Survival of Formula One Drivers

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Survival of Formula One Drivers

Onur Burak Celik

Objectives. To examine the determinants of the duration time of drivers in the Formula One (F1) competition, which is an industry with high physical capital investment and requires labor with very high human capital. *Methods.* Since estimates may be biased when the whole F1 history, starting with the 1950 season, is considered, unlike prior studies in the literature, this article limits its data set to racing seasons from 1981 to 2017. In addition, since the failure times are correlated within the drivers with multiple spells, single-spell methods used in prior studies underestimate true standard errors and produce inflated test statistics. Hence, the most appropriate approach for the duration analysis of F1 drivers would be the survival analysis for recurrent events, which is employed in this study. *Results.* Once a driver exits F1, he survives for a shorter period of time if he returns. In order to survive longer, a driver has to perform better than his teammate. Each year of age decreases the probability of exit while drivers can increase their duration time in F1 by switching teams. Completing a race does not make any difference to survival but finishing a race on the podium lowers the probability of exit. *Conclusion.* Team owners and managers should be cautious when they consider hiring a driver who exited F1 before. A driver should be at least better than his teammate in order to survive in F1. Drivers can also increase their chances of survival substantially by changing teams.

A manager's job is to organize and allocate the scarce resources of his firm in order to achieve the goals of the firm. As a part of managerial decision making, human resource management includes staffing decisions and recruitment of employees with human capital necessary for the firm. According to the labor market theory, the output depends on the productivity of labor and wages are determined by marginal revenue product of labor. The capital-skill complementarity hypothesis suggests that physical capital and skilled labor are more complementary than physical capital and unskilled labor (Griliches, 1969). In addition to the fact that the demand for skilled labor is less elastic than the demand for unskilled labor, investment in physical capital increases the demand for skilled labor, which also increases the cost of skilled labor. In light of the existing theories in labor economics, hiring decisions in an industry with high physical capital investment are very costly and critical. It thus becomes an important task to investigate the determinants of the survivability of skilled labor in such an industry.

Measuring productivity and performance of labor precisely is a major problem in studying labor economics. It is known that professional sport offers a unique opportunity for labor market research. There is no research setting other than sports where I know the name, face, and life history of every production worker and supervisor in the industry (Kahn, 2000). In the world of sports, Formula One (F1) Racing offers a clear and reliable measure of performance (Aversa, Furnari, and Haefliger, 2015) and the performance is unambiguously measurable by lap times and race results (Gino and Pisano, 2011). This article studies the determinants of the survival of the drivers in the F1 competition by

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employing survival analysis methods. As former McLaren F1 team director Ron Dennis stated, "second is first of the losers." In other team sports, as well as in F1, the revenue of the club or team is directly related to the productivity of labor, which puts the human capital at the core of the industry. The findings of this article in light of the F1 industry are not only limited to F1 teams and drivers but also they shed light on the survivability of athletes in other team sports as well as that of highly skilled labor in physical-capital-intensive industries.

Driver, crew, and car are three vital components of a team in F1. When one of these components does not perform as well as the other two during a race season, it is almost impossible to be at the top of the ranking table at the end of the season. Although the cars in F1 are technically regulated by the governing body, the Fédération Internationale de l'Automobile (FIA), teams participate in races using different cars. The quality of the staff, including the driver, is an important factor for the success of an F1 team. In addition to driving the car in the races, the driver also has a very important role in developing an F1 car. Feedback given by the driver to the engineers and mechanics is the key determinant of an F1 car's performance. Therefore, managers hire a driver who can not only drive the car skillfully in each race but also help the team improve the car (Castellucci, Padula, and Pica, 2011).

For reasons pointed out above, deciding on who will be the drivers of the team next season in the F1 competition is a critical decision for teams. Drivers should hold the FIA Super Licence in order to compete in the F1 World Championship. When I look at the labor market for F1 drivers, the number of drivers who have the skill and ability to drive an F1 car is very limited; hence, the supply side of the labor market in F1 is quite tight. Since the number of teams in F1 is also limited, the demand side is also tight. It then becomes crucial, both for the drivers and for the team owners, to know the determinants of the duration time of the drivers in the F1 industry. Drivers who are already employed by a team would like to survive in F1. Teams that are looking for a driver would like to hire one with good potential for productivity during his employment on the team so that both sides can benefit from longer contractual commitments. Hence, the exploration of the characteristics of the employee and the employer for the survival of F1 drivers is essential for both sides of the F1 drivers' labor market.

