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BUDGET EFFICIENCY PERFORMANCE IN FORMULA 1

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Abstract

This study will assess the efficiency of different F1 teams -or Constructors- based on their budget and points obtained during a racing season. A Data Envelopment Model (DEA) is used to measure each team's efficiency relative to each other. Teams or decision making units -as defined by the model- that lie on the efficient frontier are deemed efficient. We have conducted our analysis using data from 2008 to 2020 for a total of thirteen years. Most teams are inefficient, not only relative to each other but to their scale efficiency. The model also suggests projected budgets based on each constructor´s performance so that they may achieve the same result more efficiently. We will discuss the feasibility of these projections providing a variety of possible solutions and strategies taking into consideration Formula 1's current context and a detailed breakdown of a Constructor's cost.

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Acknowledgement Section

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A special thanks to the University of Queensland who provided the software utilized in this study and to Pablo Mourao who provided me with his book which helped me understand the details and costs of running an F1 team.

Introduction

We will conduct an Efficiency Frontier analysis to study the effectiveness and efficiency of Formula 1 Teams budget spending.

Since I was a kid I was intrigued by the world of cars, engines and motorsports. It was what fueled my curiosity and creativity, to understand how things worked and moved. As any kid that's into motorsports, I was attracted to the pinnacle of it, Formula 1. Airplanes on wheels that could corner at 100+ km/h is surely to be entertaining to anyone ages 4 - 99 as Lego would advertise. The particular high pitched roar of an F1 engine is I think the head-turner for everyone that walks by a tv or if you are lucky enough, a circuit. I was immediately drawn to, at the time, the only Spanish speaking driver and world champion Fernando Alonso. I like his car, his way of driving and the fact I could identify myself with him. When the time came to choose a topic for this paper I immediately thought of this idea. There has been a lot of discussion, at least in what is known as the Hybrid Era in Formula 1 (2014 - present), as to why Mercedes has been so dominant, they are the only champions during this era. A lot of questions emerge from that fact: Is it their budget? Is it the car? Is it the driver? Is it their infrastructure? Is it the way they spend their budget?

If we assign a monetary value to these different inputs, we will find the correct relationship between dollar spent and result obtained. We will find the efficient frontier and we will be able to compare the teams that are on the efficient frontier against the ones that are not. We will conduct three different analysis, yearly, three year windows and overall, which means finding the efficient frontier for each year, for 3 year windows and for the overall number of years analyzed in this study. A limitation of this paper is that we don't actually know the numbers for each input and we don't actually know what each team spent on what. There are estimates and percentages based on previous literature. A further and more interesting study could be done by actually knowing how much money was spent on the engine or on spare parts. What business strategies were used, what future investments were put in place

(R&D, infrastructure). All of these factors may affect the result at the end of the day and if studied may result in a better source of information for teams for future use as a way of knowing if they are overspending on some element or if they are under-spending on another. Maybe a team realizes it should be spending more on R&D than on its mechanics for example. Timing is also an important factor, it's not the same to be fighting for a championship all year round, rather than already knowing you are not in the championship run and devoting your resources to R&D earlier than the other teams. This was seen in the 2021 season, when Mercedes announced that they thought Red Bull had the better car so they were done developing this year´s car and had already focused all their resources on the 2022 challenger. So to summarize we will see that in monetary terms, teams who spend more will gain better results, Frank Williams (One of the motorsports entities) once said that "For six and a half days a week F1 is a business, then on Sunday afternoons it becomes a sport". So that question I think is answered by people that know more of the sport than you and I, but of course the purpose of this essay is to model the effects of money in results, so that further analysis can be carried out by teams. They may be able to see if they are underspending or overspending, to see if they should spend more on one area or another. Taking into account which costs can be lowered and which can´t, teams can redefine their strategies and think long term for ways to become more efficient. Our contribution will be a much more comprehensive analysis of teams performance in F1, the effects of the Hybrid Era and suggestions on how teams can improve efficiency and lie on the efficient frontier. Other studies limit themselves to, a smaller time window and to just identifying the problem, whilst we will analyze a longer period of time and try and make suggestions on how to fix the problem understanding the general context of running an F1 team. A even further step would be to evaluate the effectiveness of putting these suggestions into practice to compare and see if efficiency improved.

Formula 1

Formula 1 (F1 for short) is the highest level in motorsport formula racing, for the majority of regular seasons 12 teams or Constructors and a total of 24 drivers compete for the World Championship. Constructors are defined as people or corporate entities which design and build the final version of a car that is going to compete in a FIA World championship. Formula racing refers to open wheeled single seater cars. The sport was first introduced in 1950 and continues to this day delivering entertainment to its worldwide fans. Some of its most known drivers include Juan Manuel Fangio, Jackie Stewart, Niki Lauda, Ayrton Senna, Fernando Alonso and Michael Schumacher. Each Constructor competes for the World Constructors Championship and each driver competes for the World Driver's Championship. Each team has 2 drivers, 2 cars and compete in each race or Grand Prix. A regular F1 season consists of an average of 20 grand prix in different countries around the globe. Race

results are evaluated using a points system which will later be explained. Points are added to determine the victors of the two annual World Championships. Points scored by each driver are evaluated to determine who wins the World Driver's Championship and points scored by both drivers in a team add up to determine which constructor wins the World Constructors Championship.
The sport is regulated by the FIA (Federation Internationale de l`Automobile) who is in charge of reviewing fairness and competition throughout the season, reviewing both situations in the races as situations regarding the construction of the cars and anything involved or affected by the sport.

Primary Sources of income for each constructor come from sponsors and Prize Money. Prize Money is the revenue given to each constructor after every race according to their position on the championship. There are other things to consider but the basis of the distribution is in ascending order, better position, more money. So a better performance during the season may lead to more prize money available for next year’s budget and may lead to more sponsorship deals. The teams need to carefully allocate their resources because if they struggle financially they may end up struggling in performance. To do so efficiently is key to make the budget last if you are a low budget team and if you are a high budget team, money may not be an issue in terms of struggling to get to the end of the season but it is an issue regarding on what to spend it and what technology investment can bring the best results. Constructors may build their own car from scratch or outsource parts such as the engine to other manufacturers who might also be a constructor. For example, Scuderia Ferrari, derived from Ferrari car manufacturer, one of the sport’s oldest teams, builds their own car and engine, they also sell their engine to other teams. For instance during the 2020 season there were 4 engine suppliers, Mercedes, Ferrari, Renault and Honda. The first three are also constructors. Out of the 10 teams, 3 used Mercedes engines, 3 used Ferrari engines, 2 used Honda Engines and 2 used Renault engines. (Chachra, *F1 engine suppliers 2020: Who Supplies Engines to Formula 1 teams?* 2020) This means that Mercedes gained revenue from selling to two other teams, Ferrari as well, whilst Renault gained revenue from selling to one other team. Of course Honda makes a revenue from selling its engines to Red Bull and Alpha Tauri but since its not a constructor we won’t be taking it into consideration.

Related literature

DEA has been widely used to analyze efficiency among sports, not only efficiency in money as an input but various other forms of analysis that can use the DEA model to compute efficiency benchmarks and offer an easy comparison between DMUs (Decision Making Units). Not too many studies have been oriented towards Formula 1 using the DEA model, but to our knowledge there are 3 papers that use the Data Envelopment Model to analyze different research questions about Formula 1. (Gutiérrez & Lozano, 2012) utilize a DEA model to analyze performance based on each constructors budget, they show that inefficient Constructors have low efficiencies across different F1 seasons and that in order for them to reach the identified benchmarks they should have reduced their budgets substantially. Meaning that constructors tend to be less efficient through various seasons by spending more money than they should. According to their study excess budget spending ranges from 20% to 50%, this may mean they were effective but not efficient, hence the feeling that it may be big spenders who win championships, deriving in a lack of competitiveness. By taking a look at those numbers we can understand why the FIA is encouraged to put a budget cap, to level the field. Their reasoning behind it being teams are overspending and should learn to become more efficient to reach the same level of competitiveness and results, not just throw money at the problem and become effective yet very inefficient. This is why we must conduct the relative efficiency analysis, because at first glance we will see that the data shows that all but one Constructor champion were the most efficient in that respective season, so if we were to guide ourselves by this we would reach the wrong conclusion. Furthermore (Gutiérrez & Lozano, 2012) show that constructors showed a favorable evolution in their efficiency during the seasons that were considered. Even though as we said before those with low efficiency levels continue to be inefficient throughout several seasons. Furthermore they make reference to the same limitations we encounter regarding the data origin and how the analysis may be improved if the data were not estimates. Our plan is of course to improve on what (Gutiérrez & Lozano, 2012) have done and provide a broader analysis with more data so that the efficiency may be more accurate, given the fact they only analyze five F1 seasons (2003, 2006, 2008, 2010, 2011). The second one is also by (Gutiérrez & Lozano, 2018) they utilize a 2 step DEA approach to evaluate racing circuits in F1. They measure efficiency based on speed, safety and fuel efficiency to identify those circuits with superior design. They then run a regression analysis to see if certain characteristics are significant to determine said efficiency. The third one is by (Gomes Júnior & Soares De Mello, 2007) where they utilize the DEA model to asses driver performance during the 2006 season analyzing the results obtained competing for the World Driver's Championship. As we mentioned before the DEA model has been used to analyze various sports, these include baseball, where (Sexton & Lewis, 2003) utilize a Two Stage DEA model to determine the efficiency of of Major League Baseball (MLB) for the 1999 season. Basketball where (Yang et al., 2014) utilize a Two Stage DEA approach to first determine the team's player efficiency based on their salary, basically determining the wage efficiency of a team and later they utilize games won and gate receipts to determine on court team efficiency. They show that NBA teams have a better wage efficiency than on court efficiency. Meaning that a player's performance may be good enough to justify their salary, but when translated to games won or tickets sold this may change due to the fact there are factors that can't be controlled by a team or by putting the best players on a basketball court, there is a certain luck component that may affect both player performance or team performance, may that be a physical or morale factor. Prox : football, olympics, tennis.

Data

The results data for each season was collected from the official F1 website where they keep track of every race, qualifying and practice result. The team budgets for each season were taken from various sports magazines; they provide the best estimates for this as there is no official number. A litigious work had to be carried out in order to prepare tables containing the information needed to conduct the DEA Model. Our most important variables were, Budgets, Points, Wins and Podiums. All tables presented in this work were constructed from scratch using data from several magazines for the budgets these were (Collantine, 2008), (Hardy et al., 2019), (*Report reveals team budgets fell 10% in 2009* 2010), (Reid & Sylt, 2010), (Kubiccia, 2011), (Gmm, 2012), (Benson, 2012), (*Forbes,* 2012), (*Flickr*), (Boxall-Legge, 2019), (Forbes, 2014), (Walthert, 2013), (Walthert, 2014), (Forbes, 2015), (Sylt, 2018), (Rencken, 2016), (Editor, 2017), (Verlin, 2017), (Autosport, 2017), (Autosport, 2017), (TF1C, 2017), (TF1C, 2017), (TF1C, 2017), (TF1C, 2017), (TF1C, 2017), (TF1S, 2017), (treehunter8, 2018), (motorsport-total, 2017), (Rencken, 2021), (Rencken, 2021), (wheels24, 2019), (Jacobs, 2018), (GPToday.net, 2022), (Rencken, 2021), (Rencken, 2021), (Fair, 2019), (Dhruv, 2019). All of these were used to retrieve the whole grid´s budget data, some only reported a fraction of the data needed, this is why on some years more than one data set was used to complete the total data needed. On some other years many sources exposed the same data for budgets so they were used as a way of double checking the information provided. If 3 different sources give the same number then this can help us choose or discard other sources. To retrieve the information on Points, Wins, Podiums and Position delta we used information from the F1 official website. (F1, *Standings*)

A more accurate analysis could be carried out if we had access to these records. Some constructors are public companies so their balance sheet includes the budget for their F1 team but these do not specify the number designated in particular to F1 alone. They might have it under “Engine development for racing teams” which does not specify if it's only for the F1 team or other racing teams the constructor may have. A good example of this is Ferrari, their balance sheet has a category like the one I mentioned before, but given the fact Ferrari competes in F1, Le Mans, touring, among others there is no real way of knowing how much money was actually put into the development of the F1 engine alone. So that leaves us with the numbers published by various sports magazines. For some years it was easy to compute budgets as many sources published the same numbers, for others we have to come up with a way to decide on a number, given the disparity of the numbers published by different magazines and articles. We have to test the correlation between the different data sets, then average the ones that are strongly correlated, of course by doing this we could have eliminated the most accurate data set or tampered the numbers a bit. But given the fact that they are estimates this does not seem important. This is due to the fact that the number we calculated could be as near as the number provided by the magazine to the actual budget.

The most difficult year to compute a final budget was 2011 in which we have 5 different sources, only 2 had full data for all teams, whilst the other 3 only had the budget for some teams. We first have to calculate the correlation between each data set. Then we average between each pair of data sets that showed the strongest correlation. Repeat the same process once again, but calculate the correlation between the new data sets that were calculated using the average of 2 original data sets before. Then calculate the average taking into account the remaining 7 data sets, to obtain the final number. But for the most part the different data sets from different sources were pretty close to each other in other years so, in those years as they were all strongly correlated, we can just average all sources available. 2016 is also a particular case as the numbers in source 1 seemed pretty off from the others, so it was discarded. Furthermore to run the analysis on all teams for all years to find the most efficient constructor/s overall we chose to compound the budgets, so that, we can express the value of all budgets in terms of their value in 2020. In 2010 F1 changed its point scoring system, to compare all teams on equal terms we had to convert the points won by each team those years and put them in terms of the 2010 point system. Both point systems are shown below in Table 1.0

Table 1.0 Points Scoring System

Years/POS	1	2	3	4	5	6	7	8	9	10
2003 - 2009	10	8	6	5	4	3	2	1	-	-
2010 - 2020	25	18	15	12	10	8	6	4	2	1

Source: Own creation based on (Formula one racing 2022) [1]

To convert the results of both seasons we have to see where did both drivers for each team finish in each race for the season, assign the corresponding points, for 1st place, 25 points, for 2nd place 18 and so on. Add every result for both drivers in each race, add the points obtained in every race so that we can get the total points won by each team.

The team that spent the least money per point gained each year is as follows.

[1] (Formula one racing 2022)

Table 1.1 Teams that spent the least $/point

Season	Team	$/point
2008	Ferrari	$967.132,87
2009	Brawn (Mercedes)	$363.281,25
2010	Mclaren	$439.867,84
2011	Red Bull	$424.742,93
2012	Red Bull	$503.217,39
2013	Red Bull	$555.062,00
2014	Mercedes	$567.315,26
2015	Mercedes	$796.945,21
2016	Mercedes	$458.977,78
2017	Mercedes	$536.256,49
2018	Mercedes	$610.687,02
2019	Mercedes	$575.101,49
2020	Mercedes	$844.677,14

Source: Own creation based on F1 website and auto-sport magazines [2]

As we can see from the data, the team that usually spends the least money per point gained is the team that finishes 1st in the Constructors Championship. Except for 2010 where it was the team that ended 2nd in the Championship which spent the least money per point. At first glance if we can see that teams that spend more tend to have better results but of course there are exceptions. We can also say that this isn't near close to the actual analysis we want to carry out, we are not interested in just seeing who was the most efficient. We want to be able to present results useful to anyone reading this. So that is why we are using the DEA model, to come up with an index showing each team's efficiency. So that adjustments can be made based on their efficiency outcome, to gain better results.

Let's take a look at Scuderia Ferrari, Toyota and Williams´ 2008 Season in Table 1.2 below.

