Justice for All? The Effect of Competitive Balance in NHRA Pro Stock Motorcycle Racing

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Abstract

In the United States, the National Hot Rod Association (NHRA) is the premier drag racing sanctioning body. One of its popular professional categories is Pro Stock Motorcycle. In 2012, the category was dominated by two competitors from the same team. The perceived lack of parity brought criticism from the racing media and other Pro Stock Motorcycle competitors. In an effort to bring parity to the class, the NHRA revised technical rules during the 2012 season and for the 2013 season. This study examined the effects of the rules adjustments on Pro Stock Motorcycle competitive balance for the 2012 and 2013 seasons. The adjusted churn method was utilized to compute a numeric measure of competitive balance in two different ways. First, the adjusted churn was computed using the qualified racer's initial and final ranking in the event ladder for all national events featuring the Pro Stock Motorcycle category in each of the 2011, 2012, and 2013 seasons. The churn for a competitor's ranking is calculated as the absolute value of the difference between a competitor's starting and finishing positions. This value of the churn is then divided by the maximum churn possible given the number of competitors to arrive at the value known as the adjusted churn. Analysis of variance (ANOVA) using these adjusted churn values of the ladder rankings as the numeric dependent variable, and year as the factor with three levels. The results indicated a significant difference in adjusted churn for event ladder competitive balance [$F(2, 45) = 4.24$, $p = 0.021$]. Tukey's Honestly Significant Difference was used as a post-hoc multiple comparison procedure to determine the nature and direction of these differences. The adjusted churn for event ladder competitive balance was lower in 2012 ($M = 0.18$, $SD = 0.13$) than that for the 2013 season ($M = 0.33$, $SD = 0.17$). Secondly, the adjusted churn was computed for the change in each competitor's accumulated championship points before and after each national event featuring the Pro Stock Motorcycle category in the 2011, 2012, and 2013 seasons. ANOVA was then used with the adjusted churn of the accumulated championship points as the numeric dependent variable, and year as the factor with three levels. The ANOVA test results indicated significant differences in adjusted churn for accumulated championship points [$F(2, 42) = 10.45$, $p = 0.00$]. Again, Tukey's Honestly Significant Difference was used as a post-hoc multiple comparison procedure and determined that the 2012 season ($M = 0.37$, $SD = 0.09$) was lower than the 2011 season ($M = 0.29$, $SD = 0.09$) and the 2013 season ($M = 0.54$, $SD = 0.13$). No other significant differences were detected.

Keywords: competitive balance, motorcycles, drag racing, adjusted churn

Introduction

The National Hot Rod Association (NHRA) was founded in 1951 to make drag racing a legitimate sport (Burgess, 2011; Post, 1994). As the world's largest motorsports sanctioning body, the NHRA sanctions events at small, local drag racing venues in addition to its major national events (Eagleman, 2010). The top professional levels of the NHRA are the Top Fuel Dragster and Top Fuel Funny Car categories along with the Pro Stock Car and Pro Stock Motorcycle categories.

Unlike other motorsports competitions involving a mass start like NASCAR or Formula One, NHRA drag racing employs a single-elimination tournament similar to the structure utilized in tennis competitions. However, the NHRA tournament structure is dissimilar to that of tennis because past performance is not used in the seeding procedure. Rather, Pro Stock Motorcycle competitors complete up to four one-quarter mile laps to set elapsed times. The lowest elapsed time from the qualifying attempts of each competitor is then utilized to set the event ladder. This qualifying procedure produces what might be considered an anticipated outcome of the fastest qualifiers winning events. However, if the competition is balanced, it should produce some unanticipated outcomes during the event.

Competitive balance has long been considered an important aspect of spectator sport. Since Rotenberg's (1956) work, the premise of uncertainty of outcome and competitive balance in various sports has been studied. Rotenberg's theory postulates that spectators will be unwilling to pay admission to sporting events that have foregone conclusions of one team or individual winning (Fort, 2006; Rottenberg, 1956). As a result, sanctioning bodies place restraints on competitors to enhance the competition (Sanderson, 2002). The imposition of salary caps, luxury taxes on payroll, and player drafts have implemented in league sports in efforts to ensure competitive balance (Levin & MacDonald, 2009; Leeds & von Allen, 2005; Sanderson, 2002). Additionally, equipment constraints in individual sports such as golf and tennis are enforced to produce more balanced competition (Sanderson, 2002).

