0.229	0.097
NHL	0.526	0.267	0.267	0.267	0.300	0.150	0.159	0.222

balance comparison between the WDC and any type of team sports (including the WCC) suffers from the difference in length of driver careers compared with team careers. Thus, over long periods (for example, 1950–2018), the indicator for the WDC will naturally differ from that of team sports, whereas shorter time periods are more comparable.

In contrast to the WDC, the WCC is located at the other end of the scale, joining the Spanish La Liga, the Italian Serie A and the North-American NBA as unbalanced competitions. For the WCC, an exceptionally low coefficient can be observed during the 1980s. This decade was dominated by three teams: Ferrari, McLaren and Williams. The last two of these won four of the ten constructor championships each, while Ferrari won the remaining two. The choice of decades from which to analyze the static competitive balance for sub-periods is arbitrary. For instance, the ten-year period from 1999 to 2008, in which Ferrari won eight of ten possible constructor championships, produces a different result than any of the decades cited. The WCC shows its lowest value during the 2010–18 period, when two teams (Red Bull Racing and Mercedes) were dominant.

4. CONCLUSIONS AND OUTLOOK

This chapter had two main aims. First, different measures of competitive balance in F1 racing or motorsports in general were introduced. Moreover, pitfalls induced especially by type of data or calculation method have been highlighted.

Using three different dimensions of competitive balance (within-race, within-season and inter-season) in F1 motor racing, weak evidence for improvements in competitive balance over the course of the seasons exists, even though trends for some measures indicate a decline in competitive balance. However, the generally positive trend seems to be reversed in relation to many indicators since 2010.

This analysis could be extended in several ways. First, it seems to be fruitful to analyze also the dynamic aspects of competitive balance in F1 racing. A useful tool could be the Markov chain-based method developed by Hadley et al. (2005). Here, competitive balance is measured by using the transition probabilities from one season to the following season. Second, other dynamic measures such as the Spearman rank correlation coefficient or the adjusted churning index (Mizak et al. 2007; Berkowitz et al. 2011, p. 258) based on final standings position between two consecutive seasons could be employed.

Finally, operationalizing measures of competitive balance in motorsport racing could be important for further research in this area. Formula One seems to be a particularly well-suited field in which to analyze the effects of competitive balance on fan demand, especially with a view to distinguishing between the effects of competitive balance and a domestic or local hero preference.

NOTES

1. There are two world champion titles each season, one for the driver who scored the highest number of points and one for the constructor (team) that scored the highest number of points.
2. See Berkowitz et al. (2011) for a comparable analysis for NASCAR racing. For a classification of motor racing circuits see Müller and Budzinski (2014).
3. The 2019 season consists of 21 races in Europe, Asia, South America, North America and Australia and it lasts from March to December. Africa is currently the only continent without a GP, however, there have been GPs in South African and Morocco in former times.
4. In 2019, they consist of car manufacturers (and related companies), such as Mercedes, Ferrari and Renault, specialist race car constructors, for instance, McLaren, Williams and Haas, as well as the beverages producer Red Bull.
5. For more details on the commercial structure of F1 see Budzinski and Müller-Kock (2018), and generally on market-internal financial regulation in sports see Budzinski (2018).
6. For a contemporary overview over concepts, theories and measures of competitive balance see, *inter alia*, Pawlowski and Nalbantis (2019).
7. All data for the empirical analysis has been collected from <https://www.formula1.com> and <https://www.motorsport-total.com/formel-1/formel-1-datenbank/> (both accessed 10 March 2019).
8. The WCC did not start until 1958.
9. Only during the 1960 season was the winner was awarded eight instead of nine points.

10. A resulting possible error, while using the consistent point scheme to calculate a measure of competitive balance, cannot be corrected and, thus, has to be considered when interpreting the corresponding figures.

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