Table 1.2 Scuderia Ferrari / Toyota / Toro Rosso 2008 Season

Season	Scuderia Ferrari	Panasonic Toyota	Scuderia Toro Rosso
Budget	$414.900.000,00	$445.600.000,00	$128.200.000,00
Points	429	152	107
$/point	$967.132,87	$2.931.578,95	$1.198.130,84
Wins	8	0	1
Podiums	19	2	1
Fastest Laps	8	0	1
Qualifying Pole Positions	8	0	1
Qualifying Podiums	23	1	1

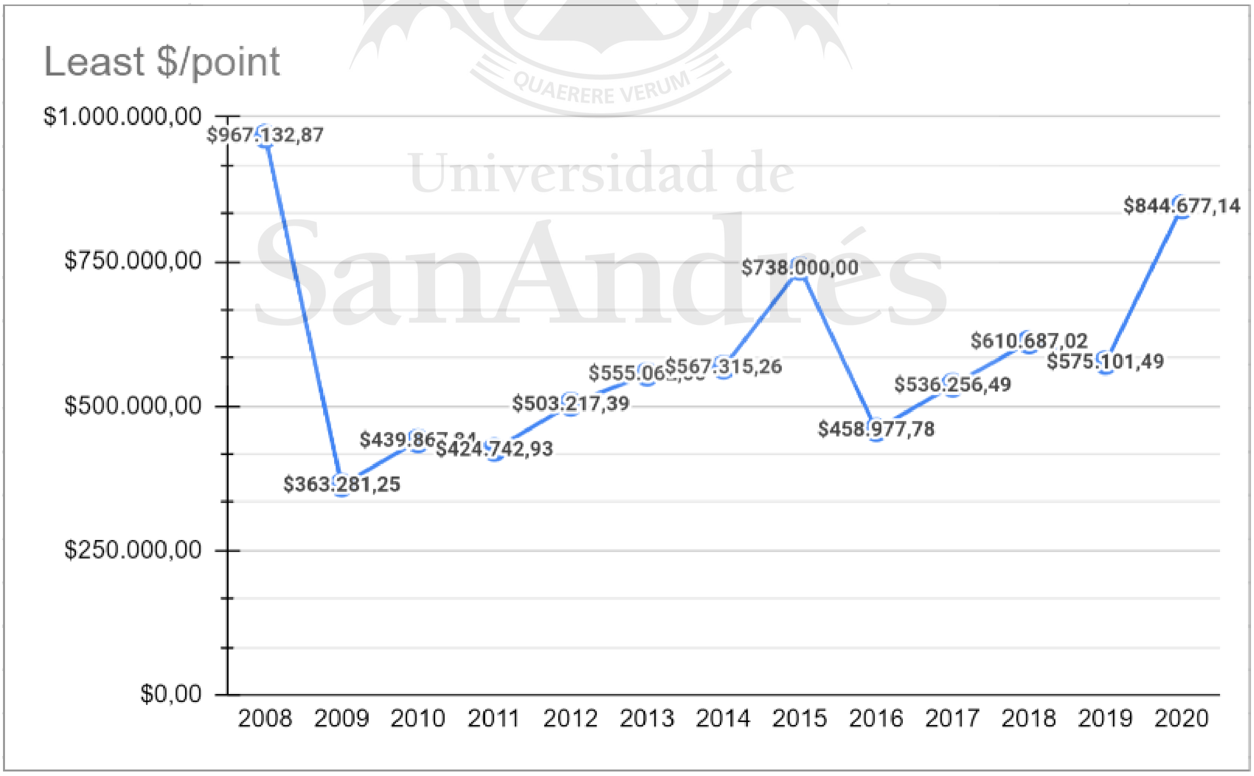
Source : Own creation based on auto-sport magazines and official F1 website [3]

[2] (F1, *Standings*) for points, For Budgets we used Budget reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section)

[3] (F1, *Standings*) for Points, Wins, Podiums, Fastest Laps, Qualifying Pole Positions, Qualifying Podiums. For Budgets we used Budget reference N. 5 (see Budget References under References Section) and (Gutiérrez & Lozano, 2012).

At first glance we see two teams which spent similar amounts of money (Toyota and Ferrari), Toyota spending more of course, but obtaining worse results. Ferrari obtained 3 times the amount of points obtained by Toyota that season, spending less. I believe this shows that efficiency goes a long way, before effectiveness. Just throwing money at a problem may not be the solution, it's how you do it that may prove the solution. Lets compare now Toyota and Williams, Toyota gained 1.42 as many points as Toro Rosso and spent 3.47 times as much money. We can clearly see that they were effective at beating Williams but it seems something of an overkill to spend that much money for 50 more points. Even so if we look at the money spent per point gained, Toyota spent 2.44 times the money Toro Rosso spent per point gained. But as I said when I started this paragraph, this is at first glance. Maybe Toyota needs to spend their money better to become more efficient and win more points whilst Toro Rosso may need to spend more money in order to gain more points even if at first glance they are the 4th most efficient team in terms of money spent per point gained.

Figure 1.0 Least $/point per year



Source: Own creation based on data from Auto sport magazines and F1 official website[4]

[4] Table 1.1 used as data base for Figure

We can see in Figure 1.0 above the amount of money spent by the constructor which spent the least amount of money per point gained each year. Ferrari (´08), Brawn (´09), Mclaren (´10), Red Bull (´11,´12,´13), Mercedes (´14,´15,´16,´17,´18,´19,´20). 2009, 2010, 2011 and 2016 are some of the years where the least amount of money per point gained was spent.

As we said before looking at Table 1.1 one could interpret these are the efficient teams, but our analysis goes beyond and will try to set up a benchmark so that we may compare even those constructors which seem efficient, but in reality may not be the most efficient. Constructors who win the championship tend to be the ones that spend the least amount of money per point gained, but this is not enough to evaluate overall efficiency. Because even if one team is not effective -wins the championship- it can still be efficient, meaning that with the money they have available and taking into account their scale efficiency[5] they were able to produce the maximum output possible, to translate it to F1 terms, with the budget available a Constructor was able to get the most amount of points possible with that budget, but it wasn't enough to win the championship, so it was efficient but not effective.

$$Scale\ efficiency\ = \frac{CRS\ EFFICIENCY}{VRS\ EFFICIENCY}$$

We are also going to add another variable, Average positions won or lost during a race or Average position delta. This won't be included in the model, but it will be included as a complementary viewing point for the analysis. This variable will help us better understand the point difference between the mid sector of the grid, where they spend differently but gain similar results. To do this we have taken the data of the starting grid position and the finishing position in the race for each race, for each year, for each of the two drivers in each constructor. We compute the difference between the starting and finishing position for each race, for each driver, add them up, which gives us the total position delta for each race. We add the total position delta for all the races, giving us the total position delta for the season and we divide that number by the total number of races in that season. Giving us the Average position delta for each season.

[5] Scale efficiency: Scale efficiency is the result of dividing CRS efficiency by VRS efficiency, it tells us how closely a DMU is operating to its most productive output.

Table 1.3 Scuderia Ferrari / Toyota / Toro Rosso 2008 Season

POS in Championship	AVG POS Delta	Max POS Delta	Min POS Delta
1	-2,784	0,45	-8,21
2	-2,994	1,90	-6,57
3	-2,241	1,66	-8,80
4	-1,667	1,15	-3,90
5	-1,794	1,88	-6,90
6	-1,726	2,57	-5,63
7	-0,606	4,76	-4,84
8	-0,361	4,82	-5,52
9	0,423	4,45	-5,76
10	0,769	4,38	-4,15
11	3,563	5,75	0,63
12	2,730	3,78	1,05

Source : Own calculations, data taken from F1 website

[6]

Here we can see the Mean AVG POS Delta for every constructors who came in 1st, 2nd, 3rd and so on till 12th place for those seasons who had 12 teams competing on the grid. We also have Maximum and Minimum AVG POS Deltas for each category. At first glance we can see that the lower position on the grid the more positive AVG Position Delta a team gets. For the top finishers in the championship we see that their AVG position Delta shows a big loss in positions during the season. This may be because usually teams that do well during the season, qualify and finish the race in similar positions, but when they crash or have a problem they might loose up to 19/23 positions. For example lets say the Ferrari drivers start the race at 1 - 2, the first driver crashes and drops to the 24th position in the grid whilst the 2nd driver finishes 2nd. The first driver will have a Position Delta for that race of -23 positions, whilst the 2nd driver will have a Position Delta of 0. If we add that number it will give a total of -23 Position Delta for that race. There is usually around 20 races per season. By having one result like the one described before, the Avg Position Delta already drops by -1,15 (-23 position change / 20 races). Therefore a crash or a bad result can have a huge negative impact on the Avg Position Delta. Because the team will later resume to qualify 1 - 2 and perhaps have a 1 - 2 finish (or a finish position that is close to their starting position), so its probable that they won't gain or counter the negative effect of that previous loss in position, due to the fact their delta for those “normal” races will be small or 0. Teams on the mid sector of the grid tend to have the possibility to gain more positions on a good day and if they drop any positions due to crashes or problems they can counter with a good result the next race, that is why we see the Mean AVG POS Delta drop in the mid sector of the grid by 1 overall position. Last but not least the lower section of the grid tend to have more positive AVG POS Deltas, given the fact that they experience the opposite of what the top sector of the grid experiences. They tend to start and finish in low positions, but when others crash or when they have a good result, they have a big positive POS Delta that can’t be countered by bad results given the fact they already tend to start the race in a bad position.

[6] (F1, *Standings*)

Methodology

To assess efficiency we first have to understand what efficiency in F1 means. We will describe what being efficient means. Being efficient in any production function means minimizing inputs and maximizing outputs. The input we have recognized in F1 is the budget which can be separated into 3 main categories, Sponsors, Prize Money, and Sales. We do not actually have the percentages for each category so we are going to use the budget as a whole. We do know that most money comes from sponsorship followed by prize money and then some have other sources of income such as Sales (Hospitality, Merchandising), Investors and Manufacturers. We will take the budget as a whole. The outputs of F1 are Points, Wins and Podiums. The Points are the total number of points obtained by both drivers for all races in a season. Wins are the number of races won by a constructor´s driver, so if Driver 1 wins 2 races and Driver 2 wins 8 then the total number of wins for the constructor is 10. Podiums are the total number of times either one of the team´s drivers finish in the race in the top 3 places, so again if Driver 1 finishes 1st, 2nd and 2nd in three races then he will have secured 3 podiums. If Driver 2 finishes 2nd, 4th and 3rd in the same three race then he will have secured 2 podiums. The total number of podiums obtained by the team would be 5. Therefore any team that wants to be efficient has to basically reduce the amount of money they spend per point won. This is efficient because they achieve better results using less money. As we mentioned before there are teams who spend less and gain better results, therefore efficiency plays a crucial role in becoming effective, which can be defined as winning the championship or obtaining the most available points per season.

To do this we propose a DEA with Constant and Variable returns to scale so that we may evaluate both implications. The DEA Model is a linear programming technique used to evaluate the efficiency of Decision Making Units or (DMUs) which in our case will be Formula 1 Constructors. Each DMU produces outputs with the inputs it receives, each tries to minimize inputs and maximize outputs. The model takes the different DMUs and determines an efficient frontier based on their relative efficiency, if the DMU is on the frontier it is deemed efficient, all of those that do not lie on the frontier are deemed inefficient. This isn't the first study to measure the efficiency and performance of F1 Constructors, (Gutierrez & Lozano 2012) propose that F1 can be seen as any productive activity. Where as we mentioned before, an Input (Budget) enters a DMU (Constructor) which manages that input to produce the best possible output (Points). Since the efficiency frontier tells us which Constructors are efficient or not, the efficiency of a Constructor is measured relative to the performance of all of the other Constructors. We will conduct our study following their same proposed DEA model. Lets consider an F1 Season in which we have *n* Constructors, each uses m inputs and produces s outputs. Let us also assume x_{ij} is the ith $(i = 1, 2,..., m)$ input usage of the jth ($j = 1, 2,..., n$) Constructor. On the other hand y_{kj} is the kth ($k = 1, 2,....., s$) output production of the jth ($j = 1, 2,..., n$) Constructor. $\alpha_0$measures the efficiency of the F1 constructor 0. λ_j is the multiplier of the jth Constructor. s_i^- and s_k^+ are the slack values for the inputs and outputs. So to put it in basic terms, the function minimizes the slack values to find the optimal level of efficiency α_0. The input-oriented model, VRS, also known as pure technical efficiency, described by (Färe, Grosskopf, & Lovell, 1985), can be seen below.

$$min\, \alpha_0 - \beta\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{s} s_k^+\right) \tag{1}$$

subject to

$$\alpha_0 x_{i0} = \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- \quad i = 1,...., m \tag{2}$$

$$y_{k0} = \sum_{j=1}^{n} \lambda_j y_{kj} + s_k^+ \quad k = 1,...., s \tag{3}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{4}$$

$$\lambda_j, s_i^-, s_k^+ \geq 0, 0 \leq \alpha_0 \leq 1 \tag{5}$$

Restraint (4) tells us that constraining the multipliers of each constructor to sum to 1 allows the efficient frontier to show, increasing, constant or decreasing returns to scale. Meaning the efficient frontier can show variable returns to scale (VRS) which is also known as pure technical efficiency. So we can see how well the data on Constructors inputs and outputs accommodate to each of the before mentioned returns to scale, so as to see the efficiency including scale efficiency. Whereas if we modify the former by omitting restraint (4) we then assume constant returns to scale (CRS) which would allow us to evaluate the technical efficiency between Constructors, without taking into account if a constructor operates at or below its scale efficiency. The proposed model is input oriented so this means the model evaluates if the Constructor (DMU) is able to reduce its usage of input for a certain level of output determined by the best observed benchmark. If a reduction of the Constructor´s budget is not possible then the model gives it a efficiency value $\alpha_j = 1$, this means it lies on the efficient frontier. If a budget reduction is possible meaning the benchmark shows that the same result can be obtained with a lower usage of the input then the model gives that Constructor an efficiency value $0 \leq \alpha_j < 1$. We can evaluate scale efficiency by dividing

CRS efficiency by the VRS efficiency, meaning the ratio between technical efficiency and pure technical efficiency.

To run the model we will use a software called DEAP from the University of Queensland who are kind enough to make it free to use. The software allows various inputs and outputs to be taken into account and both CRS and VRS analysis. We will run the model for each year, to see which was/were the most efficient constructor/s for that particular year. Then we will run the model comparing all teams from all years to see which constructor/s was/were the most efficient overall. As an additional form of analysis we will run the model in windows of three years to compare within those three years which team or teams were the most efficient. For example we will start with the first three year window of 2008 - 2009 - 2010, the next would be 2009 - 2010 - 2011, the next one 2010 - 2011 - 2012 and so on until the last one 2018 - 2019 - 2020.

Results

In this section we will discuss the results obtained form the model. As we mentioned before we chose to run an input oriented DEA model, we did it assuming both CRS and VRS to compare both efficiency scores. We will present the efficiency scores obtained by each team competing in a certain year and then we will present the results obtained from comparing all teams from all years.

Table 1.4 CRS Budget Projections for 2018 Season

Team	Projected Budget	Actual Budget	Difference	Reduction %
Mercedes F1 Team	$400,000,000.00	$400,000,000.00	$0.00	0%
Scuderia Ferrari	$348,702,290.08	$410,000,000.00	-$61,297,709.92	-15%
Red Bull Racing	$255,877,862.60	$310,000,000.00	-$54,122,137.41	-17%
Renault F1 Team	$74,503,816.79	$190,000,000.00	-$115,496,183.21	-61%
Force India F1 Team	$67,786,259.54	$120,000,000.00	-$52,213,740.46	-44%
Haas	$56,793,893.13	$130,000,000.00	-$73,206,106.87	-56%
Mclaren	$37,862,595.42	$220,000,000.00	-$182,137,404.58	-83%
Sauber F1 Team	$29,312,977.10	$135,000,000.00	-$105,687,022.90	-78%
Scuderia Toro Rosso	$20,152,671.76	$150,000,000.00	-$129,847,328.24	-87%
Williams	$4,274,809.16	$150,000,000.00	-$145,725,190.84	-97%

Source : Own creation based on data from various auto sport magazines and DEA Model results

[7]

So first we are going to take a look at where each Constructor lies in the efficiency index for each year. Taking into account both CRS an VRS models. So if we take a look at Table 1.7 in the annex we can see that in the CRS model the most efficient Constructor coincides with the Constructors which spent the least money per point seen in Table 1.0. So CRS efficient constructors could have been found by just calculating which constructor spent the least amount of money per point gained. As well, Table 1.7 (in the annex) shows the efficiency

