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Evaluating the Effects of Budget Caps on Formula 1 Team Expenditures and Competitive Results

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Abstract

This essay examines the impact of money and budget caps on F1 teams, uses linear regression analysis to study the operating exp) and performance of the participating teams (the rate of progress in the results), and discusses the positive and negative effects of the budget cap on the teams. The results showed that a modest increase in investment could help teams achieve better results, but the introduction of the budget cap reduced this effect. This study highlights the importance of the budget cap in promoting fairness in F1 races, and the need for teams to allocate resources appropriately under the budget cap to maximize efficiency.

Keywords: Budget Cap, Funding Investments, Linear Regression Analysis, Allocate Resources Wisely

Introduction

The Formula One World Championship (F1) is the world's most technical and advanced automotive event, where teams invest in technological advancements. For example, in the 2018 season, the total expenditure of the Scuderia Ferrari reached $410 million. To curb such unrestricted spending, the Fédération International de l 'Automobile (FIA) set a budget cap in 2021. It restricts what teams spend on things like car building and running, but excludes driver salaries, travel expenses, marketing spending, and more. However, there are also indications that some teams may be looking for loopholes in the budget cap rules to maintain their financial advantage. For example, some teams have effectively diluted their impact in the F1 budget by allocating personnel to multiple projects and subsidiaries.

To address these issues, the FIA plans to make major changes to the budget cap rules in 2026, including adding all F1 team personnel salaries, regardless of their part-time or full-time status, in the budget cap calculation to close loopholes in the existing rules. When the budget cap was created in 2021, the FIA stipulated that teams should not spend more than $145 million in a single season, which is about 75% less than the strongest team spent in previous seasons. By the 2023 season, that number had dropped to $135 million. This trend suggests that the budget cap is likely to remain stable or adjust slightly for the foreseeable future, rather than continuing to decline sharply.

The budget cap aims to reduce financial disparities between large and small teams, and create a more level playing field, while at the same time, the implementation of the budget cap has a profound impact on the competitiveness of F1 teams, not only changing the team's financial strategy, but also potentially affecting the team's technical development and race strategy [1-3]. With the implementation of the budget cap, F1 is expected to become more competitive and unpredictable.

This paper will analyze the impact of the budget cap on F1 teams, using a linear regression model to study the relationship between team spending and team race performance. By investigating the operating investment of each team, the total number of season points, the number and frequency of upgrades of each team and the total season points before and after the introduction of the budget cap, to judge whether the team can use the limited funds to maximize the benefits.

Literature Review

The budget cap is used as a financial constraint mechanism in several sporting events to control the spending of a team to maintain a balanced and fair competition. Many studies have focused on the impact of this mechanism on different sports, especially

in professional sports leagues in North America and soccer in Europe, and similar pay caps and fiscal fair play laws provide a rich empirical and theoretical basis for related research [3-5].

In professional sports, salary caps are common in leagues such as the United States Major League Baseball (MLB) and the National Basketball Association (NBA) in the United States. Fort and Quirk (1995) proposed that the salary cap helps to maintain the competitive balance between teams through an analysis of team salary caps. This financial constraint mechanism forces the top teams to reduce unnecessary expenses, thus narrowing the gap with the small and medium-sized teams. This finding provides an important reference for the use of budget caps in F1 events, i.e., whether budget caps will have a similar balancing effect on top teams and small and medium-sized teams.

In European football, UEFA's Financial Fair Play (FFP) also aims to limit excessive spending by clubs to maintain financial health and fairness of the game. Peters and Szymanski (2014) have shown that the implementation of FFP has reduced the financial losses of clubs to some extent but has not significantly reduced the competitive gap between top clubs and small and medium-sized clubs. This means that while financial restrictions can be effective in controlling spending, they may not immediately improve the competitive balance in the event. This conclusion may also be applicable to the implementation of budget caps, that is, whether the gap between F1 teams will be rapidly narrowed by the introduction of budget caps remains to be verified by further empirical research.