In motorsports, sanctioning bodies, such as NHRA, NASCAR, and Formula One, implement a variety of rules on equipment in their efforts to increase the uncertainty of outcome and to balance the competition. Aside from those rules mandated for safety, competitors are restricted to a number of specifications including weight, engine size, aerodynamic shape, and tires. Increased competitive balance is assumed to generate greater spectator interest (Levin & McDonald, 2009; Rottenberg, 1956). With greater spectator interest comes more opportunities of sponsorship for competitors, sanctioning bodies, and venues. Thus, there is a financial incentive for motorsport sanctioning bodies to implement rule changes to increase competitive balance (Mastromarco & Runkel, 2009). Competitive balance is even more important in an individual sport in which there are no guarantees to qualify for an event. If competitors perceive an imbalance in competition, then they might decide to exit the sport.

Rationale of the Current Study

This study focuses on the NHRA Pro Stock Motorcycle category, which competed in sixteen national events each season, for the 2011, 2012, and 2013 seasons. The primary manufacturers competing during the seasons in this study were Buell, Harley-Davidson, and Suzuki. NHRA rules for the 2012 season allowed one manufacturer, Harley-Davidson, exclusive use of a unique engine configuration. Additionally, no other teams were allowed to purchase the Harley-Davidson engine (Kernan, 2011; NHRA, 2012).

The engine configuration of the Harley-Davidsons appeared to have a significant advantage over the other manufacturers in the first race of the 2012 season. In an attempt to maintain competitive balance, the NHRA reviews performance differences among the manufacturers when one manufacturer appears to have a significant advantage over any other manufacturer ("Technically Speaking," 2012). Following the review after the first event of the 2012 season, the NHRA required the Harley-Davidsons to add weight before the second race of the season ("Harley Weight Adjustment," 2012; "Technically Speaking," 2012). However, the added weight did not appear to have a significant effect on the outcome of the races as the Harley-Davidsons persisted in winning the next nine races.

The NHRA drew criticism from the drag racing media for producing an apparent imbalance in the competition (Asher, 2012; Bennett, 2012). The criticism of Harley-Davidson was in part due to its being a major sponsor of the NHRA. Some parties saw the 2012 Pro Stock Motorcycle engine rule that favored the Harley-Davidson team as a payback to the sponsor (Asher, 2012). As the class was dominated by the Harley-Davidsons, the drag racing media (Asher, 2012; Bennett, 2012) and competitors (Proffit, 2012; "The PSM Bickering," 2012; Wade, 2012) called for greater parity throughout the season.

As a response to the criticism, the NHRA imposed a rule change to the Pro Stock Motorcycle category requiring the Harley-Davidsons to carry additional weight following the tenth event of the 2012 season ("NHRA Announces," 2012). Although the Harley-Davidsons did not win the eleventh event in Dallas, Texas, they won the remaining 2012 events.

For the 2013 season, the NHRA revised its rules for the Pro Stock Motorcycle category. All competitors were prohibited from using the engine configuration the Harley-Davidsons had used in the 2012 season ("NHRA Announces," 2012). The competitors racing on Harley-Davidsons and Buells were given the new technical rules for 2013, whereas the competitors racing Suzukis were allowed to continue the same rules as 2012 ("NHRA Announces," 2012).

In spite of the media criticism and subsequent rule changes in 2012 to attempt to produce level competition, analysis of the competitive balance in the Pro Stock Motorcycle category was lacking. The purpose of this study was to analyze event ladder competitive balance and championship points ranking competitive balance. We used data from the Pro Stock Motorcycle category for the 2011, 2012, and 2013 seasons to determine if competitive balance was improved by the rules changes.