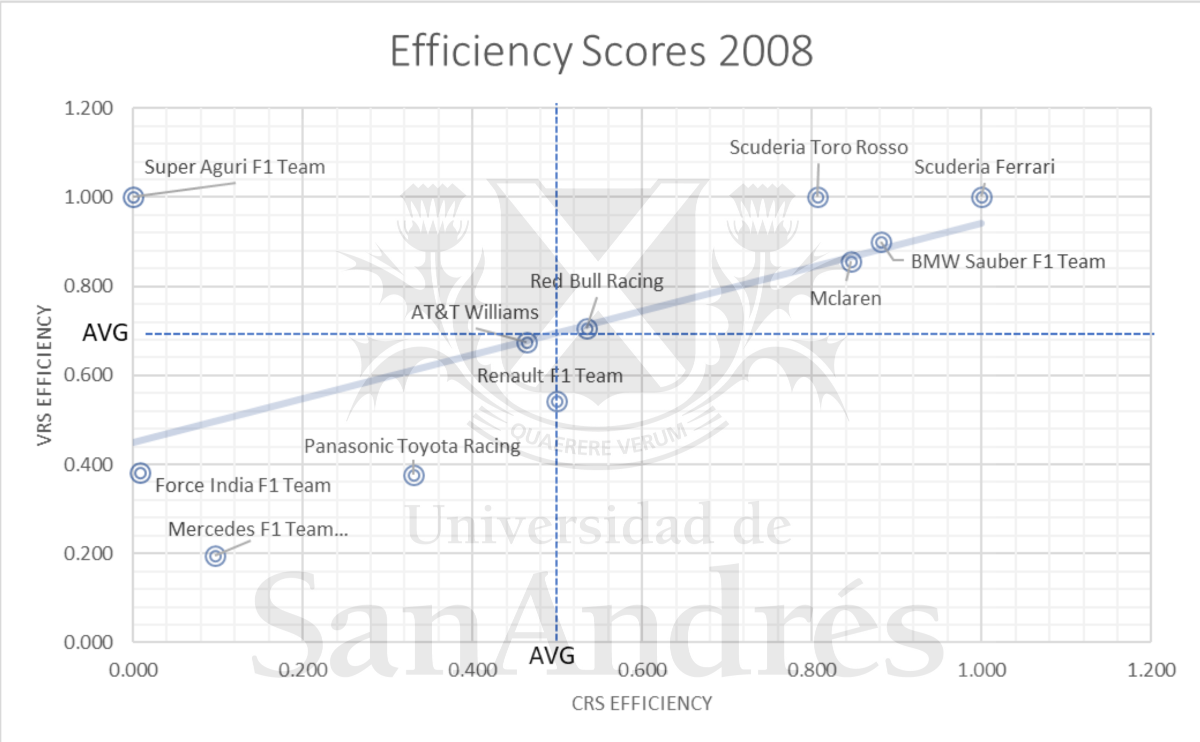
[7] Results computed using Budget data from Budget reference N.20-21-36 (see Budget References under References Section)

scores given by the model which are relative to each other, for example in 2018 Red Bull Racing was deemed inefficient and given an efficiency score of 0.852 this means that the projected budget for that Constructor, so that it may achieve the same result more efficiently should have been reduced to 85.2% of its original budget. Which put in practice would have been a budget reduction of U$D 54.122.137,41 resulting in a projected budget of U$D 255.877.862,6. All of the Constructors who receive an $\alpha < 1$ are given a projected budget, lower than their original one. This shows that teams are generally overspending. Given the fact you can´t just ask Constructors to bring in millions of dollars more, VRS allows us to understand given their current scale of operations if a Constructor might also be efficient within its area of operations. Meaning that in some cases its not fair to compare a Constructor with U$D 400.000.000 and another with U$D 130.000.000. For example in 2019 as seen when we compare Mercedes which had a budget of U$D 425.000.000 with Scuderia Toro Rosso which had a budget U$D 155.000.000. The Constructor with a bigger budget will tend to gain better results whereas the one with a lower budget may tend to gain lower results, if they do so more efficiently given their size then VRS takes this into account. If the one with a lower budget gains lower results but given its scale it operates at its maximum possible output then it will be deemed efficient. This is why teams that do not lie on the CRS efficient frontier do lie on the VRS efficient frontier.

In general teams seem to overspend, when teams increase their budget they usually receive lower efficiency scores. For example lets take a look at Table 3.3 on the annex, which shows information about Ferrari. Except for a few years like 2009 and 2010, all remaining years seem to follow this trend, where if the budget increases efficiency scores decrease, the opposite happens if budgets decrease. We see that from 2013 to 2014 there was an approximate increase in the budget of 100.000.000 and the efficiency score halved from 0,528 to 0,253. A clear sign that each dollar spent is turning into less points. Of course there are exceptions, teams who win championships tend to break this rule, these lie on the efficient frontier regardless if their budget varies, given the fact they are the best practice. Looking at Table 2.0 we have the average efficiency scores for each year. CRS efficiency tends to decrease from 2008 to 2020, there are a few years such as 2012, 2015, 2017, 2018 and 2020 where it seems to improve but it starts at 0.497 in 2008 and ends at 0.464, showing a general decline as just mentioned. VRS efficiency scores are higher than CRS because they take into account Scale efficiency, so a Constructor that seems inefficient relative to the one lying on the efficient frontier may be efficient relative to its size and to other similar constructors. VRS or pure technical efficiency seems to improve over the years meanwhile scale efficiency declines. Scale efficiency tells us if a Constructor operates at or below its maximum output possible given its size. So a team that has a 0.9 Scale efficiency such as 2010 Red Bull Racing and operates under decreasing returns to scale tells us they are too big and need to lower their budget to operate at their efficient level. When comparing all years and all teams we see that when compared in equal terms, both CRS and VRS efficiency increase, Scale efficiency doesn´t. Most teams operate below the average levels of efficiency for both CRS and VRS, we can see this in Figures 1.1 - 2.3 where most teams are clustered below the average dotted lines, whilst a only a few make it over the average lines. These Figures show us both CRS and VRS scores for each team, so they show us if the teams where efficient or not and they also show how many teams have a below or above average efficiency score.

Raw Data

Figure 1.1 Efficiency Scores for each team in the 2008 season

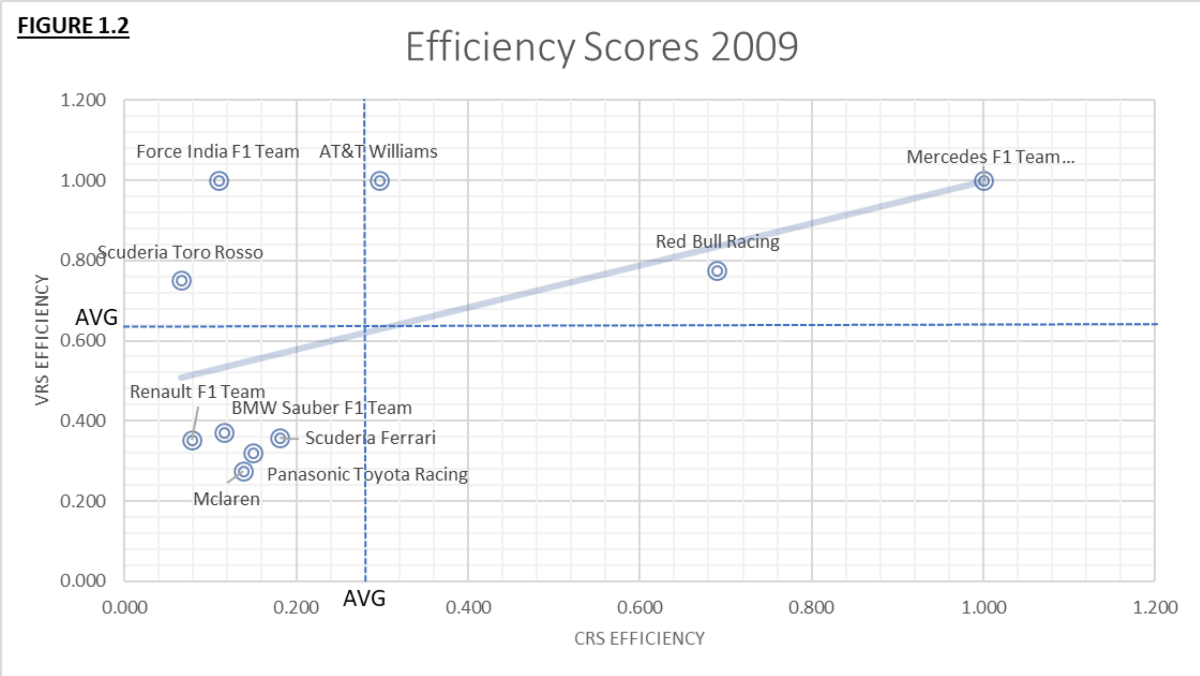


Source : Own creation based on results from DEA Model[8]

This graph shows the VRS Efficiency Score on the vertical axis and the CRS Efficiency Score on the horizontal axis, so that both scores are visible at the same time. for example that for 2008 Scuderia Ferrari received both a CRS and VRS efficiency score of 1, meaning it was deemed efficient by the model. Another observation could be that 6 out of the 11 teams that competed that season scored a below average efficiency score. To compare each constructor we must look at one of the axis at a time. For example, to compare the constructors assuming CRS then we look at the horizontal axis. Most years show similar results, most teams scoring a below average efficiency score and both score results for each team. So to analyze each and every single one of them would be repetitive.

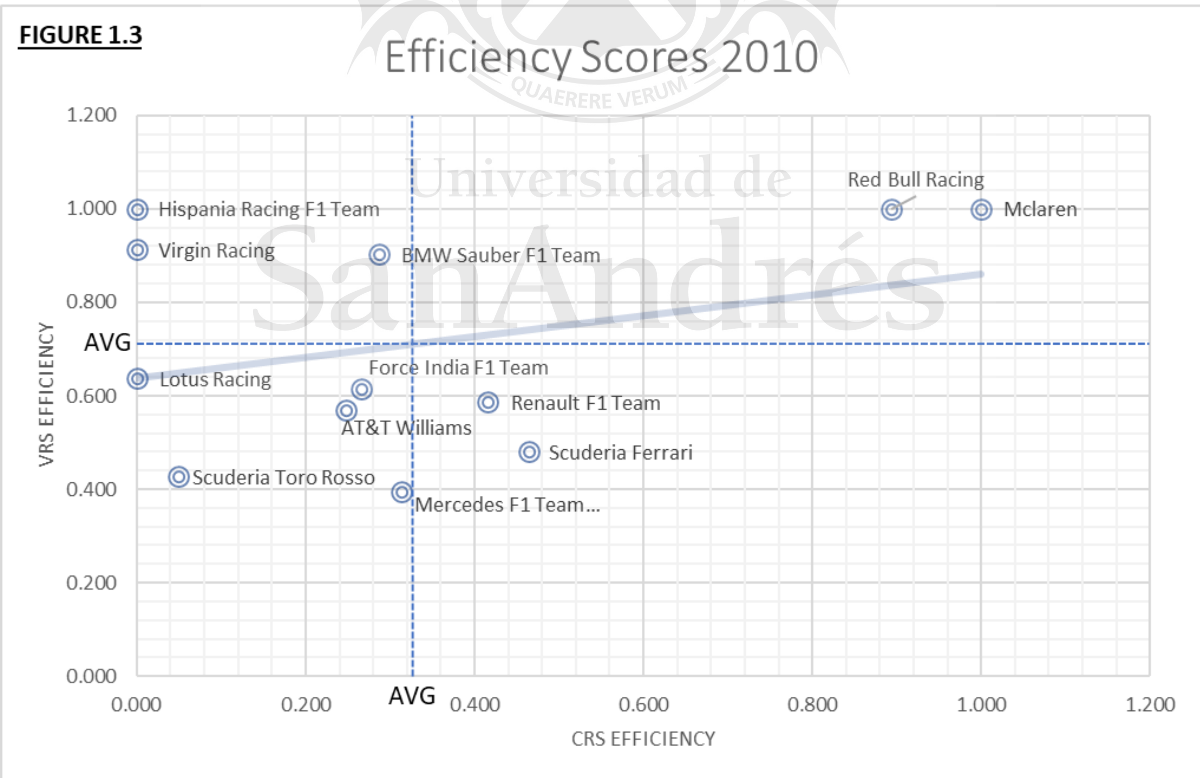
[8] Data from Tables 1.8 and 1.9 (see annex)

Figure 1.2 Efficiency Scores for each team in the 2009 season



Source : Own creation based on results from DEA Model[9]

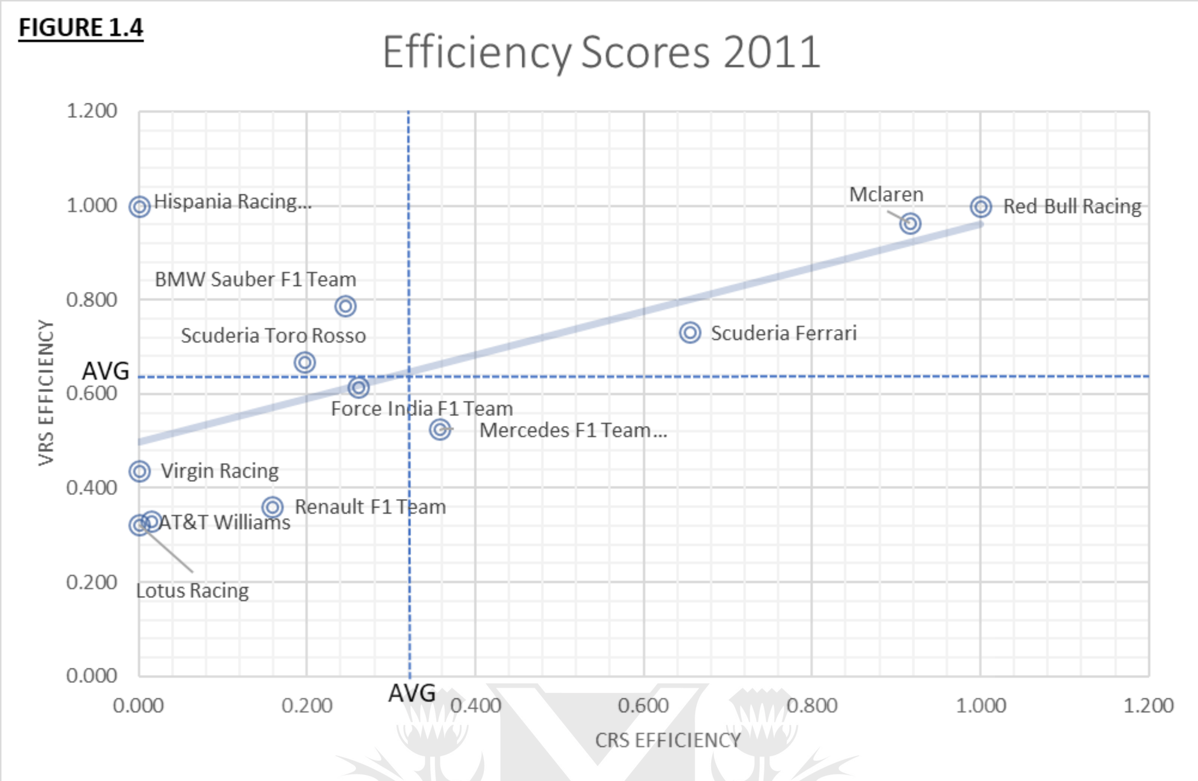
Figure 1.3 Efficiency Scores for each team in the 2010 season



Source : Own creation based on results from DEA Model[10]

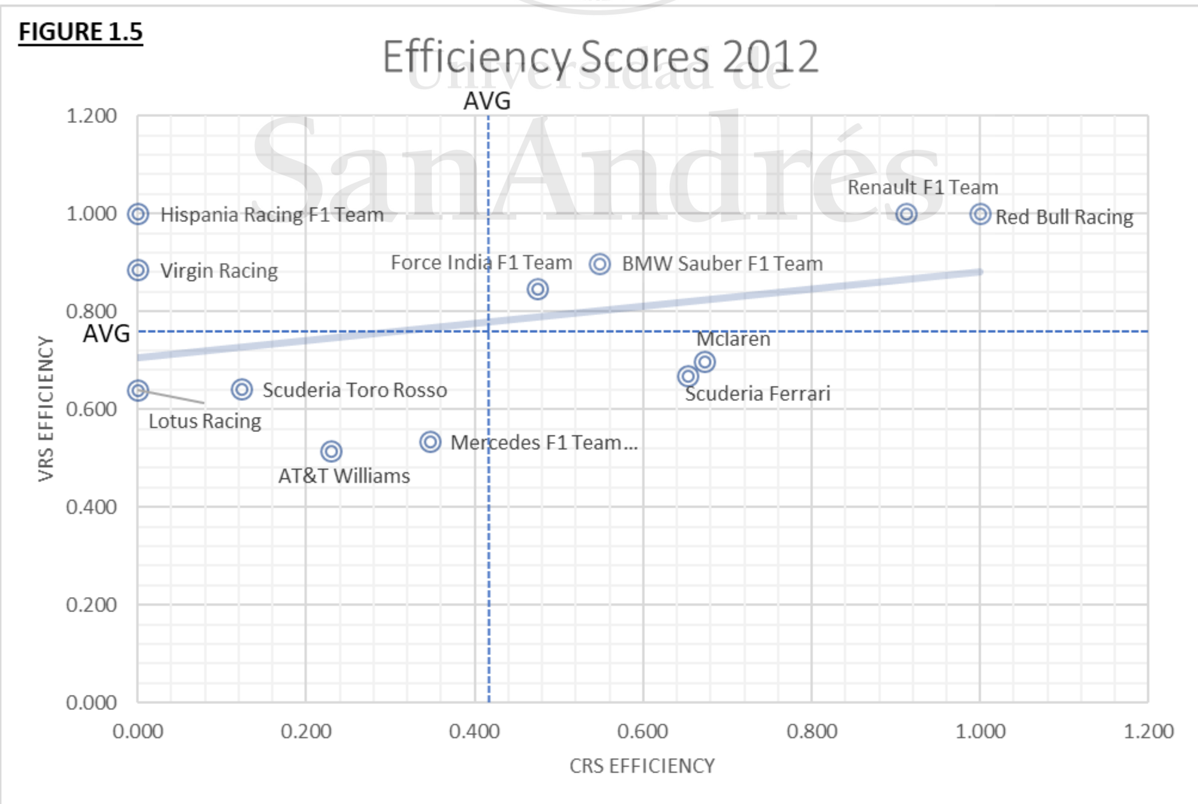
[9] Data from Tables 1.8 and 1.9 (see annex)
[10] Data from Tables 1.8 and 1.9 (see annex)