In addition, Dietl et al. (2008) explored the over-investment behavior of teams in the absence of financial constraints. They use theoretical models to illustrate that in the absence of restrictions, the top teams tend to increase their spending to maintain their top position, leaving other teams unable to match. Financial restraint mechanisms can help alleviate this excessive competition and promote a more balanced distribution of resources. This theory provides the theoretical support for the implementation of the F1 budget cap, that is, by controlling the total expenditure of the teams, the top teams can avoid maintaining a monopoly position for a long time with high investments.

Data Analysis and Discussion

The Relationship Between R&D Investment and Racing Performance

In this paper, a linear regression model is established to evaluate the relationship between team operating expenses (x) and race results (y) (race results are expressed as season team total points (α) and inter-season improvement (ΔN)). From this, we can derive the formula

$$y = \beta_0 + \beta_1 x + \epsilon$$

Further, if the impact of the budget cap (z) is considered, the formula can be extended to

$$y = \beta_0 + \beta_1 x + \beta_2 z + \beta_3 (x \times z) + \epsilon$$

Among them, the budget cap (z) is a binary variable, 0 indicates before the implementation of the budget cap, and 1 indicates after the implementation of the budget cap. The interaction item can analyze the moderating effect of the budget cap on the relationship between expenditure and performance. If the β_3is negative, it means that the effect of the budget cap on how teams spend to improve their performance is weakened. In this article, the lap progress rate is selected as a measure of the team's performance, i.e. the lap time of the current year minus the lap time of the previous year. At the same time, the lap time progress rate can reduce the chance of a series of reasons for losing points, such as car breakdowns or retirements, compared with calculating the season total, and better measure the overall strength of the car in that year.

Table 1: Lap time improvement rate of each team in Bahrain from 2016 to 2023

	2016	2017	2018	2019	2021	2022	2023
Mercedes	2.40%	8.10%	5.20%	-0.64%	5.10%	-1.80%	1.40%
Ferrari	2.00%	6.50%	4.00%	-1.20%	-1.40%	-1.60%	4.00%
Red Bull	0.30%	6.50%	6.20%	-0.93%	6.10%	-1.30%	1.80%
McLaren	2.40%	5.50%	-0.97%	0.80%	3.40%	-6.50%	1.60%
Alpine	2.90%	3.70%	4.30%	1.70%	-0.70%	-0.70%	0.50%
Aston Martin	1.80%	4.50%	4.50%	0.58%	1.70%	-1.90%	0.30%
AlphaTauri	1.90%	2.65%	1.80%	-0.50%	1.70%	-2.60%	0.03%
Alfa Romeo	1.50%	2.50%	2.50%	2.90%	3.50%	-3.50%	2.10%
Williams	3.00%	4.60%	1.30%	-0.98%	3.00%	-0.80%	0.67%
Haas	3.70%	4.70%	4.90%	1.80%	3.00%	-0.90%	0.30%

This table shows the lap progress rate of each team at the Bahrain stop, (data source: f1.com), with positive values representing an increase in lap times and negative values representing a decrease in lap times. In particular, in 2019 there were minor changes to the rules, while in 2022 there was a major rule overhaul with the reintroduction of the ground effect, which aims to reduce the interference of "dirty airflow" from the front car to the rear car, but it also brings new challenges, such as the "dolphin jump" problem, which can affect the speed of the vehicle and the safety of the driver [6, 7].

The design of the ground effect requires the vehicle to be very close to the ground, which can cause increased friction between the vehicle and the ground at high speeds, creating additional drag that can affect lap times. Secondly, the design of the ground effect may cause the vehicle to produce a "dolphin jump" phenomenon in some cases, that is, the vehicle has an uncontrollable up and down bounce at high speeds, which can affect the stability and speed of the vehicle. This explains why all teams had negative lap progress rates in 2022.

Through linear regression analysis of the lap time progress rate and operating expenditure of the fleet, a univariate linear regression model was established by establishing a one-way linear regression model by the independent variable fleet operating expenditure x and the dependent variable lap progress rate ΔN [that is, mapped as the outcome (y)], and the results shown in the following figure were obtained.