Survival analysis, also called event history analysis, is a set of statistical methods used to answer questions related to duration until the occurrence of an event. In other words, survival analysis examines how long it takes until a specified event occurs. An event may take many forms, such as death, divorce, marriage, birth, or becoming employed. The time to the occurrence of an event can be measured in diverse units, such as seconds, days, weeks, months, or years. The duration or time that it takes before an event occurs is referred to as survival time, duration time, or time at risk. It is the time that a subject of analysis "survives" the specified duration (Mills, 2011). The time interval from the beginning until the specific event occurs is called a spell and the end of each spell in this study is an exit from F1 industry as a driver.

This article investigates the determinants of the duration time of the drivers in the F1 competition by employing survival analysis for recurrent events on a data set from 1981 to 2017 where duration/survival time is measured in years. Exit is defined as voluntary or involuntary termination of the driver's contract with his team and not having any contract as a driver with any other team in F1 so that he does not participate in F1 races anymore. This study diverges from prior studies in the literature in two ways: (i) the data set is limited to F1 seasons on and after 1981 for more reliable estimation results, and (ii) the most appropriate methodology for estimation, survival analysis for recurrent events, is

employed, in contrast to common practice in prior studies, which used proportional hazard models. These differences will be discussed more in depth in the following sections.

Literature Review

Most of the literature on F1 is devoted to the competitiveness. Judde, Booth, and Brooks (2013), Mastromarco and Runkel (2009), and Krauskopf, Langen, and Bünger (2010) are only three examples of many papers that focus on the competitive balance in F1. Eichenberger and Stadelmann (2009) try to find the best driver in F1 history by separating driver talent from car quality. They use an econometric approach to evaluate driver talent. Anderson (2014) offers three alternative models of performance and the corresponding maximum likelihood estimation methods that can be used to rank competitors and overcome the shortcomings of point-based rankings. Potter (2011) investigates the behavior of F1 drivers and finds that drivers become more reckless as their cars become safer, ceteris paribus. Fairley et al. (2011) is one of many papers that study the economic and social impacts of hosting an F1 Grand Prix, such as an increased quality of life, community pride and excitement, upgraded infrastructure, increased social or recreational opportunities, enhanced economic prosperity to the region, displacement of residents, disruption to residents, crowding and congestion. In search of family connections in F1, Depken, Groothuis, and Rotthoff (2018) found that brothers of F1 drivers benefit from human capital transfer and nepotism while sons of F1 drivers gain little from human capital transfer and do not benefit from nepotism. Castellucci, Padula, and Pica (2011) estimate the effect of aging on the productivity of F1 drivers and find that age-productivity increases.

When it comes to employing survival analysis on F1, Celik (2017) analyzes the duration time of F1 teams, but not that of F1 drivers, in competition by employing survival analysis models using a sample from 1981 to 2015, where the duration is measured in years. Keeping in mind that the determinants of duration time of a team might be different from the determinants of the duration time of a driver, his study revealed that completing the race is the most important success factor, hence for the survival of a team. In a similar analysis on a data set for the whole history of F1 from 1950 to 2014, where the duration is measured in the number of races, Mourao (2017) found that the number of points in each season increases the duration time of a team while increasing numbers of withdrawals from races decrease its duration time.

In addition to the discussion of factors enhancing the duration time of F1 teams, Mourao (2017) also analyzes the determinants of duration time of a driver in an F1 team and F1 industry using proportional hazard models. He defines the exit of a driver in two ways: exiting an F1 team, that is, moving from one F1 team to another F1 team, and exiting the F1 industry, that is, stopping participation in F1 races as a driver for any reason. His results indicate that finishing the most recent five races in weaker positions, reaching a greater age, having a higher number of withdrawals, and running during the early decades of F1 increase the probability of exiting F1. On the other hand, a higher number of accumulated podiums, a higher ratio between the accumulated number of each driver's points, the accumulated number of his team's points in F1 history, and running for a team with a higher share of drivers abandoning races decrease the probability of an exit.