Figure 1.4 Efficiency Scores for each team in the 2011 season



Source : Own creation based on results from DEA Model[11]

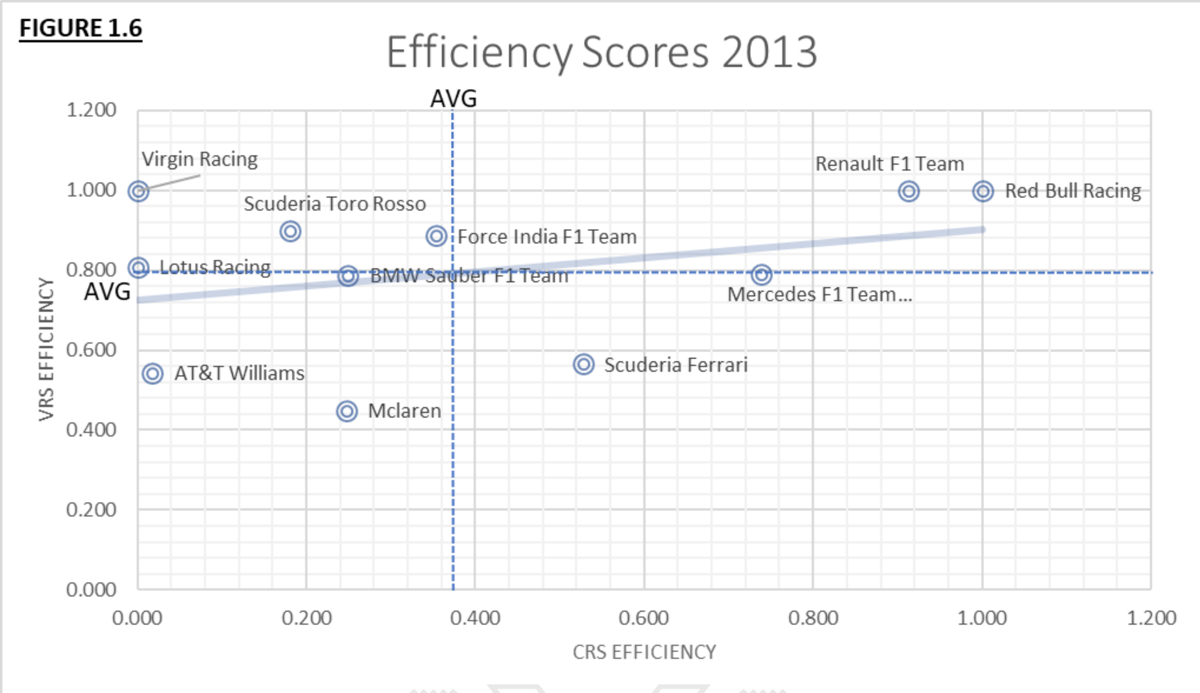
Figure 1.5 Efficiency Scores for each team in the 2012 season



Source : Own creation based on results from DEA Model[12]

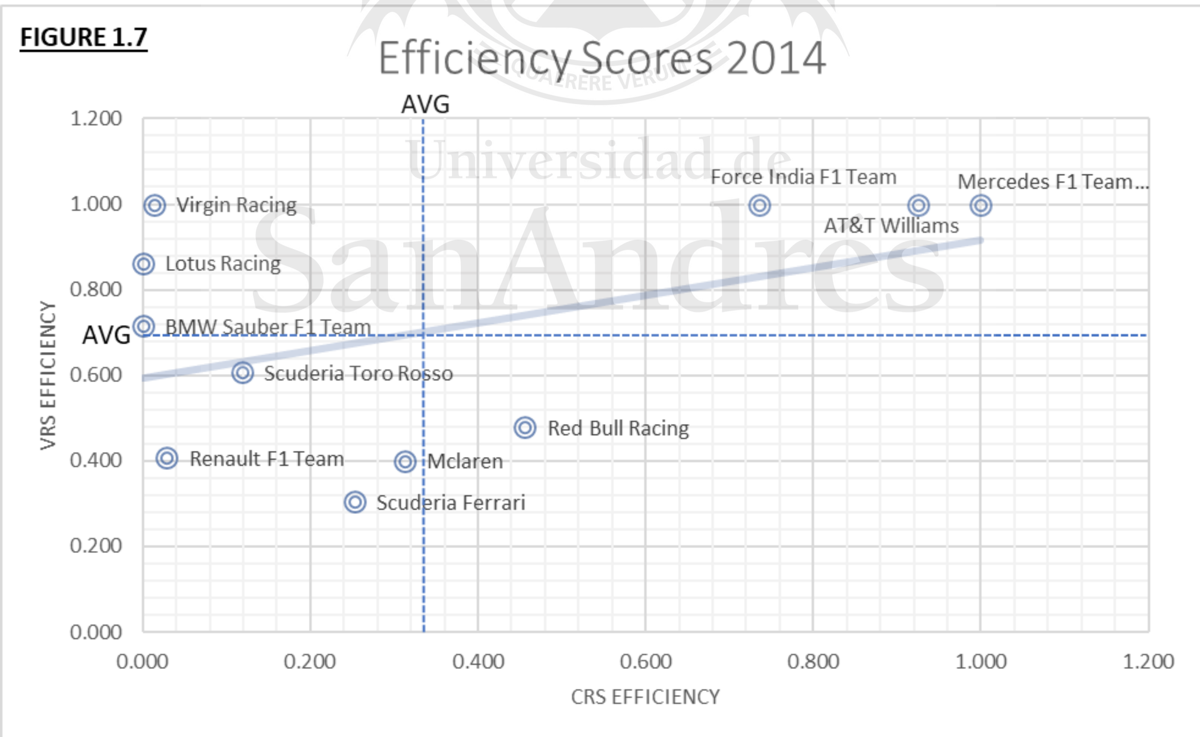
[11] Data from Tables 1.8 and 1.9 (see annex)
[12] Data from Tables 1.8 and 1.9 (see annex)

Figure 1.6 Efficiency Scores for each team in the 2013 season



Source : Own creation based on results from DEA Model[13]

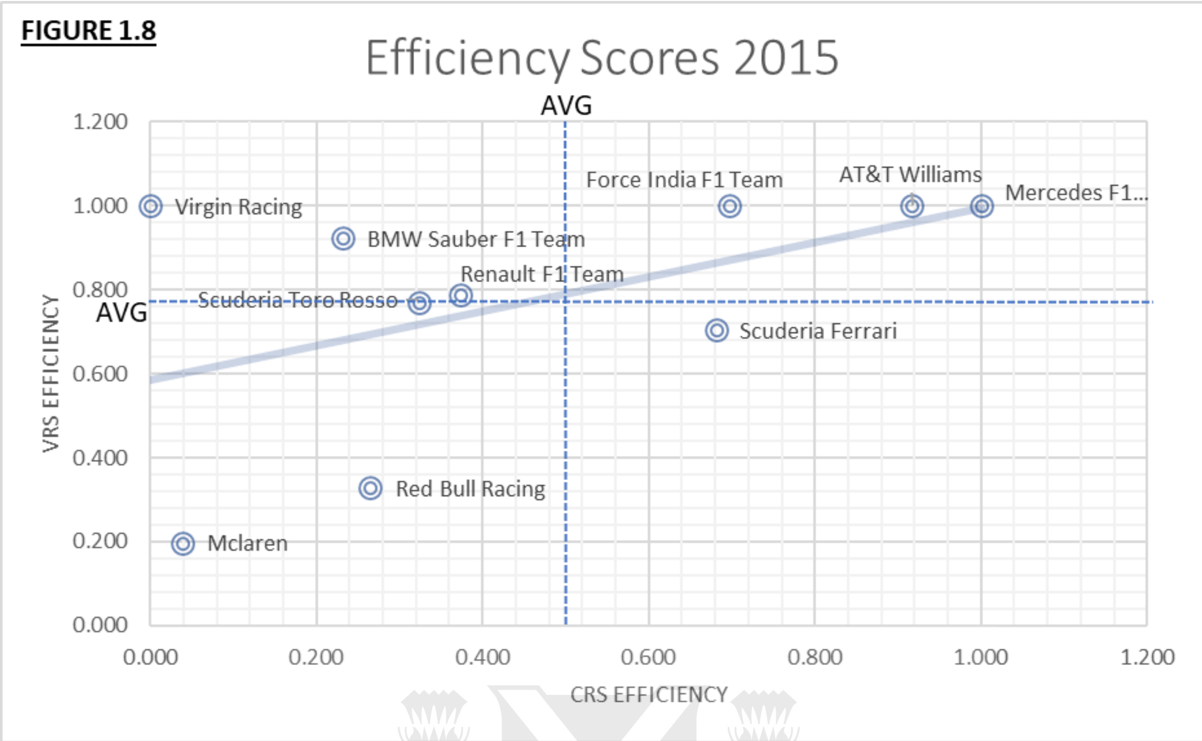
Figure 1.7 Efficiency Scores for each team in the 2014 season



Source : Own creation based on results from DEA Model[14]

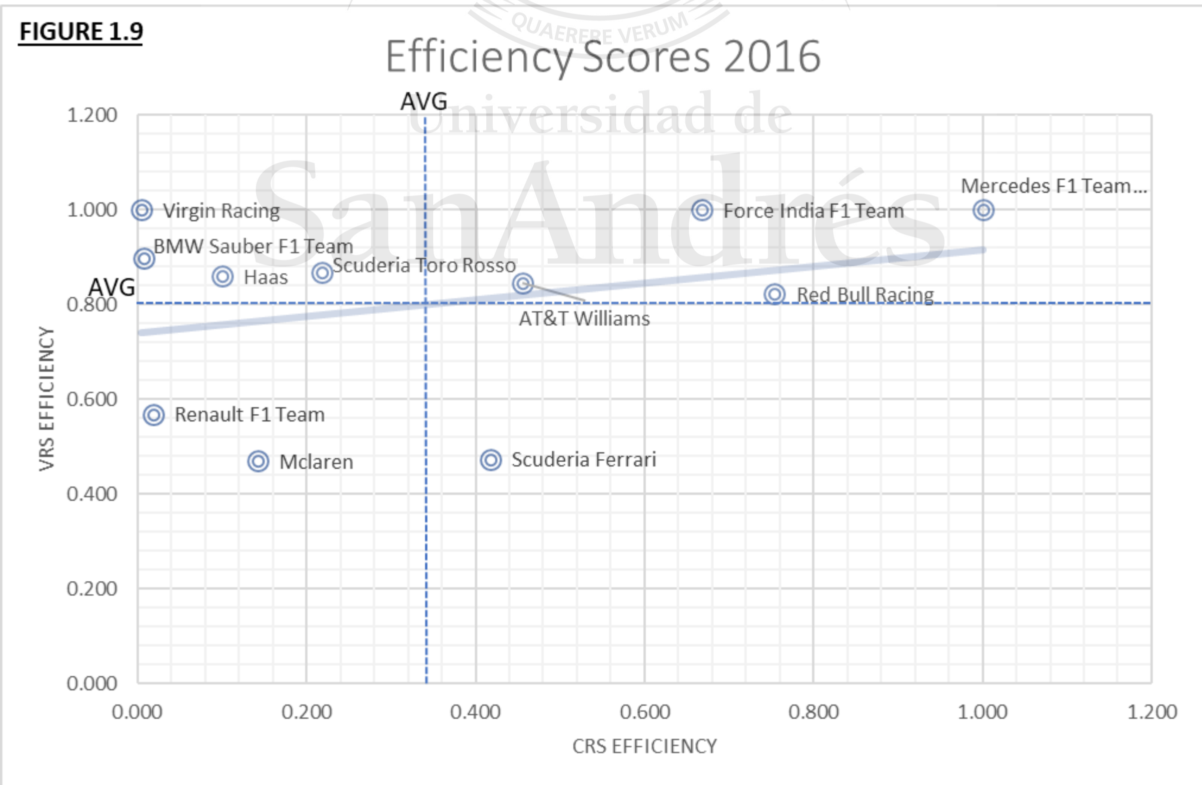
[13] Data from Tables 1.8 and 1.9 (see annex)
[14] Data from Tables 1.8 and 1.9 (see annex)

Figure 1.8 Efficiency Scores for each team in the 2015 season



Source : Own creation based on results from DEA Model[15]

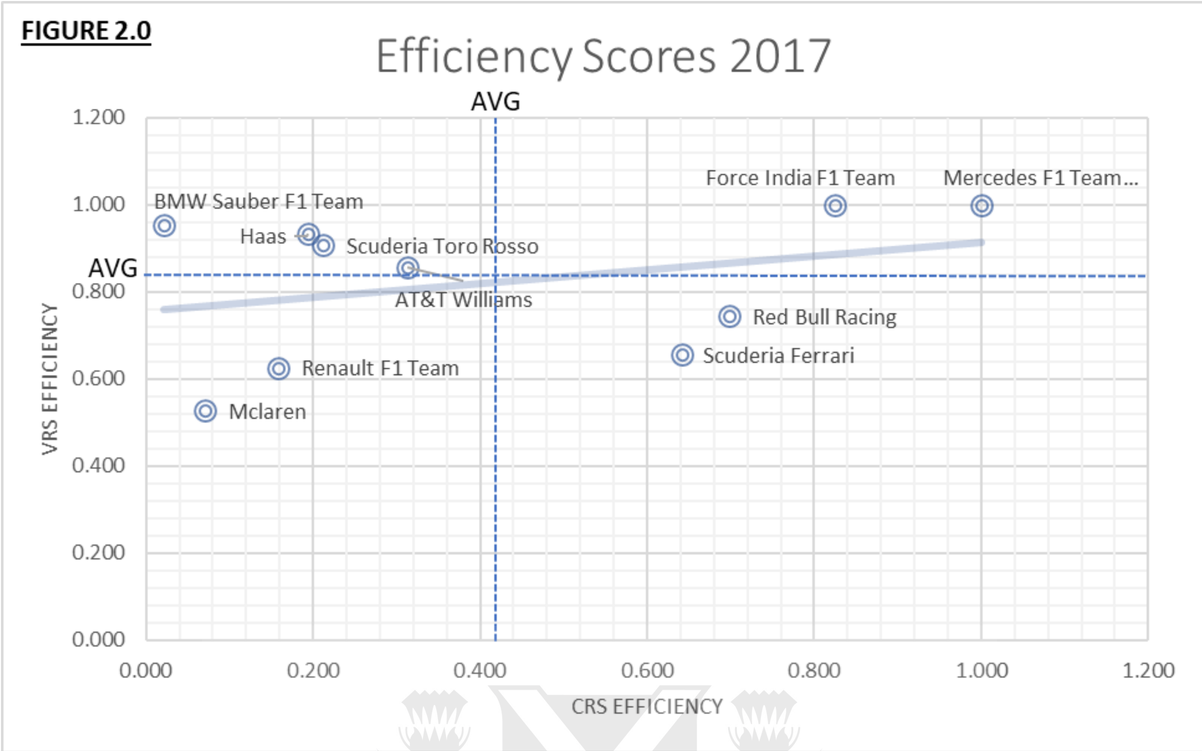
Figure 1.9 Efficiency Scores for each team in the 2016 season



Source : Own creation based on results from DEA Model[16]