Literature Review

Competitive Balance in Sport

Sport managers have long been concerned with competitive balance and the uncertainty of outcome. In his seminal work, Rottenberg (1956) postulated the uncertainty of outcome hypothesis that fans would prefer to attend professional baseball games in which each team has an equal chance of winning. This does not imply that fans wish to see their teams lose. However, it implies that fans will gain more enjoyment from a game in which there is not a foregone conclusion as to which team will win and in which the score is close (Quirk & Fort, 1992; Rascher, 1999). Within sports leagues such as the NFL, greater uncertainty of outcome results in greater competitive balance (Quirk & Fort, 1992; Rascher, 1999). Thus, it is important for sports managers to measure the competitive balance of their sport to ensure fan interest (Quirk & Fort, 1992; Rascher, 1999; Sanderson & Siegfried, 2003). Failure to remedy imbalances in competition could lead to the dissolution of the league (Rascher, 1999).

Researchers have produced a great deal of research on the competitive balance of league sports such as the National Football League (Biner, 2013; Lenten, 2015; Mills & Fort, 2014), the National Basketball Association (Fort & Lee, 2007; Mills & Fort, 2014), Major League Baseball (Biner, 2013; Knowles, Sherony, & Haupert, 1992; Mills & Fort, 2014), and National Hockey League (Mills & Fort, 2014). Research on the competitive balance in motorsports has not received a great deal of attention (Berkowitz, Depken, & Wilson, 2011; Judde, Booth, & Brooks, 2013; Krauskopf, Langen, & Bunger, 2010; Mastromarco & Runkel, 2009; Schreyer & Torgler, 2018. An exhaustive search revealed no published studies of the competitive balance in professional drag racing.

Competitive Balance in Motorsport

Much of the research on competitive balance in motorsport has focused on Formula One and NASCAR. A major difference in this research has been that the focus is on the effect of competitive balance on television spectators. Unlike fans of other professional sports such as football, baseball, or hockey, all of which have “home teams,” motorsports fans have a limited number of opportunities to attend live events (Berkowitz, Depken, & Wilson, 2011; Krauskopf, Langen, & Bünger, 2010). To attend multiple major motorsports events, most fans are required to travel great distances. However, because the premier forms of motorsport are televised, nearly any fan has the ability to view the events if they choose to do so (Krauskopf, Langen, & Bünger, 2010). Thus, to ensure that fans tune-in to the events, sanctioning bodies must maintain a level of competitive balance. If motorsports fans see a single team or driver dominating the competition, some of those fans will tune out. The number of fans viewing the events on television is important to the sanctioning bodies because broadcasting contracts provide a major source of revenue for the sport (International Speedway, 2013; Sylt, 2019).

In their study examining the impact of competitive balance on television viewership of Formula One races, Krauskopf, Langen, and Bünger (2010) found that competitive balance was not necessarily desired by German fans. Instead of balanced competition, fans in the study desired close competition throughout the season for the driver’s championship among a few superstars of the sport (Krauskopf, Langen, & Bünger, 2010). To ensure close competition for the championship, the *Federation Internationale de l’Automobile* (FIA), the sanctioning body of Formula One, was found to implement rule changes to enhance competitiveness following seasons in which the championship was determined too early in the season (Mastromarco & Runkel, 2009).

In a study similar to Krauskopf, Langen, and Bünger (2010), television ratings for individual Formula One races from the 1993 through the 2014 seasons were studied to determine if the uncertainty of outcome affected viewership in Germany. Schreyer and Torgler (2018) found that more German fans of Formula One watched races in which the expected competition among the best three to four qualifiers was relatively balanced; however, the viewers did not appear to favor a races scenarios in which there was significant competitive balance among all of the competitors (Schreyer & Torgler, 2018). Rather more viewers watched those races in which there was only balance among the top qualifiers (Schreyer & Torgler, 2018). In other words, when the time gaps among the best qualifiers were small, there were more viewers of those races (Schreyer & Torgler, 2018). Conversely, when there were large gaps of time among the best three or four qualifiers, which suggested a lack of competitive balance, fewer fans watched the races on television (Schreyer & Torgler, 2018).

Judde, Booth, and Brooks (2013) examined competitive balance of Formula One over the 1950-2010 seasons. They concluded that rules changes over the years contributed to the championship being decided later in the season from previous seasons. The result “supports Mastromarco and Runkel’s (2009) conclusion that regulation change contributes to increased uncertainty of championship outcome” (Judde, Booth, & Brooks, 2013, p. 425). By determining the championship later in the season, Formula One remained relevant to the fans throughout the season.