In another study, Mourao (2018) employs proportional hazard models in search for the determinants of the duration time of F1 drivers in an F1 team and in F1 competition using a data set from 1950 to 2014. His study presents results from two data sets, F1 drivers without points and F1 drivers without victories. He finds that worse standings, higher age,

racing for historical teams, racing in earlier F1 seasons, higher number of withdrawals from races, and losing ranks from the starting grid are the primary factors that increase the risk of a driver exiting an F1 team or F1 competition.

However, there are problems with the data set and the methodology of Mourao (2017, 2018). Using the data set from 1950 creates noise and biased results since in the early years of F1, some drivers only participated in selected races. Some drivers participated in one or two races of their choice each year while they actually competed in some other motorsport organization, not in F1. Hence, the main goal of these drivers is not to survive and compete in F1. Eichenberger and Stadelmann (2009) emphasize that estimates may be biased when the whole F1 history is considered since at the beginning of F1, many drivers participated in races without clear career perspectives, and they often survived in F1 for a short time, so that their race results depended heavily on fortune. Mourao (2017) also confirms this fact by mentioning that 50 percent of the drivers in his data set did not participate in more than five races. Moreover, there were different numbers of cars for different teams in each race prior to 1981. Some teams participated with only one car, and some other teams participated with as many cars as they wanted, depending on their budget. Hence, more reliable research on a solid data set is needed on the survival of F1 drivers.

The rules changed as of the 1981 season. Teams are now obliged to produce their own car bodies called a chassis, and, more importantly for the current study, teams commit to participating in all races in a season with only two cars. As a result, with a much more mature competition, data on F1 after 1981 are much more reliable than the data prior to 1981. The current work focuses on the duration time of a driver in the F1 industry from the 1981 season to the 2017 season.

Data

The data set contains all drivers who appeared on track in an F1 car in an official grand prix from 1981 to 2017. Race results are taken from the website ⟨www.statsf1.com⟩. Information on drivers and teams is gathered from ⟨www.wikipedia.org⟩. There is a total of 255 individual drivers, 35 different nationalities, 321 spells, 303 exits, and 1,195 times at risk from 1981 to 2017. Eighteen drivers survived in the 2018 F1 season. The end of a spell in the data reflects an exit from F1 (whether it be voluntary or involuntary) and does not include death or permanent injury. Figure 1 shows the number of drivers who enter and exit each year from 1981 to 2017. Prior to 1996, both the number of entries to F1 and the number of exits from F1 are higher than they are after 1996. The averages are 9 exits and 10 entries in the 1980s, and 10.8 exits and 9.1 entries in the 1990s. In the 2000s, the average number of entries and exits are both 6.6, and in the 2010s, the average number of entries and exits are both 6. Therefore, in terms of employee turnover, the F1 labor market for drivers has become more stable in the last two decades.

The number of spells by duration time is shown in Figure 2, and the Kaplan-Meier survival estimate is shown in Figure 3. The average duration time of drivers in the whole data set is 3.75 years. When the spells are considered, it is 4.09 years (255 drivers) in the first spell, 2.6 years (55 drivers) in the second spell, 1.8 years (9 drivers) in the third spell, and 1 year (2 drivers) in the fourth spell. Out of 321 spells, the median duration time is less than two years. That means half of the drivers survive less than two years. At the end of two years, 59 percent of the drivers exited F1. In addition, according to Figure 2, there are 119 spells that last 1 year, 66 spells that last 2 years, and 30 spells that last 3 years.