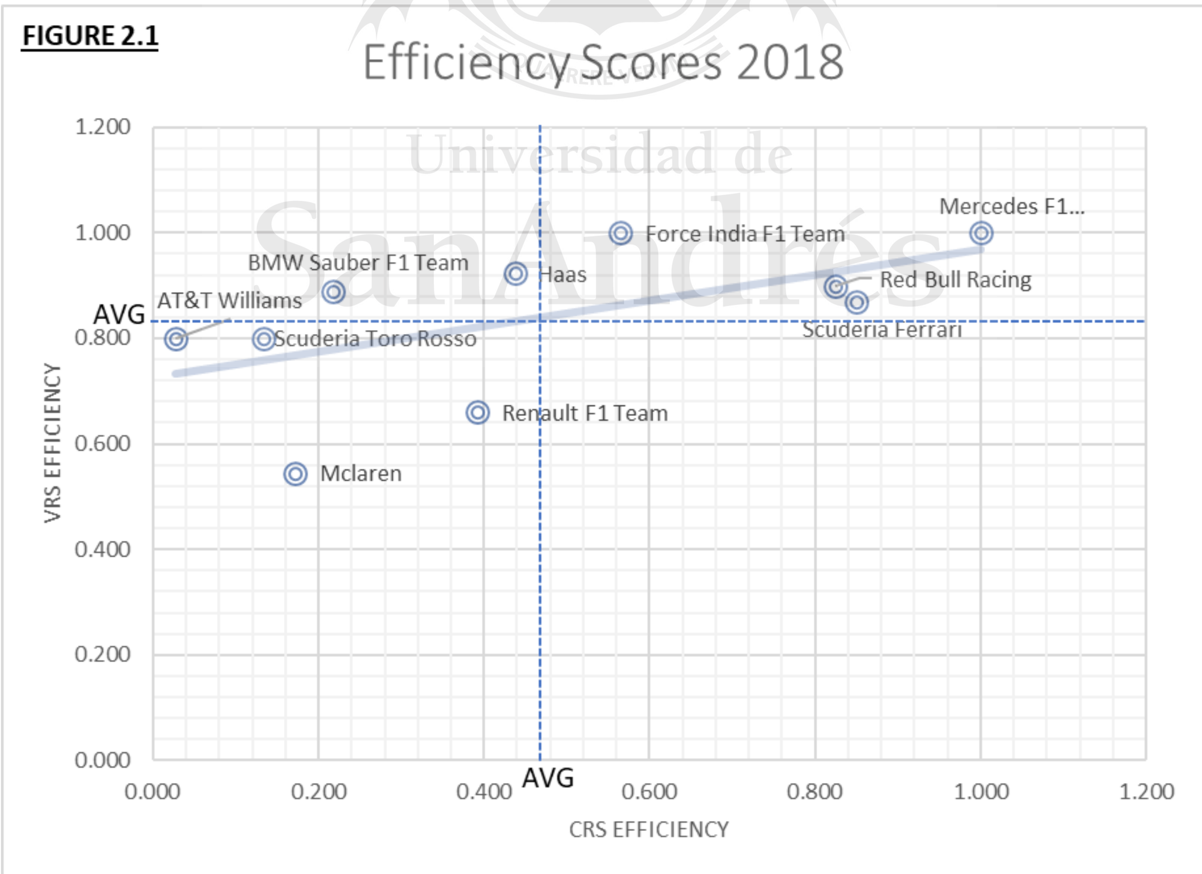
[15] Data from Tables 1.8 and 1.9 (see annex)
[16] Data from Tables 1.8 and 1.9 (see annex)

Figure 2.0 Efficiency Scores for each team in the 2017 season



Source : Own creation based on results from DEA Model[17]

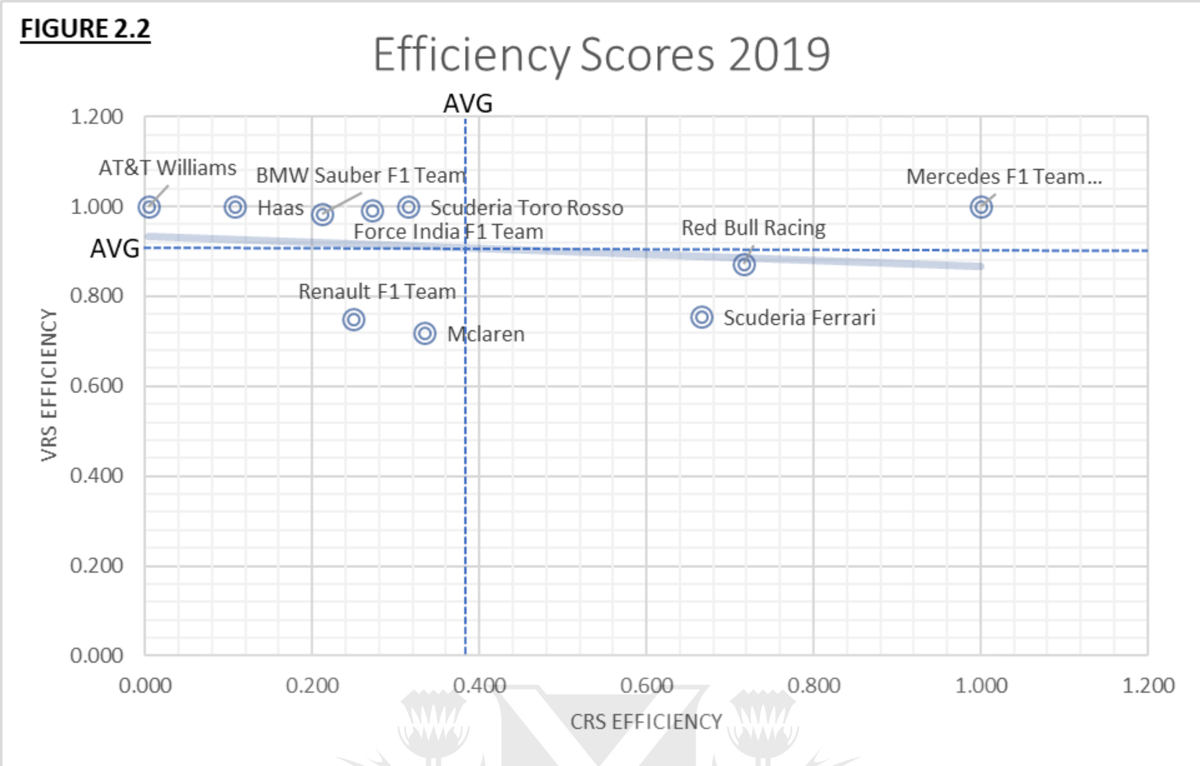
Figure 2.1 Efficiency Scores for each team in the 2018 season



Source : Own creation based on results from DEA Model[18]

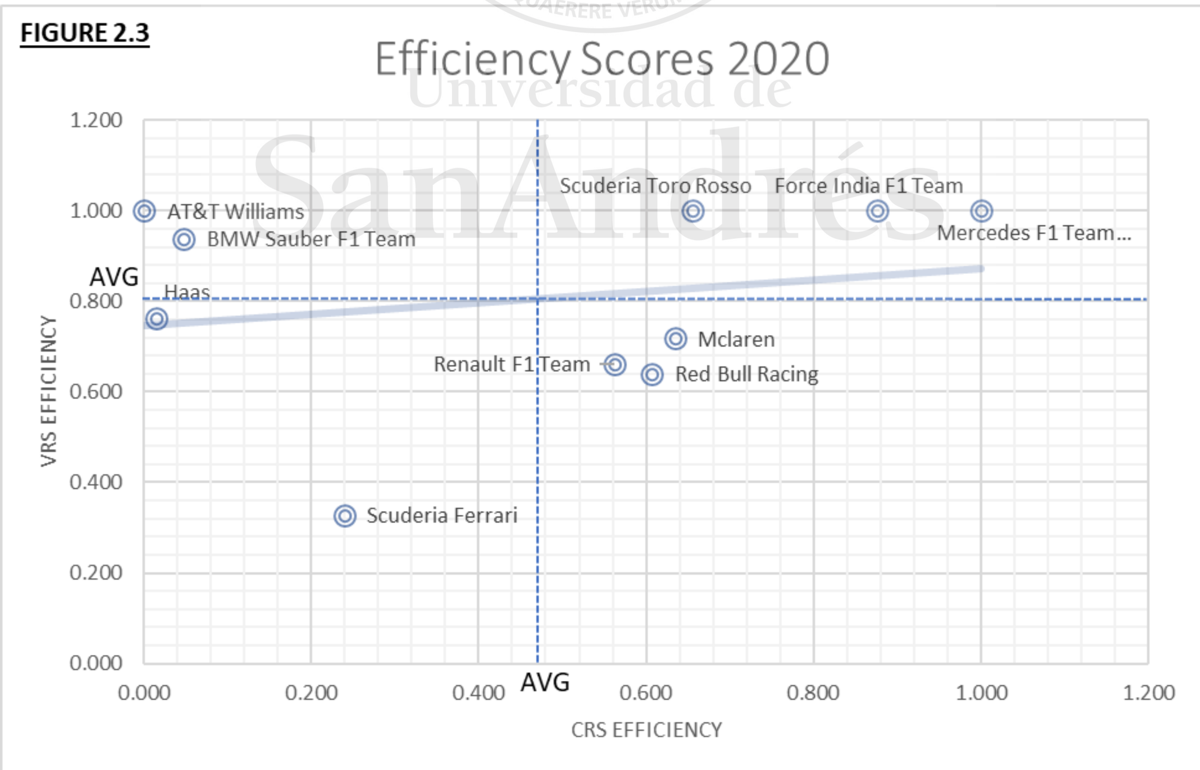
[17] Data from Tables 1.8 and 1.9 (see annex)
[18] Data from Tables 1.8 and 1.9 (see annex)

Figure 2.2 Efficiency Scores for each team in the 2019 season



Source : Own creation based on results from DEA Model[19]

Figure 2.3 Efficiency Scores for each team in the 2020 season



Source : Own creation based on results from DEA Model[20]

[19] Data from Tables 1.8 and 1.9 (see annex)
[20] Data from Tables 1.8 and 1.9 (see annex)

Table 1.8 below shows the CRS efficiency scores obtained for all years by each team, we can see which teams are the most efficient compared to others, we can see their trajectory through the years, tendencies and evolution. For example Mclaren shows an increase in efficiency until 2011, then a big drop 2017 when they started to improve their efficiency. Renault on the other hand shows many ups and downs through the years, with an unclear upwards trend -seen by looking at the CRS efficiency in 2008 and the one in 2020- unclear because they end up with a better efficiency score in 2020 but as we mentioned with big ups and downs. Williams shows a low efficiency at first, an improvement towards the Hybrid Era (2014) which doesn´t too long due to the fact there is a clear drop in efficiency towards 2020. The same can be seen and said about Table 1.9, the main difference between the results exposed by each table is that VRS tends to award higher efficiency scores to each constructor due to the fact that it takes into account each team´s scale of operations, awarding a score according to their efficiency based on their output capacity. Scale efficiency scores can be seen in Table 2.0 below. As we mentioned before with the help of the figures above most constructors are deemed inefficient and are said to be operating at below its maximum output capacity.

Table 1.8 : CRS EFFICIENCY

Team	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scuderia Ferrari	1.000	0.180	0.464	0.654	0.652	0.528	0.253	0.681	0.418	0.641	0.850	0.666	0.239
Mclaren	0.846	0.138	1.000	0.916	0.672	0.247	0.312	0.039	0.142	0.070	0.172	0.334	0.634
BMW Sauber F1 Team	0.881	0.116	0.287	0.245	0.548	0.249	0.000	0.232	0.007	0.021	0.217	0.211	0.048
Renault F1 Team	0.499	0.078	0.416	0.159	0.912	0.913	0.028	0.373	0.018	0.158	0.392	0.249	0.562
Panasonic Toyota Racing	0.330	0.150	-	-	-	-	-	-	-	-	-	-	-
Scuderia Toro Rosso	0.807	0.066	0.049	0.197	0.123	0.180	0.119	0.324	0.218	0.212	0.134	0.315	0.655
Red Bull Racing	0.534	0.690	0.894	1.000	1.000	1.000	0.455	0.265	0.753	0.698	0.825	0.716	0.606
AT&T Williams	0.464	0.296	0.248	0.015	0.229	0.018	0.925	0.917	0.455	0.313	0.028	0.004	0.000
Mercedes F1 Team (Prev. Honda F1 Team)	0.097	1.000	0.314	0.357	0.347	0.739	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Force India F1 Team	0.008	0.109	0.266	0.261	0.474	0.353	0.736	0.697	0.667	0.825	0.565	0.271	0.876
Super Aguri F1 Team	0.000	-	-	-	-	-	-	-	-	-	-	-	-
Lotus Racing	-	-	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-
Hispania Racing F1 Team	-	-	0.000	0.000	0.000	-	-	-	-	-	-	-	-
Virgin Racing	-	-	0.000	0.000	0.000	0.000	0.014	0.000	0.004	-	-	-	-
HAAS	-	-	-	-	-	-	-	-	0.100	0.194	0.437	0.107	0.015

Source : Results from DEA Model computed with data from autosport magazines and F1 official website

[21]

[21] See Annex below

Table 1.9 : VRS EFFICIENCY

Team	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scuderia Ferrari	1.000	0.359	0.480	0.902	0.670	0.566	0.305	0.704	0.474	0.631	0.870	0.754	0.328
Mclaren	0.855	0.275	1.000	0.943	0.699	0.449	0.400	0.198	0.471	0.376	0.545	0.719	0.719
BMW Sauber F1 Team	0.901	0.372	0.903	1.000	0.899	0.788	0.716	0.924	0.898	0.681	0.889	0.984	0.939
Renault F1 Team	0.543	0.353	0.587	0.276	1.000	1.000	0.407	0.789	0.569	0.459	0.661	0.750	0.662
Panasonic Toyota Racing	0.378	0.320	-	-	-	-	-	-	-	-	-	-	-
Scuderia Toro Rosso	1.000	0.750	0.428	0.851	0.641	0.900	0.608	0.771	0.869	0.658	0.800	1.000	1.000
Red Bull Racing	0.706	0.776	1.000	1.000	1.000	1.000	0.478	0.328	0.823	1.000	0.898	0.872	0.641
AT&T Williams	0.674	1.000	0.569	0.249	0.516	0.543	1.000	1.000	0.846	0.674	0.800	1.000	1.000
Mercedes F1 Team (Prev. Honda F1 Team)	0.196	1.000	0.396	0.455	0.534	0.791	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Force India F1 Team	0.381	1.000	0.615	0.467	0.847	0.886	1.000	1.000	1.000	1.000	1.000	0.993	1.000
Super Aguri F1 Team	1.000	-	-	-	-	-	-	-	-	-	-	-	-
Lotus Racing	-	-	0.638	0.287	0.639	0.808	0.862	-	-	-	-	-	-
Hispania Racing F1 Team	-	-	1.000	1.000	1.000	-	-	-	-	-	-	-	-
Virgin Racing	-	-	0.913	0.333	0.885	1.000	1.000	1.000	1.000	-	-	-	-
HAAS	-	-	-	-	-	-	-	-	0.860	1.000	0.923	1.000	0.764

Source : Results from DEA Model computed with data from autosport magazines and F1 official website

22

[22]See Annex below

Table 2.0 : SCALE EFFICIENCY

Team	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scuderia Ferrari	1.000	0.501	0.967	0.936	0.973	0.933	0.830	0.967	0.882	0.970	0.977	0.883	0.729
Mclaren	0.989	0.502	1.000	0.971	0.961	0.550	0.780	0.197	0.301	0.178	0.316	0.465	0.882
BMW Sauber F1 Team	0.978	0.312	0.318	0.437	0.610	0.316	0.000	0.251	0.008	0.029	0.244	0.214	0.051
Renault F1 Team	0.919	0.221	0.709	0.576	0.912	0.913	0.069	0.473	0.032	0.327	0.593	0.332	0.849
Panasonic Toyota Racing	0.873	0.469	-	-	-	-	-	-	-	-	-	-	-
Scuderia Toro Rosso	0.807	0.088	0.114	0.412	0.192	0.200	0.196	0.420	0.251	0.309	0.168	0.315	0.655
Red Bull Racing	0.756	0.889	0.894	1.000	1.000	1.000	0.952	0.808	0.915	1.000	0.919	0.821	0.945
AT&T Williams	0.688	0.296	0.436	0.060	0.444	0.033	0.925	0.917	0.538	0.444	0.035	0.004	0.000
Mercedes F1 Team (Prev. Honda F1 Team)	0.495	1.000	0.793	0.785	0.650	0.934	1.000	1.000	1.000	0.955	1.000	1.000	1.000
Force India F1 Team	0.021	0.109	0.433	0.559	0.560	0.398	0.736	0.697	0.667	0.788	0.565	0.273	0.876
Super Aguri F1 Team	0.000	-	-	-	-	-	-	-	-	-	-	-	-
Lotus Racing	-	-	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-
Hispania Racing F1 Team	-	-	0.000	0.000	0.000	-	-	-	-	-	-	-	-
Virgin Racing	-	-	0.000	0.000	0.000	0.000	0.014	0.000	0.004	-	-	-	-
HAAS	-	-	-	-	-	-	-	-	0.116	0.278	0.473	0.107	0.020

Source : Results from DEA Model computed with data from autosport magazines and F1 official website

[23]

[23] See Annex below

Window Analysis

To put all three teams in equal terms we compound the first two to put them in terms of the third year. (*Inflation rates in the United States*) If we rake a look at Table 3.8 (see Annex below) we will see that CRS efficiency improved over time, as did VRS. Scale efficiency decreased. So this form of analysis seems to show that over time teams have improved their efficiency yet they are still on average very inefficient. Looking at Table 3.7 (see Annex below) we can see that the most efficient Constructor for that time window was the Mercedes 2009 team or Brawn. VRS efficiency deemed the Mercedes 2009, Red Bull 2010 and Hispania 2010 teams as efficient. Mercedes and Red Bull make sense, Hispania doesn't seem appropriate given they didn´t score a single point, win or podium. Something we can point out is that there is some sort of interdependence between budgets, particularly in that three year window. For example the 2010 budget for lets say Scuderia Ferrari depends on the 2009 budget and will also impact the 2011 budget. This is because depending on how the team performed in 2009 they will gain or loose money for next year, may that be new or leaving sponsors, more or less prize money or other form of financing teams have. So the three year window allows teams to see in a shorter period of time how their performance affects future years and adjust goals accordingly. For example in 2008 Mercedes obtained a CRS efficiency score of 0.035 in 2009 they received a 1.000 and in 2010 they received 0.259, something clearly went wrong or affected the team in the 2009 - 2010 time period and something really good happened in the 2008 - 2009 time period. Constructors may use this to identify the problem, look into their finances, look into where they allocated resources and see which combination or practices worked and which didn´t so as to not repeat them in the future.