For the rules changes to have a significant impact on the competitive balance in Formula One, they must be implemented at the beginning of the season. Rule changes during a season did not have a significant impact on the competitive balance (Mastromarco & Runkel, 2009). Additionally, the rules changes must not affect the quality of the competition. Lowering the performance of competitors has a negative effect on spectatorship, which can affect revenue from attendance and broadcasting (Mastromarco & Runkel, 2009). Therefore, sport managers must be cognizant of the impact of the rule changes and of the timing of their implementation.

The uncertainty of outcome is an important component of the fan experience in motorsports. Fans appreciate closely matched competitors over a single dominant driver. In the lower levels of stock car racing found on short tracks throughout the United States, there has long been a rumor of an unwritten rule or agreement among competitors and promoters that influences the perceived uncertainty of outcome of races to enhance the fans’ experiences. According to NASCAR historian Buz McKim, the “rule” is that the leader of the race should make it appear as if the second-place driver possibly has a chance of winning (B. McKim, personal correspondence, June 30, 2014). Although this would not affect competitive balance, it heightens the fans’ perceptions of an uncertain outcome, which leads to a more exciting experience for the fans.

Berkowitz, Depken, and Wilson (2011) found that NASCAR fan interest in viewing events was affected by a lack of uncertainty of outcome. This was especially true for the season-long championship points competition. If the championship is decided too soon in the season, fewer fans tuned into the season ending races (Berkowitz, Depken, & Wilson, 2011). Perhaps, NASCAR took this in consideration when it implemented a new “playoff” format for the “Chase for the Championship” in 2014. The new format put four drivers on equal standing to race for the championship in the final race of the season

("NASCAR Chase Explained," 2015). The new format was seen as successful because the number of viewers increased by 2% for the final 2014 race over the same 2013 race ("2015 NASCAR Television Ratings," n.d.).

Competitive Balance in Drag Racing

Research on the competitive balance of drag racing is lacking. Unlike other forms of motorsports such as NASCAR and Formula One in which one class competes at a time, drag racing events have multiple professional classes competing sequentially throughout the event. For example, the first round of eliminations for Pro Stock Motorcycle will be followed by Pro Stock Car, which will be followed by the Top Fuel categories before the second round of Pro Stock Motorcycle eliminations begins. Therefore, it is not possible to measure the attendance or television viewership for Pro Stock Motorcycle alone because only the total attendance or viewership would be reported. Thus, the influence of competitive balance on Pro Stock Motorcycle spectators or fans cannot be measured and remains unknown.

Competitive imbalances in drag racing have an effect on competitors and their sponsorship opportunities. For example, L. E. Tonglet, the 2010 Pro Stock Motorcycle champion, cited the perceived lack of balance as a major reason for the loss of his sponsor in 2012 (Proffit, 2012). Thus, it is important for the NHRA to implement rules to ensure balanced competition and to monitor the ongoing competition to revise rules as needed.

Methods

Measurement with Adjusted Churn

To measure the competitive balance of the Pro Stock Motorcycle category, we utilized the adjusted churn. The adjusted churn is a method that can be employed in the measurement of competitive balance based on previous performance (Mizak, Neral, & Stair, 2007). For this study, adjusted churn measures the competitive balance in NHRA Pro Stock Motorcycle for the 2011, 2012, and 2013 seasons. These data were selected because of the perceived imbalance and subsequent rules changes during the 2012 season (Asher, 2012; Bennett, 2012; "NHRA Announces," 2012; Proffit, 2012; "The PSM Bickering," 2012; Wade, 2012).

Adjusted churn is calculated by dividing the churn (the absolute value of the change between a competitor's starting position and finishing position) by the maximum churn possible (Mizak, Neral, & Stair, 2007). An adjusted churn value of zero indicates that no changes occurred, and a value of one indicates the maximum change possible. The index allows for comparisons of competitive balance among different events in which there might be a varying number of competitors. The following is an explanation of how adjusted churn was calculated for this study.

Maximum Churn

Maximum churn is found when the worst qualifiers win in each round of an event. For example, in the first round of eliminations with sixteen competitors, all of the top eight qualifiers would lose to the bottom eight qualifiers. The absolute value of the differences derived from subtracting the finishing position from the starting position results in the churn for a competitor. When the number of competitors is even, the churn for each competitor is totaled, then divided by the number of competitors (*n*) to arrive at the maximum churn (C_{max}) for an event. Figure 1 illustrates an example of maximum churn in an event ladder with sixteen competitors. Table 1 shows the calculations utilized to calculate maximum churn in the event ladder of sixteen.