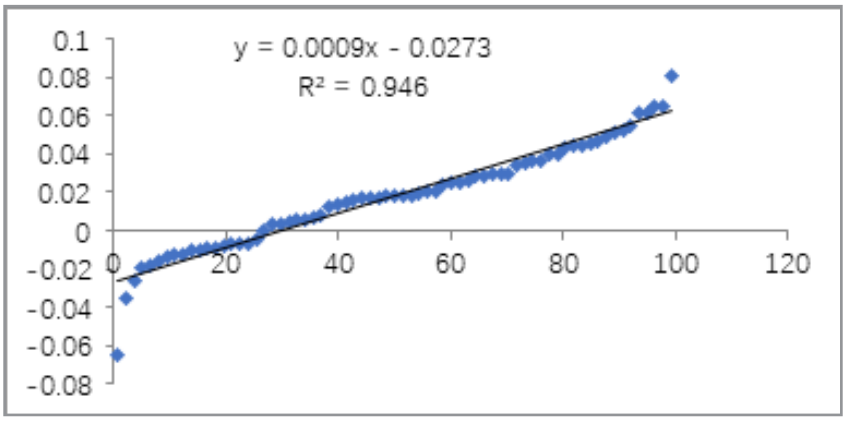

Figure 1: Univariate linear regression plot

Figure 2 shows the scatterplot of the regression distribution with 95% confidence and the straight-line equation, and Table 5 shows the residual distribution for each point. From Figure 2, we can get β_0=-0.0273, which means that the intercept from the y-axis is negative. This means that the team will receive negative effects on their results if they don't give any updates [8]. The last numerical value of β_1(0.0009) is small due to the small growth rate, but it also suggests that increasing operating expenditures (mostly R&D spending) has a positive effect on performance. R^2=0.946, which indicates a high degree of fit. From Figure 3, the residuals of most points are distributed within ±0.5, showing a significant linear relationship.

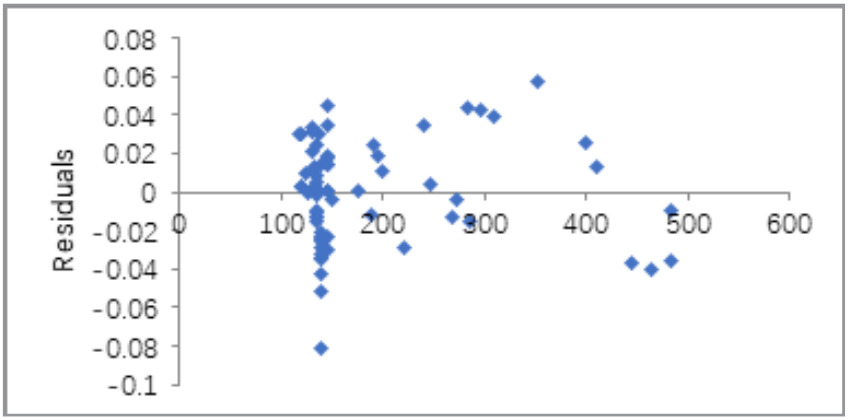

Figure 2: Residual distribution

The Positive Effect of the Budget Cap on the Event

The table below shows the investment expenditure of each fleet from 2018 to 2023 (in millions of US dollars), of which 2021 and beyond are calculated according to the maximum budget cap. (2020 is due to the epidemic of COVID-19 and the schedule is too short to be representative.)

Table 2: Input expenditure by fleet from 2018 to 2023 (in millions of dollars)

	2018	2019	2021	2022	2023
Mercedes	400	484	145	140	135
Ferrari	410	463	145	140	135
Red Bull	310	445	145	140	135
McLaren	220	269	145	140	135
Alpine	190	272	145	140	135
Aston Martin	120	188	145	140	135
AlphaTauri	120	138	145	140	135
Alfa Romeo	135	132	145	140	135
Williams	150	141	145	140	135
Haas	130	175	145	140	135

According to the table, according to the input cost of each team, we can divide the participating teams into 3 levels. 1st level: Mercedes, Ferrari, Red Bull; 2nd level: McLaren, Alpine, Aston Martin; 3rd level: Alpha Tauri, Sauber, Williams, Hass. The teams in level 1 typically cost more than $400 million, and due to the backing of large parent companies, they will invest heavily in research and development with no upper limit before the budget cap is issued.