Overall comparison

As we mentioned before in order to evaluate which team or teams where the most efficient overall, taking into account each team for each year as a unique DMU, we have to compound their budgets to put them all on equal terms. (*Inflation rates in the United States*) We then run the model and get the results. The results are expressed on Table 2.0 which can be found in the annex. The table shows that the most technically efficient team compared to all others including itself in other years was the Mercedes 2009 team, which also proved to be the most efficient in both three year windows 08/09/10 and 09/10/11. they obtained 57% of all obtainable points, 44% of all wins and 41% of all Podiums. If we look at the VRS efficiency, three teams appear to have made it on the efficient frontier. The Mercedes 2009 team, the Mercedes 2016 Team and the Hispania 2011 Team. Again out of those three Hispania seems to be a technicality and not an actual efficient team given the fact they gained 0 points and achieved nothing during the season, disappearing from

Formula 1 two years later in 2013. These differ from the three window analysis where we selected the 2010 Red bull team as efficient but here it seems it cannot be considered as such.

Projected Budgets

The model also gives us suggestions on budget reductions, given the fact all inefficient Constructors overspend, DEA suggests a lower projected budget that would technically allow them to obtain the same points they got but spending less money. This suggested budget projection would prompt them all the way up so that the team may lie on the efficient frontier. The following are just some of the examples suggested by the model. For 2011 there is an average CRS budget reduction suggestion of U$D 85.641.935. The lowest and highest CRS budget reductions suggested were U$D 19.242.212,36 for Mclaren and U$D 164.341.948,33 for Renault.[24] Ferrari was recommended a budget reduction of U$D 84.394.657,27 resulting in a projected budget of U$D 159.278.599,87. Given the fact that VRS efficiency scores are higher than CRS, VRS projected budget reductions are lower because VRS sees the same Constructor as more efficient if its scale efficiency is taken into account. VRS projected budget for Ferrari that same year is U$D 178.078.313,05 resulting in a lower budget reduction of U$D 65.594.944,09. For 2020 Ferrari[25] had a budget of U$D 463 million, the second biggest budget that season yet they only scored 131 points placing them 6th in the championship. The model interprets this as a big inefficiency, giving it a 0.239 CRS efficiency score and suggesting a budget reduction of U$D 352.347.294,94.[26] These are the kind of examples we mentioned before in which spending huge amounts of money doesn't always translate into good performance. That same year Force India spent only U$D 188 million scoring 195 points receiving a CRS efficiency score of 0.876, VRS gives it a 1 efficiency score, meaning it lies on the efficient frontier, recommending no budget reduction.[27]

We cannot blindly suggest teams simply cut down their budgets by these amounts, further analysis must be carried out, we will attempt to make suggestions as to what Constructors may do to implement said budget reductions below. To do this we must understand the dimensionality and context of each expenditure to know where improvements can be made.

Table 1.5 shows an approximation of the costs of running a Formula 1 team as seen in Pablo Mourao's book *The Economics of Motorsports : the case of Formula 1*.

[24] See Table 1.7 in the annex
[25] See Table 3.3 in the annex
[26] See Table 1.7 in the annex
[27] See Tables 1.7 and 1.9 in the annex

Table 1.5 Distribution of Costs in Formula 1

Category		
Fixed Costs		
	Non Drivers or Managers Salaries	13.4%
	F1 Car	40.8%
Total Fixed Costs		**54.2%**
Quasi Fixed Costs		
	Driver´s Salaries	7.2%
	Manager´s Expenses	2.2%
Fixed Costs + Quasi Fixed Costs		**63.6%**
Variable Costs		
	R&D	16.5%
	Consultancy/Advisory Services	2.7%
	Fuel	1.3%
	Logistics & Hospitality	6.2%
	Training & Clinical Expenses	4.2%
	Additional testing in private circuits	2.2%
	Softwares	2.3%
	Entry Fees	1.0%
Total Variable Costs		**36.4%**
TOTAL COSTS		**100%**

Source : Own creation based on data from The Economics of Motorsports : The case of Formula 1

[28]

Given the fact fixed costs represent 54.2% of a team's expenditure then a budget reduction cannot be interpreted as such without taking into account feasibility. Meaning that even if expenditure on each of these items could be lowered, there is restraint and a negative impact on lowering said expenditure. The restraint is represented by those costs which cannot be lowered, for example entry fees or fuel. A car's engine is developed under regulations meaning it has to follow certain guidelines, so usually F1 engines consume similar amounts of fuel, the regulations actually force fuel consumption down and specify a quasi fixed fuel consumption rate, making the engine more efficient than a regular engine. Nonetheless an F1 engine can consume up to 110 kg of fuel per race, this amount is fixed and not very malleable, if we cut down costs on fuel then the car might not have enough fuel to make it to the end of the race resulting in a DNF (Did not finish), meaning zero points. (Duxbury, *How much fuel does a Formula 1 car use? F1, WEC & More compared* 2021) So fuel cost is sort of a cost you don't want to spare on when there are other available expenditures that could be lowered without compromising performance.

Costs that if lowered would have a negative impact on the team's performance would be for example, the car. Its not feasible to just blindly lower the expenditure on an F1 car if this is one of the key components of success. Instead the team could look into ways of obtaining the same performance with lower costs, lowering expenditure in the future. An example of

[28] (Mourão, 2017)

this could be developing their own parts. F1 teams develop their car´s design but not all of them actually build the parts needed, they might outsource this to manufacturers or other Constructors. Maybe they could invest in machines to build their own parts, this would imply an initial investment but could lead to lower costs in the future. They could build their own engine instead of buying from other manufacturer Constructors. These two ideas could also lead to a new source of income if other teams want their manufacturing services.
Testing is crucial for developing the car, less testing means knowing less about the car's performance, which translates to poor development throughout the season. To put it in other words, lets say the car has a bit of oversteer[29] in corners, if a team does not see this due to lack of testing then they will lose lap time because of it. (Lingeman, *What is oversteer/understeer? Autoweek explains* 2020) Losing lap time translates into worse results, all of this because not enough testing was carried out.

If we use this table to analyze the costs in an F1 Constructor such as Ferrari we would get the results displayed in Table 1.6 below.

Table 1.6 Distribution of Costs for 2011 Scuderia Ferrari

Category		
Fixed Costs		
	Non Drivers or Managers Salaries	36.995.109, 46
	F1 Car	112.641.825, 82
Total Fixed Costs		**$ 149.636.935,29**
Quasi Fixed Costs		
	Driver´s Salaries	19.877.969, 26
	Manager´s Expenses	6.073.823, 94
Fixed Costs + Quasi Fixed Costs		**$ 175.588.728,49**
Variable Costs		
	R&D	45.553.679, 56
	Consultancy/Advisory Services	7.454.238, 47
	Fuel	3.589.077, 78
	Logistics & Hospitality	17.117.140, 19
	Training & Clinical Expenses	11.595.482, 07
	Additional testing in private circuits	6.073.823, 94
	Softwares	6.349.906, 84
	Entry Fees	2.760.829, 06
Total Variable Costs		**$ 100.494.177,94**
TOTAL COSTS		**$ 276.082.906,44**

Source : Table 1.5 & Results from DEA Model

[30]

[29] Oversteer is when a car turns more than the driver intends to while he or she is applying a steady steering input. The visible results of oversteer can include the tail sliding out or a full spin. Oversteer occurs when the rear wheels lose traction before the fronts.
[30] Based on (Mourão, 2017) and Table 3.3 in the annex

Another cost that could be looked into can be Logistics & Hospitality. Ferrari spent around U$D 17 million. Maybe they should look into new solutions for traveling from destination to destination. Thinking in today terms they could look into E-trucks for moving around their cars and equipment. These would drastically reduce their fuel expenditure, which would be a benefit given the current context of diesel fuel shortage. These trucks must also come with tax benefits, better autonomy, a longer lifetime and even autonomous driving. (*Tesla* 2022) Which can save big amounts of money per season. So to perform a proper budget reduction there should be a brainstorming session and follow up analysis of what strategies should be implemented such as the one done above. We are of course limited to suggesting solutions a better analysis could include data or information regarding teams that have implemented certain solutions to improve efficiency and how did these impact efficiency.

Similar results can be seen in other non mentioned seasons therefore similar suggestions can be made to all teams.

Conclusions

FIA claims F1 has pioneered cutting edge technological developments and has always sought to push technological boundaries whilst preserving the environment and their capacity to thrill which has been at the heart of the sport since its earliest days. (*2022 FIA Formula One World Championship*) Even though this has been the case for technological efficiency we have decided to put Constructor's budget efficiency to the test. To do this we utilized a Data Envelopment Analysis model which measures Constructor's efficiency based on their input usage and output production. We also conducted both CRS and VRS analysis in order to compare results and come up with a more comprehensive analysis. Looking at our results we can see that most Constructors are considered inefficient, efficiency tends to decrease over the years but when the overall assessment of the teams was made efficiency seems to improve, meaning that when comparing teams in similar monetary terms an improvement tendency seems to be arising but its still too far from being considered efficient by both CRS and VRS models. Scale efficiency scores also tell us that teams operate below their productive capacity. 2010, a year in which big budgetary changes were put in place shows surprising efficiency results in average efficiency whilst 2014 the start of the Turbo-Hybrid Era a year in which big regulatory changes were made to the cars Constructors show a big fall in efficiency. This might suggest that managers might be more effective at dealing with money being regulated rather than the car itself which can lead to big discomfort and inefficiency if the team cannot produce a well performing car. Data shows that for the most part big spenders tend to obtain better results meaning they tend to be effective but as seen in our analysis they lack efficiency.

Due to the fact F1 is an industry with high fixed costs -almost 55% of their total expenditure- we see that usually top performing teams have spent the least $/point whilst the opposite happens to underperforming teams. Mid grid teams could have another factor affecting their performance which is their AVG position delta, given the fact that these teams usually spend similar amounts of money there must be a reason other than efficiency that can help us understand why some teams do better than others, if their drivers did not lose to many positions per race then this might be a reason they perform at another level ultimately making the difference in the championship.

Overspending seems te be the clear trend among inefficient constructors, we have made a few suggestions as to where can teams try and reduce costs or invest in long term projects so that lower expenditure may arise from that investment. This is because as we established before, just identifying that teams overspend is not solving the problem. This would be the equivalent of going to the doctor with an disease and the doctor only telling us that we are sick with the flew. We know the diagnosis but suggestions must be made, to cure the disease based on each patient. The same goes for Formula 1 Teams, we know overspending is the problem so we´ve suggested, for example, investing in newer transportation technologies, might help teams lower Logistics costs. Taking a look at all three types of analysis allows Constructors to have a better understanding and precise analysis so that their strategies and goals can be set accordingly. If a team is in the lower section of the grid and wants to be in the mid section in three years then this analysis might help them see if adjustments have to made, where can they be made and see which teams succeded or failed at achieving the same goal they have set for themselves.

On a final note we must say that a better analysis could be carried out if we had access to teams actual budgets and data on their strategies. In order to see if efficiency improving strategies were put in place and if these actually worked. Further analysis could be made by including these factors and studying the data in windows of three years, we believe that there is an interdependence between budgets that may affect suggestions made to the teams based on their short, mid and long term goals.

Annex

Table 1.7 Budget Projections (millions of dollars) and CRS Scores

Constructor	Actual Budget	CRS Efficiency Score	Projected Budget	Budget Reduction	%
2008 Season					
Scuderia Ferrari	414.9	1.000	414.9	-	-
Mclaren	433.3	0.846	366.5	66.7	15.5
BMW Sauber F1 Team	366.8	0.881	323.0	43.7	11.9
Renault F1 Team	393.8	0.499	196.3	197.4	50.1
Panasonic Toyota	445.6	0.330	147.0	298.5	67.0
Scuderia Toro Rosso	128.2	0.807	103.4	24.7	19.3
Red Bull Racing	164.7	0.534	88.0	76.6	46.6
AT&T Williams	160.6	0.464	74.4	86.1	53.6
Mercedes (Honda)	398.1	0.097	38.6	359.4	90.3
Force India F1 Team	121.8	0.008	0.9	120.8	99.2
Super Aguri F1 Team	45.6	0.000	0.0	45.6	100
2009 Season					
Mercedes (Brawn)	162.7	1.000	162.7	-	-
Red Bull Racing	200.0	0.690	138.0	61.9	31.0
Mclaren	483.8	0.138	66.8	417.0	86.2
Scuderia Ferrari	370.7	0.180	66.8	303.9	82.0
Panasonic Toyota	411.3	0.150	61.7	349.5	85.0
BMW Sauber F1 Team	334.8	0.116	38.8	295.9	88.4
AT&T Williams	123.7	0.296	36.6	87.0	70.4
Renault F1 Team	346.6	0.078	26.8	319.7	92.2
Force India F1 Team	120.2	0.109	13.0	107.1	89.1
Scuderia Toro Rosso	160.4	0.066	10.5	149.8	93.4
2010 Season					
Red Bull Racing	244.9	0.894	219.0	25.9	10.6
Mclaren	199.7	1.000	199.7	-	-
Scuderia Ferrari	375.1	0.464	174.1	200.9	53.6
Mercedes	299.3	0.314	94.1	205.2	68.6
Renault F1 Team	172.5	0.416	71.6	100.8	58.4
AT&T Williams	122.1	0.248	30.3	91.7	75.2
Force India F1 Team	112.3	0.266	29.9	82.3	73.4
BMW Sauber F1 Team	67.5	0.287	19.3	48.1	71.3
Scuderia Toro Rosso	117.9	0.049	5.7	112.1	95.1
Lotus Racing	72.2	0.000	-	72.2	100
Hispania Racing	46.1	0.000	-	46.1	100
Virgin Racing	50.5	0.000	-	50.5	100

(continued below)

Table 1.7 (Continued)