Figure 1 *Illustration of Single-Elimination Ladder with Sixteen Competitors Resulting in Maximum Churn in NHRA Drag Racing*

To simplify the calculation for the maximum churn for an event with an even number of competitors (*n*), the formula is:

$$C_{max(even)} = \frac{n}{2}$$

Thus, the maximum churn for an event with sixteen competitors (n = 16) is calculated as

$$C_{max(even)} = \frac{16}{2}$$

$$C_{max(even)} = 8$$

Table 1 *Calculation of Maximum Churn for Single-Elimination Ladder with Sixteen Competitors in NHRA Drag Racing*

	Churn	
Starting Position	Finishing Position	Absolute Value of Change in Position
1	9	8
2	10	8
3	11	8
4	12	8
5	13	8
6	14	8
7	15	8
8	16	8
9	8	1
10	7	3
11	6	5
12	5	7
13	4	9
14	3	11
15	2	13
16	1	15
	Total Churn	128

$$C_{max} = \frac{Total\ Churn}{Number\ of\ Competitors}$$

$$C_{max} = \frac{128}{16} = 8$$

Competitors in NHRA drag racing are free to choose the events in which they enter. Some competitors choose to compete in the full season, while others might choose to compete in selected events throughout the season. Thus, the number of competitors can vary at each event. Although in most cases there are sixteen qualifiers for the event, at least one event in two of the seasons studied (2012 and

2013), only fifteen competitors entered. As a result, there were only fifteen qualifiers for those events. When there is an odd number of qualifiers, an adjustment to the maximum churn calculation is required (Mizak, Neral, & Stair, 2007). The simplified calculation for maximum churn for an odd number of competitors (n) is:

$$C_{max(odd)} = \frac{(n^2 - 1)}{2n}$$

Figure 2 shows an example of maximum churn with fifteen competitors in an event ladder. Table 2 displays the calculations utilized to calculate maximum churn in the event ladder of fifteen.

Thus, maximum churn calculation for those events with fifteen competitors (n = 15) is calculated as:

$$C_{max(odd)} = \frac{(15^2 - 1)}{2(15)}$$

$$C_{max(odd)} = \frac{(225 - 1)}{30}$$

$$C_{max(odd)} = \frac{(224)}{30}$$

$$C_{max(odd)} = 7.4667$$

Adjusted Churn

Calculating the adjusted churn is a straight forward procedure in which the calculated churn (*C*) is divided by the calculated maximum churn (C_{max}) (Mizak, Neral, & Stair, 2007).

$$AC = \frac{C}{C_{max}}$$

Event Ladder Competitive Balance

To analyze the impact of the rules changes implemented by the NHRA on event ladder competitive balance, the adjusted churn was calculated for each event in the 2011, 2012, and 2013 Pro Stock Motorcycle seasons. NHRA drag racing events utilize up to four qualifying rounds and a single-elimination tournament format for each national event. To qualify for the eliminations rounds, known as "eliminations," competitors complete up to four laps on the quarter-mile track. The sixteen competitors with the lowest elapsed times posted for any lap in qualifying advance to the eliminations. Qualifiers are then seeded on the ladder based on their lowest elapsed times.