FIGURE 1

The Number of Drivers Who Enter and Exit Formula One by Year

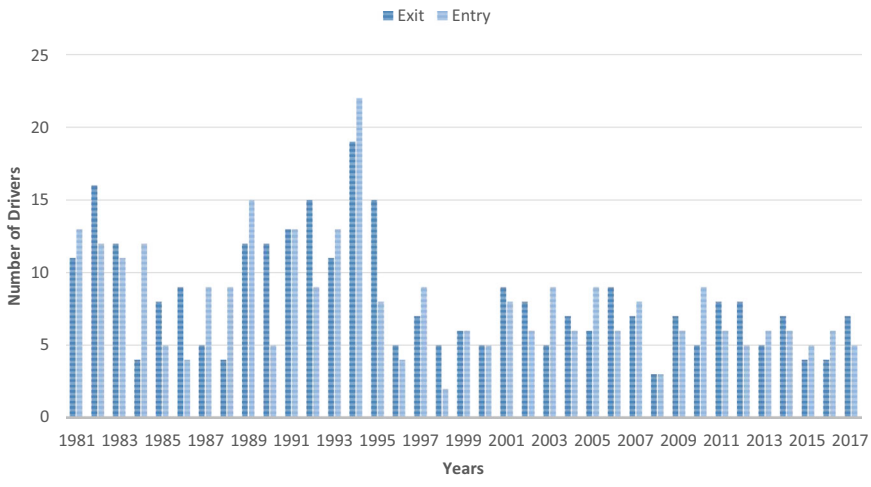
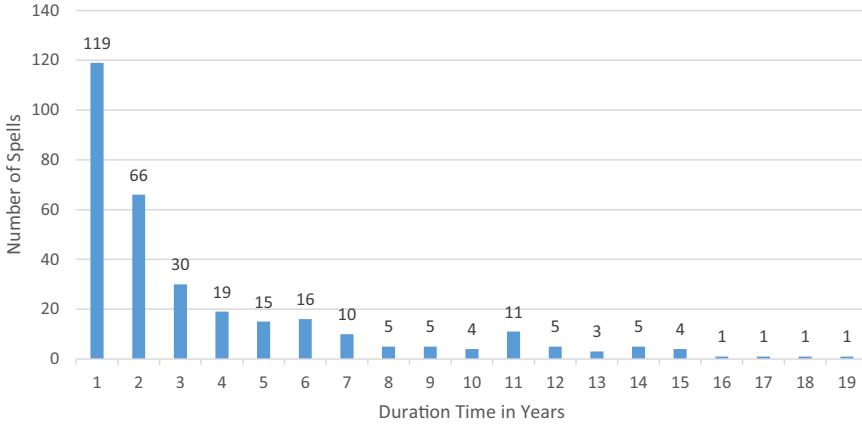


FIGURE 2

The Number of Spells by Duration Time in Years, Total of 321 Spells



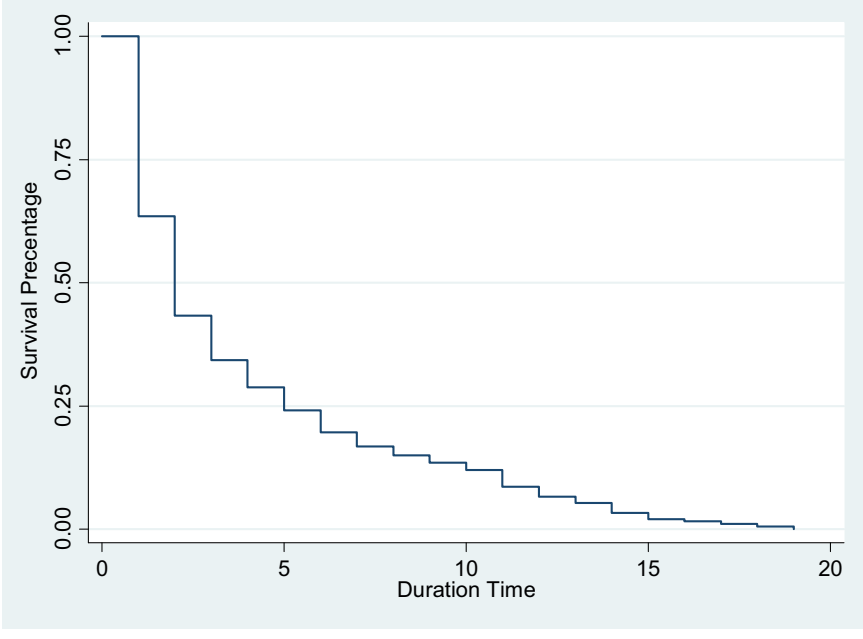
Two hundred fifteen spells of 321 last only 3 years or less. These numbers indicate that surviving in F1 is very competitive for drivers.