Constructor	Actual Budget	CRS Efficiency Score	Projected Budget	Budget Reduction	%
2011 Season					
Red Bull Racing	276.0	1.000	276.0	-	-
Mclaren	230.3	0.916	211.0	19.2	84.0
Scuderia Ferrari	243.6	0.654	159.2	84.3	34.6
Mercedes	196.3	0.357	70.0	126.3	64.3
Renault F1 Team	195.3	0.159	31.0	164.3	84.1
Force India F1 Team	112.3	0.261	29.3	83.0	73.9
BMW Sauber F1 Team	76.3	0.245	18.6	57.6	75.5
Scuderia Toro Rosso	88.3	0.197	17.4	70.9	80.3
AT&T Williams	139.8	0.015	2.1	137.7	98.5
Lotus Racing	138.1	0.000	0.0	138.1	100
Hispania Racing	44.4	0.000	0.0	44.4	100
Virgin Racing	101.4	0.000	0.0	101.4	100
2012 Season					
Red Bull Racing	231.4	1.000	231.4	-	-
Scuderia Ferrari	308.6	0.652	201.2	107.3	34.8
Mclaren	282.9	0.672	190.2	92.7	32.8
Renault F1 Team	167.1	0.912	152.4	14.7	8.8
Mercedes	205.7	0.347	71.4	134.3	65.3
BMW Sauber F1 Team	115.7	0.548	63.4	52.3	45.2
Force India F1 Team	115.7	0.474	54.8	60.8	52.6
AT&T Williams	167.1	0.229	38.2	128.9	77.1
Scuderia Toro Rosso	106.7	0.123	13.0	93.6	87.7
Lotus Racing	92.5	0.000	0.0	92.5	100
Hispania Racing	59.1	0.000	0.0	59.1	100
Virgin Racing	66.8	0.000	0.0	66.8	100
2013 Season					
Red Bull Racing	330.8	1.000	330.8	-	-
Mercedes	270.3	0.739	199.8	70.5	26.1
Scuderia Ferrari	372.2	0.528	196.4	175.7	47.2
Renault F1 Team	191.5	0.913	174.8	16.6	8.7
Mclaren	274.2	0.247	67.7	206.4	75.3
Force India F1 Team	120.9	0.353	42.7	78.1	64.7
BMW Sauber F1 Team	126.8	0.249	31.6	95.1	75.1
Scuderia Toro Rosso	101.5	0.180	18.3	83.2	82.0
AT&T Williams	150.0	0.018	2.77	147.3	98.2
Lotus Racing	98.6	0.000	0.0	98.6	100
Virgin Racing	79.7	0.000	0.0	79.7	100

(continued below)

Table 1.7 Budget Projections (millions of dollars) and CRS Scores

Constructor	Actual Budget	CRS Efficiency Score	Projected Budget	Budget Reduction	%
2014 Season					
Mercedes	397.6	1.000	397.6	-	-
Red Bull Racing	505.0	0.455	229.7	275.2	54.5
AT&T Williams	196.3	0.925	181.5	14.8	7.5
Scuderia Ferrari	485.1	0.253	122.5	362.6	74.7
Mclaren	329.0	0.312	102.6	226.3	68.8
Force India F1 Team	119.4	0.736	87.9	31.4	26.4
Scuderia Toro Rosso	142.7	0.119	17.0	125.6	88.1
Renault F1 Team	200.4	0.028	5.6	194.7	97.2
Virgin Racing	79.5	0.014	1.1	78.4	98.6
BMW Sauber F1 Team	111.0	0.000	0.0	111.0	100
Lotus Racing	92.2	0.000	0.0	92.2	100
2015 Season					
Mercedes	518.8	1.000	518.8	-	-
Scuderia Ferrari	463.9	0.681	315.8	148.1	31.9
AT&T Williams	206.9	0.917	189.6	17.2	8.3
Red Bull Racing	520.2	0.265	138.0	382.2	73.5
Force India F1 Team	143.9	0.697	100.3	43.5	30.3
Renault F1 Team	154.4	0.373	57.5	96.8	62.7
Scuderia Toro Rosso	152.5	0.324	49.4	103.1	67.6
BMW Sauber F1 Team	114.6	0.232	26.5	88.0	76.8
Mclaren	516.1	0.039	19.9	496.2	96.1
Virgin Racing	92.1	0.000	0.0	92.1	100
2016 Season					
Mercedes	351.1	1.000	351.1	-	-
Red Bull Racing	285.1	0.753	214.8	70.3	24.7
Scuderia Ferrari	437.2	0.418	182.6	254.5	58.2
Force India F1 Team	119.0	0.667	79.4	39.6	33.3
AT&T Williams	139.2	0.455	63.3	75.8	54.5
Mclaren	245.4	0.142	34.8	210.5	85.8
Scuderia Toro Rosso	132.5	0.218	28.9	103.5	78.2
Haas	132.5	0.100	13.3	119.1	90.0
Renault F1 Team	199.0	0.018	3.67	195.3	98.2
BMW Sauber F1 Team	125.7	0.007	0.91	124.8	99.3
Virgin Racing	112.9	0.004	0.45	112.4	99.6

(continued below)

Table 1.7 Budget Projections (millions of dollars) and CRS Scores

Constructor	Actual Budget	CRS Efficiency Score	Projected Budget	Budget Reduction	%
2017 Season					
Mercedes F1 Team	358.2	1.000	358.2	-	-
Scuderia Ferrari	436.7	0.641	279.9	156.8	35.9
Red Bull Racing	282.6	0.698	197.3	85.2	30.2
Force India F1 Team	121.5	0.825	100.2	21.2	17.5
AT&T Williams	141.9	0.313	44.5	97.4	68.7
Renault F1 Team	194.0	0.158	30.5	163.5	84.2
Scuderia Toro Rosso	133.9	0.212	28.4	105.5	78.8
Haas	129.9	0.194	25.2	104.7	80.6
Mclaren	230.4	0.070	16.0	214.3	93.0
BMW Sauber F1 Team	127.2	0.021	2.6	124.5	97.9
2018 Season					
Mercedes	400.0	1.000	400.0	-	-
Scuderia Ferrari	410.0	0.850	348.7	61.2	15.0
Red Bull Racing	310.0	0.825	255,8	54.1	17.5
Renault F1 Team	190.0	0.392	74.5	115.4	60.8
Force India F1 Team	120.0	0.565	67.7	52.2	43.5
Haas	130.0	0.437	56.7	73.2	56.3
Mclaren	220.0	0.172	37.8	182.1	82.8
BMW Sauber F1 Team	135.0	0.217	29.3	105.6	78.3
Scuderia Toro Rosso	150.0	0.134	20.1	129.8	86.6
AT&T Williams	150.0	0.028	4.2	145.7	97.2
2019 Season					
Mercedes	425.0	1.000	425.0	-	-
Scuderia Ferrari	435.0	0.666	289.8	145.1	33.4
Red Bull Racing	335.0	0.716	239.8	95.1	28.4
Mclaren	250.0	0.334	83.3	166.6	66.6
Renault F1 Team	210.0	0.249	52.3	157.6	75.1
Scuderia Toro Rosso	155.0	0.315	48.8	106.1	68.5
Force India F1 Team	155.0	0.271	41.9	113.0	72.9
BMW Sauber F1 Team	155.0	0.211	32.7	122.2	78.9
Haas	150.0	0.107	16.1	133.8	89.3
AT&T Williams	150.0	0.004	0.57	149.4	99.6

(continued below)

Table 1.7 Budget Projections (millions of dollars) and CRS Scores

Constructor	Actual Budget	CRS Efficiency Score	Projected Budget	Budget Reduction	%
2020 Season					
Mercedes	484.0	1.000	484.0	-	-
Red Bull Racing	445.0	0.606	269.4	175.5	39.4
Mclaren	269.0	0.634	170.6	98.3	36.6
Force India F1 Team	188.0	0.876	164.7	23.2	12.4
Renault F1 Team	272.0	0.562	152.8	119.1	43.8
Scuderia Ferrari	463.0	0.239	110.6	352.3	76.1
Scuderia Toro Rosso	138.0	0.655	90.3	47.6	34.5
BMW Sauber F1 Team	141.0	0.048	6.7	134.2	95.2
Haas	173.0	0.015	2.5	170.4	98.5
AT&T Williams	132.0	0.000	0.0	132.0	100

Source: Own creation based on data from various auto sport magazines and DEA Model results

[31]

[31] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section) and Inputs from official F1 website (F1, *Standings*)

Table 1.8 : CRS EFFICIENCY

Team	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scuderia Ferrari	1.000	0.180	0.464	0.654	0.652	0.528	0.253	0.681	0.418	0.641	0.850	0.666	0.239
Mclaren	0.846	0.138	1.000	0.916	0.672	0.247	0.312	0.039	0.142	0.070	0.172	0.334	0.634
BMW Sauber F1 Team	0.881	0.116	0.287	0.245	0.548	0.249	0.000	0.232	0.007	0.021	0.217	0.211	0.048
Renault F1 Team	0.499	0.078	0.416	0.159	0.912	0.913	0.028	0.373	0.018	0.158	0.392	0.249	0.562
Panasonic Toyota Racing	0.330	0.150	-	-	-	-	-	-	-	-	-	-	-
Scuderia Toro Rosso	0.807	0.066	0.049	0.197	0.123	0.180	0.119	0.324	0.218	0.212	0.134	0.315	0.655
Red Bull Racing	0.534	0.690	0.894	1.000	1.000	1.000	0.455	0.265	0.753	0.698	0.825	0.716	0.606
AT&T Williams	0.464	0.296	0.248	0.015	0.229	0.018	0.925	0.917	0.455	0.313	0.028	0.004	0.000
Mercedes F1 Team (Prev. Honda F1 Team)	0.097	1.000	0.314	0.357	0.347	0.739	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Force India F1 Team	0.008	0.109	0.266	0.261	0.474	0.353	0.736	0.697	0.667	0.825	0.565	0.271	0.876
Super Aguri F1 Team	0.000	-	-	-	-	-	-	-	-	-	-	-	-
Lotus Racing	-	-	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-
Hispania Racing F1 Team	-	-	0.000	0.000	0.000	-	-	-	-	-	-	-	-
Virgin Racing	-	-	0.000	0.000	0.000	0.000	0.014	0.000	0.004	-	-	-	-
HAAS	-	-	-	-	-	-	-	-	0.100	0.194	0.437	0.107	0.015

Source : Results from DEA Model computed with data from autosport magazines and F1 official website

[32]

[32] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section) and Inputs from official F1 website (F1, *Standings*)

Table 1.9 : VRS EFFICIENCY

Team	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scuderia Ferrari	1.000	0.359	0.480	0.902	0.670	0.566	0.305	0.704	0.474	0.631	0.870	0.754	0.328
Mclaren	0.855	0.275	1.000	0.943	0.699	0.449	0.400	0.198	0.471	0.376	0.545	0.719	0.719
BMW Sauber F1 Team	0.901	0.372	0.903	1.000	0.899	0.788	0.716	0.924	0.898	0.681	0.889	0.984	0.939
Renault F1 Team	0.543	0.353	0.587	0.276	1.000	1.000	0.407	0.789	0.569	0.459	0.661	0.750	0.662
Panasonic Toyota Racing	0.378	0.320	-	-	-	-	-	-	-	-	-	-	-
Scuderia Toro Rosso	1.000	0.750	0.428	0.851	0.641	0.900	0.608	0.771	0.869	0.658	0.800	1.000	1.000
Red Bull Racing	0.706	0.776	1.000	1.000	1.000	1.000	0.478	0.328	0.823	1.000	0.898	0.872	0.641
AT&T Williams	0.674	1.000	0.569	0.249	0.516	0.543	1.000	1.000	0.846	0.674	0.800	1.000	1.000
Mercedes F1 Team (Prev. Honda F1 Team)	0.196	1.000	0.396	0.455	0.534	0.791	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Force India F1 Team	0.381	1.000	0.615	0.467	0.847	0.886	1.000	1.000	1.000	1.000	1.000	0.993	1.000
Super Aguri F1 Team	1.000	-	-	-	-	-	-	-	-	-	-	-	-
Lotus Racing	-	-	0.638	0.287	0.639	0.808	0.862	-	-	-	-	-	-
Hispania Racing F1 Team	-	-	1.000	1.000	1.000	-	-	-	-	-	-	-	-
Virgin Racing	-	-	0.913	0.333	0.885	1.000	1.000	1.000	1.000	-	-	-	-
HAAS	-	-	-	-	-	-	-	-	0.860	1.000	0.923	1.000	0.764

Source : Results from DEA Model computed with data from autosport magazines and F1 official website

[33]

[33] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section) and Inputs from official F1 website (F1, *Standings*)

Table 2.0 : SCALE EFFICIENCY[34]

Team	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scuderia Ferrari	1.000	0.501	0.967	0.936	0.973	0.933	0.830	0.967	0.882	0.970	0.977	0.883	0.729
Mclaren	0.989	0.502	1.000	0.971	0.961	0.550	0.780	0.197	0.301	0.178	0.316	0.465	0.882
BMW Sauber F1 Team	0.978	0.312	0.318	0.437	0.610	0.316	0.000	0.251	0.008	0.029	0.244	0.214	0.051
Renault F1 Team	0.919	0.221	0.709	0.576	0.912	0.913	0.069	0.473	0.032	0.327	0.593	0.332	0.849
Panasonic Toyota Racing	0.873	0.469	-	-	-	-	-	-	-	-	-	-	-
Scuderia Toro Rosso	0.807	0.088	0.114	0.412	0.192	0.200	0.196	0.420	0.251	0.309	0.168	0.315	0.655
Red Bull Racing	0.756	0.889	0.894	1.000	1.000	1.000	0.952	0.808	0.915	1.000	0.919	0.821	0.945
AT&T Williams	0.688	0.296	0.436	0.060	0.444	0.033	0.925	0.917	0.538	0.444	0.035	0.004	0.000
Mercedes F1 Team (Prev. Honda F1 Team)	0.495	1.000	0.793	0.785	0.650	0.934	1.000	1.000	1.000	0.955	1.000	1.000	1.000
Force India F1 Team	0.021	0.109	0.433	0.559	0.560	0.398	0.736	0.697	0.667	0.788	0.565	0.273	0.876
Super Aguri F1 Team	0.000	-	-	-	-	-	-	-	-	-	-	-	-
Lotus Racing	-	-	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-
Hispania Racing F1 Team	-	-	0.000	0.000	0.000	-	-	-	-	-	-	-	-
Virgin Racing	-	-	0.000	0.000	0.000	0.000	0.014	0.000	0.004	-	-	-	-
HAAS	-	-	-	-	-	-	-	-	0.116	0.278	0.473	0.107	0.020

Source : Results from DEA Model computed with data from autosport magazines and F1 official website

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[34] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section) and Inputs from official F1 website (F1, *Standings*)

Table 2.1 : Mean Efficiencies

All Teams													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
AVG CRS Efficiency	0.497	0.282	0.328	0.362	0.413	0.384	0.349	0.453	0.344	0.437	0.462	0.387	0.464
AVG VRS Efficiency	0.694	0.621	0.711	0.647	0.778	0.794	0.707	0.771	0.801	0.784	0.839	0.907	0.805
AVG Scale Efficiency	0.684	0.439	0.472	0.478	0.525	0.480	0.500	0.573	0.429	0.528	0.529	0.441	0.601
AVG Overall CRS Eff.	0.180	0.282	0.270	0.275	0.312	0.268	0.242	0.245	0.300	0.312	0.313	0.286	0.237
AVG Overall VRS Eff.	0.381	0.412	0.627	0.598	0.600	0.519	0.482	0.444	0.527	0.524	0.523	0.481	0.424
AVG Overall Scale Eff.	0.546	0.602	0.464	0.410	0.515	0.484	0.474	0.532	0.477	0.521	0.540	0.539	0.527

Source : Results from DEA Model computed with data from autosport magazines and F1 official website

[35]

[35] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section) and Inputs from official F1 website (F1, *Standings*)

Table 2.2 : WILLIAMS

AT&T WILLIAMS													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$160,600,000.00	$123,750,000.00	$122,143,333.33	$139,898,941.18	$167,180,000.00	$150,077,000.00	$196,344,000.00	$206,904,000.00	$139,216,200.00	$141,992,000.00	$150,000,000.00	$150,000,000.00	$132,000,000.00
POS in Chmp.	8	7	6	9	8	9	3	3	5	5	10	10	10
Points	77	101	69	5	76	5	320	257	138	83	7	1	0
AVG POS Delta	2.611111111	-2.882352941	-5.631578947	-3.421052632	-4.7	1.421052632	-2.947368421	-3.263157895	-2.952380952	0.7	2.380952381	3.238095238	1.941176471
CRS Efficiency	0.464	0.296	0.248	0.015	0.229	0.018	0.925	0.917	0.455	0.299	0.028	0.004	0.000
VRS Efficiency	0.674	1.000	0.569	0.249	0.516	0.543	1.000	1.000	0.846	0.674	0.800	1.000	1.000
Scale Efficiency	0.688	0.296	0.436	0.060	0.444	0.033	0.925	0.917	0.538	0.444	0.035	0.004	0.000
Over. VRS Eff.	0.386	0.571	0.507	0.327	0.400	0.321	0.710	0.596	0.636	0.517	0.347	0.343	0.395

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[36]