Usually, they occupy many of the points. The second-tier teams, which cost around $200 million, are competitive, lagging the first-tier teams in terms of development progress and intensity, and they have fewer points, but they are also competitive. The third-tier team is less expensive, around $150 million. Such fleets are smaller, and there are also fleets controlled by private capital. These teams are often at the bottom of the pack and have a harder time earning points [9]. Since the introduction and implementation of the budget cap by the FIA in 2021, the budgets of the teams have been significantly reduced, with the 2021 budget being reduced to approximately 70% to $150 million compared to the highest investment in 2019 ($484 million). This initiative helps to close the investment gap between teams and promote a more level playing field to make the game more exciting.

Table 3: Points earned by teams from 2016 to 2023

	2016	2017	2018	2019	2021	2022	2023
Mercedes	765	668	655	739	631.5	515	409
Ferrari	398	522	571	504	323.5	554	406
Red Bull	468	368	419	417	585.5	759	860
McLaren	76	30	62	145	275	195	302
Alpine	8	57	122	91	155	173	120
Aston Martin	173	187	52	73	77	55	280
AlphaTauri	63	53	33	85	142	35	25
Alfa Romeo	266	5	48	57	13	55	16
Williams	138	83	7	1	23	8	28
Haas	29	47	93	28	0	37	12

This table shows the points earned by each team from 2016 to 2023. In 2016, the first-tier team had a point difference of 367 points, while the second-tier team had a 165 points difference, and the third-tier team had 237 points [10]. kis now defined as the difference level rate for teams in the same bracket, which is calculated as a table showing the points earned by each team from 2016 to 2023. In 2016, the first-tier team had a point difference of 367 points, while the second-tier team had a 165 points difference, and the third-tier team had 237 points. Now define k as the difference level rate of the same team, and the formula is:

$$k = \frac{\alpha_{\max} - \alpha_{min}}{\alpha_{\max}} \times 100\%$$

According to the formula, the α represents the points which a team earned each year. So, the bigger numeric value means the bigger gap in each level.

Then, we can get that in 2016 the k value of the first gear is 47.9%, the K value of the second gear is 95.4%, and the k value of the third gear is 89%. Similarly, we can calculate that in 2023 the K value of the first gear is 41.1%, the k value of the second gear is 60.2%, and the K value of the third gear is 57.1%. Compared with 2016, the k value of each grade in 2023 has decreased significantly, indicating that the score difference within each grade has decreased, further indicating that the competition between groups is fiercer than in 2016.

The Negative Effect of the Budget Cap on the Team

The introduction of the budget cap has limited the cost and intensity of research and development for the team. The biggest beneficiary of which is the third gear fleet. It didn't put too much of a limit on these teams. It's a big disadvantage for big teams (first and second gear). The uncapped amount of money to spend in front of the budget cap allows teams to explore many different philosophies over the course of the season. After the introduction of the budget cap, due to the extremely limited capital investment of the team, the team can only stick to one plan, and constantly update on this basis. In the case of Mercedes Racing, Mercedes Team Principal Wolf admits: “The decision to use the zero-side box concept in 2022 was the biggest mistake I made since taking the helm of the team, and continuing to use it in 2023 was my second biggest mistake”.

James Allison, head of technical staff at Mercedes, said that the introduction of a budget cap in F1 has led to a lag in the development of cars, making multiple upgrades a thing of the past. Before the budget cap, the time difference between the two was "only a few weeks". Today, the team can only afford a maximum of two, and less than three major upgrades in a season. "Another way it's impacting is that it's harder to find resources, people, and hardware to invest in [11]. If you spend all your money and time on those few upgrades and building a race car for the new year, it's hard to make the infrastructure better,” he said. Before the budget cap, the impact of the wrong direction of development could be minimized by investing in redesign, but now the budget cap prevents large teams from throwing money at the possibility of finding the best solution.