Methodology and Model

When failure times are correlated within the subject with multiple spells, the independence of failure times assumption required in traditional survival analysis is violated (Cleves, 1999). Assuming the independence of observations, when, in fact, they are cluster-correlated, will lead to underestimating the true standard errors. Therefore, the values of test statistics will be inflated (Kovacevic and Roberts, 2007). In case of the duration time

FIGURE 3

Kaplan-Meier Survival Estimate



of F1 drivers in competition, exiting F1 can occur more than once for the same driver so that failure times are correlated within the drivers with multiple spells. For this reason, single-spell methods used by Mourao (2017, 2018) are not appropriate in the analysis of the survival of F1 drivers. This is the methodological fallacy in prior studies in the literature. In the data set, of 255 drivers, 55 drivers (21.6 percent of drivers) exited F1 more than once. Moreover, exits are chronologically ordered for the same subject, that is, the second exit cannot happen before the first one. Prentice, Williams, and Peterson (1981) propose the conditional risk set model when the data set is stratified by the order of failures. This article employs survival analysis for recurrent events, which is the most appropriate approach for the duration analysis of F1 drivers. Duration time is measured as the time from the previous exit, that is, the time is set to zero at the beginning of each spell for each driver.

As an explanatory variable in the model, the age of the employee is an important factor in hiring and firing decisions in F1, as it is in every labor market. Since the human capital accumulated is crucial for success in F1, more mature drivers are more likely to survive longer. Moreover, the productivity of a driver in F1 increases with age (Castellucci, Padula, and Pica, 2011), thus, the age of the driver is thought to be important in the duration time of a driver in F1.

Celik (2017) finds that the percentage of the races completed each season is a significant factor in the duration time of an F1 team. Similarly, Mourao (2017, 2018) finds that the number of withdrawals increases the probability of exiting F1 for drivers. Along with these findings, the effect of the percentage of the races that the driver successfully completed each season on his survival is tested in this research.

TABLE 1

Points Scoring System in Formula One Since 1981

Years/Position	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1981–1990	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 to present[a]	25	18	15	12	10	8	6	4	2	1

[a]In the 2014 season only, double points were awarded in the final race of the season.
SOURCE: ⟨Wikipedia.com⟩.

In order to take the competitiveness of the driver into account, the number of podium finishes is used in the current study. Since the duration time in each spell is under investigation in this study, different from Mourao (2017), the number of podiums in the spell is used rather than the number of podiums in the driver's whole career. The square of this variable is also introduced into the regression for nonlinear effects. Similarly, for the competitiveness of the team(s) that employed the driver, the average of the points collected by the driver's team(s) in each season in the spell is used in the model here rather than the accumulated points of the team. Note that a driver can be employed by different teams in a spell.

Each team in F1 participates in races with only two cars. If a team considers changing its driver for the next season, it will choose to replace the less productive driver. In order to be able to survive in F1, the driver should perform at least better than his teammate. The driver's average point percentage in his team's total points during his employment in the team is used as a measure of the performance of the driver relative to his teammate. Mourao (2017) finds an insignificant effect of this ratio when the season results are considered but a significant effect when the whole F1 history of the driver and the team are considered.

The remaining explanatory variables in the model discussed here are the contributions of this research to the gaps in the literature. During the time period under investigation, 55 of 255 drivers returned to F1 once they exited. In order to test the significance of the differences in the duration time of each successive spell for a driver, the number of prior exits from F1 in a driver's career is included in the model.