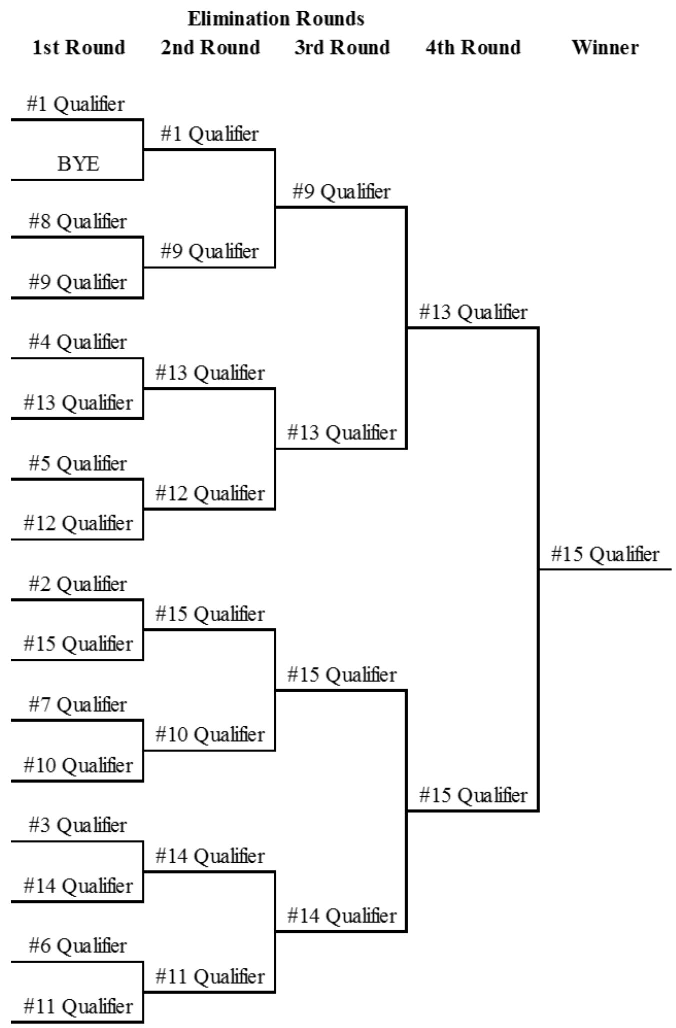

Figure 2 *Illustration of Single-Elimination Ladder with Fifteen Competitors Resulting in Maximum Churn in NHRA Drag Racing*

In this study, the starting position was the qualifying position of the competitor on a single-elimination tournament ladder. Finishing positions of the qualifiers were determined based upon their success in the ladder and their qualifying position. The winner and runner-up of the event were awarded

Table 2 *Calculation of Maximum Churn for Single-Elimination Ladder with Fifteen Competitors in NHRA Drag Racing*

Churn

Starting Position	Finishing Position	Absolute Value of Change in Position
15	1	14
14	3	11
13	2	11
12	4	8
11	5	6
10	6	4
9	7	2
8	8	0
7	9	2
6	10	4
5	11	6
4	12	8
3	13	10
2	14	12
1	15	14
	Total Churn	112

$$C_{max} = \frac{Total\ Churn}{Number\ of\ Competitors}$$

$$C_{max} = \frac{112}{15} = 7.4667$$

first and second places, respectively. For the finishing positions of third through sixteenth positions, the finishing position was determined by the round in which the competitor lost and her/his starting position. For example, if the first place qualifier were to lose in the first round of eliminations, that competitor would be awarded the ninth-place finishing position. Competitors failing to qualify for an event were excluded from this study.

Churn for Event Ladder Competitive Balance

Churn for an event ladder is calculated as follows:

$$C_e = \frac{\left[\sum_{i=1}^{n} \left| f_{i,p2} - f_{i,p1} \right| \right]}{n}$$

C_e is the churn for the event ladder, $f_{i,p1}$ is the qualifying position for individual competitor, $f_{i,p2}$ is finishing position for individual competitor, and n is number of event competitors.

Adjusted Churn for Event Ladder Competitive Balance

The adjusted churn for within event competitive balance is calculated by dividing the churn for the event by the maximum churn possible for that event.

$$AC_e = \frac{C_e}{C_{max}}$$

The result ranges from zero, indicating no changes from starting position to finishing position, to one, indicating the maximum change possible.

Championship Points Ranking Competitive Balance

Unlike most sports leagues, NHRA drag racing allows competitors to select the national events in which they compete. Thus, not all licensed NHRA Pro Stock Motorcycle competitors choose to enter all sixteen national events. To determine the season champion, the NHRA awards points for event performance (NHRA, 2012). The data utilized to analyze the seasonal competitive balance were the championship points earned at each national event by the competitors who entered all sixteen national events.

Event points are awarded based on the finishing order of the competitors. In fifteen of the sixteen national events, competitors earn 10 points for making a qualifying attempt, and those qualifying for the event earn an additional 20 points. Once the elimination rounds begin, competitors are awarded 20 points for each round win, with the overall event winner earning 100 points for the win (NHRA, 2012).