The Impact of Budget Caps on Team R&D

Constructors	Total	
Haas	$ 5,002,000	1
Williams	$ 4,622,000	2
Mercedes	$ 3,779,000	3
Aston Martin	$ 3,659,000	4
Alfa Romeo	$ 3,376,000	5
Ferrari	$ 3,047,000	6
Alpine	$ 3,030,000	7
AlphaTauri	$ 2,190,000	8
McLaren	$ 1,345,000	9
Red Bull	$ 1,247,000	10

Pricing	
Front Wing	$125,000
Brake Drum Deflector	$10,000
Monocoque	$675,000
Front Suspension	$125,000
Wheel	$5,000
Side Pod	$95,000
Rear Suspension	$100,000
Rear Wing	$92,000
Additional Chassis	$275,000
Floor/Diffuser	$225,000
GearBox	$500,000
Electronics	$50,000
Brakes	$25,000

Figure 3: 2023 Drivers' Repair Spending Rankings

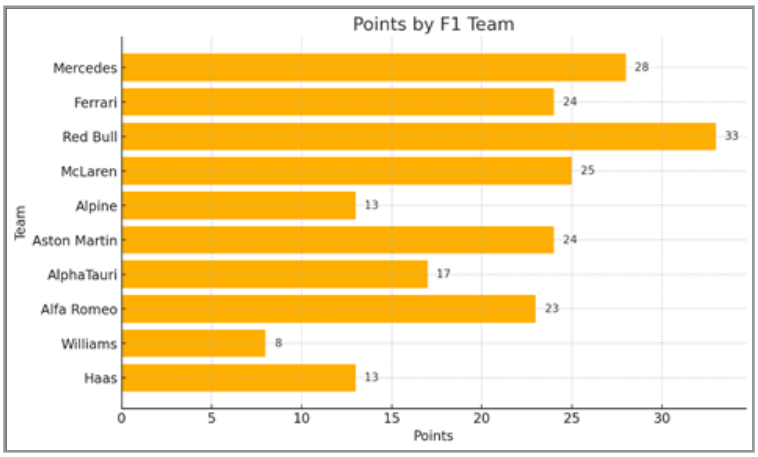

Figure 4: Number of team upgrades in 2023

The chart above shows the 2023 ranking of all drivers' repair spending. The table above shows the total number of upgrades for each team in the 2023 season. The number of upgrades reflects the R&D efficiency of a fleet, and the amount of money invested in R&D. As can be seen, Hass and Williams spent much more on repairing their cars than other teams, amounting to about $5 million. Correspondingly, in terms of the number of team upgrades, these two teams also have significantly fewer upgrades than the other teams [12].

At the same time, Red Bull and McLaren are the last teams to spend about $1 million on car repairs, and they have slightly

more upgrades than the other teams. Spending too much on repairs can squeeze the space in the team's budget cap, preventing the team from upgrading too many cars. This makes it imperative for teams to be fully considerate of their own resource allocation (Jenkins ,2010; Hall and Lerner ,2010). The chart above also shows how much it costs to develop new parts, as the average fleet will stock up on multiple sets of parts and use the rest of the budget to develop new parts [13].

Conclusion

This study examines the impact of money and budget caps on F1 teams. By analyzing data from 2016 to 2023 and using a linear regression model to analyze the impact of money on performance, we found that money does indeed enhance the competitiveness of the car. At the same time, the budget cap can promote a more level playing field. However, the limitation of this study is that many teams are so secretive about their own support that we can only extrapolate the team's expenses based on the budget cap.

Before the era of the budget cap, teams could achieve better results by investing more money to find the best design solution, constantly reinventing the wheel, and using money as the wrong cost. After the introduction of the budget cap, the investment of each team was limited to a certain amount, which ensured the financial fairness of the teams to a certain extent and made the competition more intense. But on the other hand, the implementation of the budget cap has also made the team more cautious and conservative in conceptual design, and at the same time, the cost of trial and error has become higher, which has also led to the emergence of few more innovative and revolutionary designs, and to a certain extent, it has also curbed the team's innovation ability. But all in all, the budget cap has changed the perception that F1 used to be a money-burner, and a series of initiatives could lead to a healthier, more alcohol-producing development of F1 racing [14].

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