When a driver terminates his contract with an employer, he will seek job opportunities in other F1 teams. However, does changing the team help survival in F1, or is it a bad signal to the employer that the driver is not skilled enough for F1 races? The number of prior teams of the driver in his F1 career is introduced into the model as an explanatory variable to find an answer to this question.

Since 1950, many different point scoring systems have been used in F1. Even since 1981, the point scoring system has changed three times (see Table 1). Since the most recent system awards points to more drivers than previous point systems prior to the 2010 season, in order to provide consistency in the point and point percentage calculations over the years and to minimize the number of "zero" values in the explanatory variables in the regression, the current points award system is used in the calculations. First, the points are awarded to the teams and drivers according to the most recent point scoring system, and then the explanatory variables are calculated for each driver and team in the data set.

There is a long-time debate on the nationality of the team and the driver in F1. It is widely believed in the F1 industry that it gives an advantage to the driver and the team if they have the same nationality and speak the same native language. If such an advantage

TABLE 2

Hazard Ratios and Robust Standard Errors from Regression Results

Variables	Hazard Ratio
Age	0.945***
	(0.015)
The number of prior F1 exits in driver's career	3.34***
	(0.856)
The number of prior teams in driver's F1 career	0.597***
	(0.041)
Average of the percentage of the races completed each season in the spell	0.935
	(0.275)
The number of podiums in the spell	0.932***
	(0.011)
Square of the number of podiums in the spell	1.0003***
	(0.00007)
Average of driver's point percentage in his team's total points in the spell	0.2***
	(0.074)
Average of team(s) points in the spell	0.998*
	(0.001)
Dummy variable for the driver and the team being from the same country	0.874
	(0.107)
Dummy variable for 1990s	1.042
	(0.165)
Dummy variable for 2000s	0.838
	(0.156)
Dummy variable for 2010s	0.447***
	(0.109)
The number of spells	321
The number of clusters (drivers)	255
Total time at risk	1,195

***Significant at $p < 0.01$
**significant at $p < 0.05$
*significant at $p < 0.1$.

exists, teams would like to hire and keep a driver on the team from the team's home country, which gives the driver a higher chance of survival. In order to test this hypothesis, a dummy variable is used for the driver and the team being from the same country.

Finally, since there are rule and regulation changes on track and out of the track every season, there exist unobservable differences over years and decades. In order to capture the change in the probability of exits over decades, a set of dummy variables has been used for the 1980s (reference group), 1990s, 2000s, and 2010s.

Results

Variance inflation factors (VIFs) are checked for the explanatory variables in the model, and all VIF values are found to be less than 2.71. Thus, there is no correlation among the independent variables of the regression. Regression results from the duration of multiple spells model are presented in Table 2. The age of the driver appears to be a significant factor that affects the duration time. Each year of age decreases the probability of exit by 5.5 percent. One more year of age for the driver means one more year of racing experience

(even if it is not in F1), which is very valuable to the teams. In line with the findings here, Castellucci, Padula, and Pica (2011) found that the productivity of an F1 driver increases by age, relatively little at the beginning of the career, more from age 28, peaks at the age of 30–32. As drivers are becoming more productive, longer duration time can be expected. On the other hand, according to Mourao (2017, 2018), each year of age increases the probability of exit. In this study, the result on the age of the driver contradicts the findings of Mourao (2017, 2018).

The most influential factor in the duration time of a driver is the number of prior F1 exits in a driver's career. Each return to the F1 industry as a driver increases the probability of exit by more than three times. As a result, each successive spell is more likely to last shorter than the previous one for the driver. Besides, each increase in the number of prior F1 teams in a driver's career decreases the probability by 40.3 percent. Thus, drivers can increase their duration time in F1 by switching teams, where high-skilled drivers will move to more competitive teams, and less skilled drivers will move to less demanding teams.

In contrast to Mourao (2017, 2018), completing a race, a prerequisite for success in F1, is not a significant variable. On the other hand, the number of podiums in the spell of the driver is significant. Each podium finish decreases the probability of exit by 6.8 percent. Hence, teams are expecting more from the drivers than just completing a race. Completing a race does not make any difference to duration time but finishing a race on the podium is a signal for the quality of the driver. A driver with more podium finishes could be an indicator of higher quality; hence, he has longer duration time in F1. The square of the number of podiums is also significant but has the opposite effect on survival, which means there is a nonlinear relationship between the number of podium finishes and the duration time of the driver.