For the United States Nationals event, a qualifying attempt is awarded 15 points. Competitors qualifying for the U.S. Nationals earn an additional 30 points. Elimination round winners earning 30 points for each round they win. The U.S. Nationals winner earns 150 points for the event win. Bonus points are awarded to the three competitors posting the quickest elapsed times for each of the rounds of qualifying, as well as, for any competitors setting national speed records during an event (NHRA, 2012).

To analyze competitive balance in the NHRA Pro Stock Motorcycle category, the competitors entering all events for each season studied were ranked relative to one another for each event based on the points they earned for the event. If multiple competitors earned the same number of points for an event, they were given the same ranking. Table 3 shows an example of the rankings from two events from the 2011 season and the churn value for each competitor between the two races.

Churn for Championship Points Ranking Competitive Balance

Churn for the championship points is calculated as follows:

$$C_r = \frac{\left[\sum_{i=1}^{n} \left| f_{i,r} - f_{i,r-1} \right| \right]}{n}$$

For the competitive balance calculations in this study, C_r is the churn for the ranking in points, $f_{i,r}$ is an individual competitor's ranking by points earned at a race, $f_{i,r-1}$ is an individual competitor's ranking by points at the previous race, and n is number of competitors racing the complete season.

Table 3 *Example of Relative Rankings of Competitors Entering All National Events in 2011*

Competitor	Event 1 Points	Event 1 Rank	Event 2 Points	Event 2 Rank	Churn of Rank
Kraweic	124	1	78	4	3
Arana, Sr.	104	2	37	9	7
Stoffer	100	3	79	3	0
Tonglet	74	4	42	8	4
Hines	62	5	122	1	4
Smith, M.	54	6	34	10	4
Savoie	53	7	54	5	2
Underdahl	32	8	32	11	3
Smith, A	32	8	31	12	4
Johnson	31	10	51	6	4
Arana, Jr.	10	11	51	6	5
Phillips	10	11	97	2	9
Whitaker	10	11	10	13	2
Finley	10	11	10	13	2

Adjusted Churn for Championship Points Ranking Competitive Balance

The adjusted churn for the full-season competitors was calculated for the 2011, 2012, and 2013 seasons based on their rankings by dividing C_r by the maximum churn for the respective seasons.

$$AC_r = \frac{C_r}{C_{max}}$$

The result ranges from zero, indicating no changes in rankings from one event to the next, to one, indicating the maximum change possible.

Data

Data were collected from the NHRA's website at www.nhra.com for all Pro Stock Motorcycle events for the 2011, 2012, and 2013 seasons. The qualifying position, finishing position, and championship points earned were obtained for each competitor attempting to qualify for a national event. We utilized these data to calculate the adjusted churn for analysis.

Analysis

$$C_r = \frac{\left[\sum_{i=1}^{n} \left| f_{i,r} - f_{i,r-1} \right| \right]}{n} AC_r = \frac{C_r}{C_{max}}$$The

$$AC_r = \frac{C_r}{C_{max}}$$The

Results

Event Ladder Competitive Balance

The adjusted churn for the qualifiers of each event was calculated for the 2011, 2012, and 2013 seasons. A significant difference in event competitive balance was found at the $p < .05$ level for the three seasons studied [F (2, 45) = 4.24, p = 0.021]. Post hoc analysis utilizing the Tukey HSD test indicated that the mean adjusted churn for the events in the 2012 season (M = 0.18, SD = 0.13) was significantly lower than the mean adjusted churn for the events in the 2013 season (M = 0.33, SD = 0.17). However, the mean adjusted churn for the events in the 2011 (M = 0.29, SD = 0.17) was not significantly different from the 2012 season nor the 2013 season.

Championship Points Ranking Competitive Balance

The adjusted churn for the championship rankings between races was calculated for the competitors entering all sixteen national events for the 2011, 2012, and 2013 seasons. The adjusted churn for points earned between races were found to be significantly different [F (2, 42) = 10.45, p = 0.00]. Post hoc analysis utilizing the Tukey HSD test indicated that the mean adjusted churn for the points rankings in the 2012 season (M = 0.37, SD = 0.09) was significantly lower from the adjusted churn of the championship rankings for the preceding 2011 season (M = 0.52, SD = 0.11) and for the subsequent 2013 season (M = 0.54, SD = 0.13). No other significant differences were detected.

Discussion

The effects of rule changes on the competitive balance in Pro Stock Motorcycle were analyzed in this study. Although there was a decline in the competitive balance from the 2011 season to the 2012 season, the decline was not statistically significant. This result was interesting because there was considerable media attention and competitor complaints about the decline in competition (Asher, 2012; Bennett, 2012; "The PSM Bickering," 2012; Wade, 2012). The low adjusted churn value for qualifiers below 0.20 indicates that there was a considerable gap between the top qualifiers and other competitors. In fact, one event had an adjusted churn of 0.00, which showed that the competitors finished in the same positions as they started. In other words, there were no upsets in the elimination rounds of that event. The results of the 2012 events lacked the uncertainty of outcome that is appreciated by fans (Rottenberg, 1956). For this reason, the NHRA attempted to address the lack of competitive balance by changing the rules for the Harley-Davidsons twice in the season ("Technically Speaking," 2012). However, these attempts at leveling the field did not produce a significant improvement.

The NHRA revised the Pro Stock Motorcycle technical rules for the 2013 season to address the decline in competitive balance in 2012. These changes significantly improved the competitive balance of the Pro Stock Motorcycle category in the 2013 season. In addition to improving the competitive balance over the 2012 season, the improvement was significant over the 2011 season. The mean adjusted churn for 2013 was above 0.30, which indicates that there were a number of upsets during the elimination rounds. One event in the 2013 season had an adjusted churn of 0.76, indicating a substantial number of upsets during the event. The increase in the adjusted churn for competitive balance indicates that the competitors in Pro Stock Motorcycle were more closely matched following the implementation of the 2013 rule changes. Thus, the NHRA produced greater uncertainty of outcome in 2013, which should have led to increased interest from fans (Berkowitz, Depken, & Wilson, 2011; Rottenberg, 1956).

Analysis of the competitive balance among the full-season competitors revealed that the rule allowing the Harley-Davidsons to compete with an exclusive engine configuration at the beginning of the 2012 season created a significant imbalance in competition. Therefore, the media (Asher, 2012; Bennett, 2012) and competitor ("The PSM Bickering," 2012; Wade, 2012) concerns were validated by the results of this study. Additionally, the significant improvement in competitive balance in the 2013 season indicates that the NHRA moved in the right direction with its rules modifications for that season.

The findings of this study regarding rule changes implemented during a season were consistent with prior research (Mastromarco & Runkel, 2009). Although the rule changes that were implemented following the first and tenth events of the 2012 season improved the competitive balance in the Pro Stock Motorcycle class, the improvement was not significant. It is unknown if the effect of the second rule change following the tenth event would have been greater if it had been implemented earlier in the season.

Limitations

The primary limitation to the current study is that it is based solely on outcomes of the eliminations rounds and championship points. Perhaps, there are more appropriate data to analyze for determining competitive balance in drag racing competitions. Data such as the qualifying times and speeds might produce a more informed understanding of the competitive balance in the sport.

Conclusion

Changes to the NHRA Pro Stock Motorcycle rules in the 2012 and 2013 seasons had direct effects on the competitive balance in the category. The NHRA produced a competitive imbalance in the 2012 Pro Stock Motorcycle season by allowing only the Harley-Davidson team to use an exclusive engine configuration. The revisions to the rules for 2013 brought the Harley-Davidsons in line with the Buells and Suzukis. This produced greater competitive balance at the individual national events as well as greater competitive balance throughout the season.

It is critical that the NHRA, and all motorsports sanctioning bodies, implement rules that produce quality competition at events and for the season championships. If one manufacturer has a significant advantage over any other manufacturer, revisions to the rules must be implemented early in the season so that competition is balanced. The NHRA attempted to remedy an imbalance competition after the first 2012 race, but that remedy was ineffective. The adjusted churn method proved to be an efficient means of measuring both competitive balance following rule changes. Motorsports sanctioning bodies could implement the use of the adjusted churn method to determine if a perceived imbalance in competition is a reality and inform their fans, competitors, and other stakeholders of the results of the analysis.

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