The driver's performance relative to his teammate is also found to be an important factor for his survival. The effect of this variable is found to be significant but much smaller in Mourao (2017) than it is in this study. The average of the driver's point percentage in his team's total points each season in the spell decreases the probability by 80 percent. Consequently, in order to survive in F1, the driver needs to perform better than his teammate so that he collects more points than his teammate does. Points earned by a team in a season represent the competitiveness of the team. The effect of the average of the points that the team(s) collected each season in the spell of the driver is significant but small. It decreases the probability only by 0.2 percent. In a more competitive and demanding team, the driver's duration time is higher, but the difference is very small.

The findings of this article will also help end the long-time debate on the nationality of the drivers and the teams. The results of this article reveal that the driver and the team with the same nationality have no significant effect on the duration time of the driver. Finally, the probability of exit has decreased for F1 drivers in the current decade, compared to the 1980s. In the 1990s and the 2000s, there is no significant difference, but the probability has decreased by 55.3 percent in the 2010s when compared to the probability in the 1980s. Comparing the decades prior to the 1980s, Mourao (2017) also finds an increase in the survival rates of drivers in the more recent decades, that is, a decrease in the probability of exit, but Mourao (2018) concludes the opposite, saying that drivers have shorter careers in F1 in more recent decades. Since the number of teams, hence the number of cars, does not change much from season to season, the increase in the duration time of existing drivers indicates that entry to F1 is more difficult in the most recent decade.

Conclusion

This study analyzes the duration time of drivers in F1 using a more reliable and stable data set compared to data prior to 1981, from 1981 to 2017. Survival analysis with multiple spells is the most appropriate methodological approach, which is the missing piece in the existing literature. The findings of this research in light of F1 drivers help athletes develop their own strategies to follow in order to manage their plans better for a longer sports career and help club managers increase the efficiency of the use of scarce resources of the club/team.

The most important factor to the duration time of F1 drivers is found to be the number of prior exits. Once a driver exits F1, the length of each successive spell is shorter than that of previous spells. Hence, team owners and managers should be cautious when they consider hiring a driver who exited F1 previously. When one considers athletes in other sports, this finding is not different. In addition to legendary F1 driver Michael Schumacher, superstars in other team sports, such as Michael Jordan from the NBA and Pele from European soccer, did not have bright careers when they returned after their retirement.

Another important factor is the average of the percentage of points the driver earns in the team's total points each season. A driver should be at least better than his teammates in order to survive in F1. This is one of the excitement sources in F1. Although two drivers of a team are cooperating to achieve the common goals of the team, they actually compete against one another in order to survive. This result confirms the famous saying in the F1 industry, "your teammate is your worst enemy." This is true in other sports as well. When there are two or more players playing in the same position in a team, the player should be better than his/her teammate in order to survive.

As the years pass, the driver gets older but more experienced. Since the human capital accumulated is very important in F1, aging decreases the probability of exit. In addition, the number of podium finishes has a nonlinear and positive effect on survival. Drivers can also increase their chances of survival substantially by changing teams. Similarly, in other team sports, players can increase their chances of survival by moving to a less competitive club in the same-tier sports league.

As a minimum requirement, a driver is expected to finish each race, but this does not seem to be important for the teams since the average of the percentage of the races completed does not affect the duration time of drivers in F1. Teams are expecting more from drivers than just finishing the race since the number of podium finishes has significant effect, but the average of the percentage of races completed in each season is insignificant. Having a common nationality is also found to be insignificant in this research so that there is no reason to believe that a team has an advantage over other teams if the driver is from the same country and speaks the same language as the rest of the team. Finally, the probability of exiting F1 is halved in the 2010s compared to 1980s. In the most recent decade, the policy that the teams follow when driver employment is considered is to keep the existing drivers, or to swap drivers with other teams rather than hiring a driver new to the F1 world.

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