[36] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 2.3 : Sauber

SAUBER													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$366,800,000.00	$334,850,000.00	$67,506,666.67	$42,800,000.00	$115,740,000.00	$126,817,666.67	$111,011,600.00	$114,607,500.00	$125,799,400.00	$127,257,400.00	$135,000,000.00	$155,000,000.00	$141,000,000.00
POS in Chmp.	3	6	8	7	6	7	10	8	10	10	8	8	8
Points	334	107	44	44	126	57	0	36	2	5	48	57	8
AVG POS Delta	1.666666667	-0.352941176	-4.105263158	0.210526316	-2.55	0.210526316	-4.157894737	1.947368421	4.380952381	1.9	1.047619048	0.380952381	4.823529412
CRS Efficiency	0.881	0.116	0.287	0.437	0.548	0.249	0.000	0.232	0.007	0.020	0.217	0.211	0.048
VRS Efficiency	0.901	0.372	0.903	1.000	0.899	0.788	0.716	0.924	0.898	0.681	0.889	0.984	0.939
Scale Efficiency	0.978	0.312	0.318	0.437	0.610	0.316	0.000	0.251	0.008	0.029	0.244	0.214	0.051
Over. VRS Eff.	0.348	0.216	0.820	0.737	0.698	0.496	0.428	0.513	0.389	0.396	0.477	0.444	0.387

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[37]

[37] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 2.4 : Force India

Force India													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$121,850,000.00	$120,250,000.00	$112,300,000.00	$112,363,602.45	$115,740,000.00	$120,914,000.00	$119,422,000.00	$143,967,000.00	$119,091,000.00	$121,559,266.67	$120,000,000.00	$155,000,000.00	$188,000,000.00
POS in Chmp.	10	9	7	6	7	6	6	5	4	4	5	7	4
Points	1	36	68	69	109	77	155	136	173	187	111	73	195
AVG POS Delta	1.5	0.941176471	-1.368421053	-0.157894737	0.2	-1.315789474	2.578947368	-2.052631579	-2.333333333	1.15	-1.666666667	4.761904762	-2.529411765
CRS Efficiency	0.008	0.109	0.266	0.261	0.474	0.353	0.736	0.697	0.667	0.788	0.565	0.271	0.876
VRS Efficiency	0.381	1.000	0.615	0.467	0.847	0.886	1.000	1.000	1.000	1.000	1.000	0.993	1.000
Scale Efficiency	0.021	0.109	0.433	0.559	0.560	0.398	0.736	0.697	0.667	0.788	0.565	0.273	0.876
Over. VRS Eff.	0.349	0.444	0.549	0.560	0.657	0.567	0.770	0.611	0.830	0.857	0.696	0.476	0.604

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

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[38] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 2.5 : HAAS

HAAS					
	2016	2017	2018	2019	2020
Budget	$132,507,800.00	$86,664,000.00	$130,000,000.00	$150,000,000.00	$173,000,000.00
POS in Chmp.	8	8	6	9	9
Points	29	47	93	28	3
AVG POS Delta	-1.857142857	1.45	-4.523809524	-5.761904762	0.882352941
CRS Efficiency	0.100	0.278	0.437	0.107	0.015
VRS Efficiency	0.860	1.000	0.923	1.000	0.764
Scale Efficiency	0.11627907	0.278	0.473456121	0.107	0.019633508
Over. VRS Eff.	0.428	0.483	0.600	0.399	0.307

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[39]

[39] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 2.6 : Hispania

Hispania			
	2010	2011	2012
Budget	$46,100,000.00	$33,832,114.29	$59,156,000.00
POS in Chmp.	11	11	11
Points	0	0	0
AVG POS Delta	5.368421053	3.315789474	3.1
CRS Efficiency	0.000	0.000	0.000
VRS Efficiency	1.000	1.000	1.000
Scale Efficiency	0.000	0.000	0.000
Over. VRS Eff.	0.948	1.000	0.775

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[40]

[40]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 2.7 : Lotus

Lotus					
	2010	2011	2012	2013	2014
Budget	$72,250,000.00	$118,073,714.29	$92,592,000.00	$98,675,150.00	$92,254,400.00
POS in Chmp.	10	10	10	10	11
Points	0	0	0	0	0
AVG POS Delta	-0.421052632	0.842105263	-3.75	-0.947368421	0.631578947
CRS Efficiency	0.000	0.000	0.000	0.000	0.000
VRS Efficiency	0.638	0.287	0.639	0.808	0.862
Scale Efficiency	0.000	0.000	0.000	0.000	0.000
Over. VRS Eff.	0.605	0.322	0.495	0.474	0.515

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[41]

[41]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 2.8 : Mclaren

McLaren													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$433,300,000.00	$483,850,000.00	$199,700,000.00	$230,339,450.05	$282,920,000.00	$274,200,000.00	$329,060,800.00	$516,150,000.00	$245,443,800.00	$230,433,266.67	$220,000,000.00	$250,000,000.00	$269,000,000.0
POS in Chmp.	2	3	2	2	3	5	5	9	6	9	7	4	3
Points	379	184	454	497	378	122	181	27	76	30	62	145	202
AVG POS Delta	-6	-2.058823529	-2	-4.157894737	-8.8	1.526315789	-1.789473684	1.526315789	-1	-2.3	2.19047619	-2.047619048	-0.76470588
CRS Efficiency	0.846	0.138	1.000	0.916	0.672	0.247	0.312	0.039	0.142	0.067	0.172	0.334	0.634
VRS Efficiency	0.855	0.275	1.000	0.943	0.699	0.449	0.400	0.198	0.471	0.376	0.545	0.719	0.719
Scale Efficiency	0.989473684	0.501818182	1	0.971367975	0.961373391	0.550111359	0.78	0.196969697	0.3014862	0.178191489	0.316	0.464534075	0.88178025
Over. VRS Eff.	0.321	0.192	0.827	0.822	0.532	0.297	0.302	0.109	0.287	0.251	0.312	0.384	0.430

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

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[42] Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 2.9 : Mercedes

Mercedes													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$398,100,000.00	$162,750,000.00	$299,346,666.67	$196,387,298.65	$205,760,000.00	$270,344,000.00	$397,688,000.00	$518,814,000.00	$351,118,000.00	$358,219,333.33	$400,000,000.00	$425,000,000.00	$484,000,000.
POS in Chmp.	9	1	4	4	5	2	1	1	1	1	1	1	1
Points	40	448	214	165	142	360	701	703	765	668	655	739	573
AVG POS Delta	0.777777778	0.235294118	-1.631578947	-3.421052632	-6.9	-6.157894737	-3.421052632	-3.157894737	-0.952380952	0.45	-1.476190476	-0.666666667	-3.35294117
CRS Efficiency	0.097	1.000	0.314	0.357	0.347	0.739	1.000	1.000	1.000	0.955	1.000	1.000	1.000
VRS Efficiency	0.196	1.000	0.396	0.455	0.534	0.791	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Scale Efficiency	0.495	1.000	0.793	0.785	0.650	0.934	1.000	1.000	1.000	0.955	1.000	1.000	1.000
Over. VRS Eff.	0.132	1.000	0.335	0.452	0.414	0.550	0.782	0.611	1.000	0.844	0.754	0.840	0.550

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[43]

[43]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.0 : Panasonic Toyota

Panasonic Toyota		
	2010	2011
Budget	$445,600,000.00	$411,350,000.00
POS in Chmp.	5	5
Points	152	170
AVG POS Delta	-2.666666667	1.882352941
CRS Efficiency	0.330	0.150
VRS Efficiency	0.378	0.320
Scale Efficiency	0.873	0.469
Over. VRS Eff.	0.182	0.216

Source : Results from DEA Model computed and data from autosport magazines and F1 official website [44]

[44]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.1 : Red Bull Racing

Red Bull Racing													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$164,700,000.00	$200,000,000.00	$244,966,666.67	$276,082,906.44	$231,480,000.00	$330,816,950.00	$505,058,000.00	$520,257,000.00	$285,140,800.00	$188,400,000.00	$310,000,000.00	$335,000,000.00	$445,000,000.0
POS in Chmp.	7	2	1	1	1	1	2	4	2	3	3	3	2
Points	91	380	498	650	460	596	405	187	468	368	419	417	319
AVG POS Delta	-2.166666667	-3.294117647	-8.210526316	-2.105263158	-2.75	-2.842105263	-0.105263158	-1.473684211	-1.142857143	-4.3	-1.523809524	0.476190476	-5.647058824
CRS Efficiency	0.534	0.690	0.894	1.000	1.000	1.000	0.455	0.265	0.753	1.000	0.825	0.716	0.606
VRS Efficiency	0.706	0.776	1.000	1.000	1.000	1.000	0.478	0.328	0.823	1.000	0.898	0.872	0.641
Scale Efficiency	0.756	0.889	0.894	1.000	1.000	1.000	0.952	0.808	0.915	1.000	0.919	0.821	0.945
Over. VRS Eff.	0.398	0.724	0.762	0.962	0.761	0.760	0.324	0.198	0.666	0.558	0.569	0.538	0.343

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[45]

[45]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.2 : Renault

Renault													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$393,800,000.00	$346,600,000.00	$172,536,666.67	$195,348,182.44	$167,180,000.00	$191,511,666.67	$200,433,600.00	$154,401,000.00	$199,038,400.00	$194,069,200.00	$190,000,000.00	$210,000,000.00	$272,000,000.0
POS in Chmp.	4	8	5	5	4	4	8	6	9	6	4	5	5
Points	203	74	163	73	303	315	10	78	8	57	122	91	181
AVG POS Delta	-2.166666667	-1.823529412	-3	-2.894736842	-3.9	-0.947368421	0.315789474	-4.789473684	2.19047619	-4.2	-1.095238095	-2.571428571	-0.941176471
CRS Efficiency	0.499	0.078	0.416	0.159	0.912	0.913	0.028	0.373	0.018	0.150	0.392	0.249	0.562
VRS Efficiency	0.543	0.353	0.587	0.276	1.000	1.000	0.407	0.789	0.569	0.459	0.661	0.750	0.662
Scale Efficiency	0.919	0.221	0.709	0.576	0.912	0.913	0.069	0.473	0.032	0.327	0.593	0.332	0.849
Over. VRS Eff.	0.239	0.183	0.503	0.328	0.777	0.710	0.251	0.460	0.254	0.339	0.457	0.378	0.401

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

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[46]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.3 : Scuderia Ferrari

Scuderia Ferrari													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$414,900,000.00	$370,750,000.00	$375,166,666.67	$188,808,971.43	$308,640,000.00	$372,211,000.00	$485,173,600.00	$463,980,000.00	$437,220,400.00	$436,751,333.33	$410,000,000.00	$435,000,000.00	$463,000,000.0
POS in Chmp.	1	4	3	3	2	3	4	2	3	2	2	2	6
Points	429	184	396	375	400	354	216	428	398	522	571	504	131
AVG POS Delta	-7.944444444	-0.176470588	-0.421052632	-3.315789474	1.9	0.210526316	-1.105263158	-0.210526316	-4.095238095	-4.4	-3.761904762	-3.952380952	-1.058823529
CRS Efficiency	1.000	0.180	0.464	0.844	0.652	0.528	0.253	0.681	0.418	0.612	0.850	0.666	0.239
VRS Efficiency	1.000	0.359	0.480	0.902	0.670	0.566	0.305	0.704	0.474	0.631	0.870	0.754	0.328
Scale Efficiency	1.000	0.501	0.967	0.936	0.973	0.933	0.830	0.967	0.882	0.970	0.977	0.883	0.729
Over. VRS Eff.	0.366	0.250	0.396	0.596	0.508	0.395	0.226	0.373	0.376	0.508	0.620	0.510	0.202

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[47]

[47]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.4 : Scuderia Toro Rosso

Scuderia Toro Rosso													
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Budget	$128,200,000.00	$160,400,000.00	$117,900,000.00	$49,562,500.00	$106,738,000.00	$101,595,400.00	$142,716,800.00	$152,569,500.00	$132,507,800.00	$133,927,333.33	$150,000,000.00	$155,000,000.00	$138,000,000.
POS in Chmp.	6	10	9	8	9	8	7	7	7	7	9	6	7
Points	107	29	13	41	26	33	30	67	63	53	33	85	107
AVG POS Delta	-1.777777778	-0.058823529	1.684210526	0.736842105	4.45	-5.526315789	-4.842105263	-2.157894737	-2.285714286	-0.7	0.952380952	2.333333333	0.941176471
CRS Efficiency	0.807	0.066	0.049	0.351	0.123	0.180	0.119	0.324	0.218	0.203	0.134	0.315	0.655
VRS Efficiency	1.000	0.750	0.428	0.851	0.641	0.900	0.608	0.771	0.869	0.658	0.800	1.000	1.000
Scale Efficiency	0.807	0.088	0.114	0.412	0.192	0.200	0.196	0.420	0.251	0.309	0.168	0.315	0.655
Over. VRS Eff.	0.543	0.322	0.400	0.627	0.497	0.552	0.393	0.444	0.503	0.482	0.399	0.500	0.622

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[48]

[48]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.5 : Super Aguri

Super Aguri	
	2008
Budget	$45,600,000.00
POS in Chmp.	11
Points	0
AVG POS Delta	5.75
CRS Efficiency	0.000
VRS Efficiency	1.000
Scale Efficiency	0.000
Over. VRS Eff.	0.927

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[49]

[49]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.6 : Virgin Racing

Virgin Racing							
	2010	2011	2012	2013	2014	2015	2016
Budget	$50,500,000.00	$101,468,483.93	$66,872,000.00	$79,751,850.00	$79,537,600.00	$92,130,000.00	$112,936,000.00
POS in Chmp.	12	12	12	11	9	10	11
Points	0	0	0	0	2	0	1
AVG POS Delta	1.052631579	3.789473684	3.35	4.210526316	2.157894737	3.157894737	2.571428571
CRS Efficiency	0.000	0.000	0.000	0.000	0.014	0.000	0.004
VRS Efficiency	0.913	0.333	0.885	1.000	1.000	1.000	1.000
Scale Efficiency	0.000	0.000	0.000	0.000	0.014	0.000	0.004
Over. VRS Eff.	0.866	0.438	0.685	0.587	0.604	0.524	0.430

Source : Results from DEA Model computed and data from autosport magazines and F1 official website

[50]

[50]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.7 Budget Projections (millions of dollars) and Efficiency Scores

	Input	Outputs			CRS Efficiency			VRS Efficiency		
Constructor	Budget	Points	Wins	Podiums	Score	Projected Budget	Budget Reduction	Score	Projected Budget	Budget Reduction
2008 - 2009 - 2010										
2008										
Red Bull 2008	170.4	91	-	1	0.193	32.9	137.4	0.409	69.6	100.7
Mclaren 2008	448.3	379	6	14	0.306	137.1	311.1	0.322	144.2	304.0
Ferrari 2008	429.2	429	8	19	0.362	155.2	273.9	0.366	157.2	272.0
Mercedes 2008	411.8	40	0	1	0.035	14.4	397.4	0.137	56.4	355.4
Renault 2008	407.4	203	2	4	0.180	73.4	333.9	0.242	98.6	308.7
Williams 2008	166.1	77	-	2	0.168	27.8	138.2	0.397	66.0	100.1
Force India 2008	126.0	1	-	-	0.003	0.36	125.7	0.368	46.3	79.7
Sauber 2008	379.5	334	1	10	0.319	120.8	258.6	0.349	132.6	246.8
Toro Rosso 2008	132.6	107	1	1	0.292	38.7	93.9	0.557	73.8	58.8
Toyota 2008	461.0	152	-	2	0.119	55.0	0.40	0.185	85.4	0.37
Super Aguri 2008	47.1	0	-	-	0.000	0.0	47.1	0.977	46.1	1.08
2009										
Red Bull 2009	199.2	380	6	16	0.690	137.5	61.7	0.725	144.5	54.7
Mclaren 2009	482.1	184	2	5	0.138	66.6	415.5	0.194	93.7	388.3
Ferrari 2009	369.4	184	1	6	0.180	66.6	302.8	0.254	93.7	275.6
Mercedes 2009	162.1	448	8	15	1.000	162.1	0.0	1.000	162.1	0.0
Renault 2009	345.3	74	-	1	0.078	26.7	318.5	0.189	65.2	280.0
Williams 2009	123.3	101	-	-	0.296	36.5	86.7	0.586	72.2	51.0
Force India 2009	119.8	36	-	1	0.109	13.0	106.7	0.463	55.4	64.3
Sauber 2009	333.6	107	-	2	0.116	38.7	294.9	0.221	73.8	259.8
Toro Rosso 2009	159.8	29	-	-	0.066	10.4	149.3	0.335	53.6	106.2
Toyota 2009	409.8	170	-	5	0.150	61.5	348.3	0.220	90.1	319.7

(continued below) [51]

[51]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.7 Budget Projections (millions of dollars) and Efficiency Scores

	Input	Outputs			CRS Efficiency			VRS Efficiency		
Constructor	Budget	Points	Wins	Podiums	Score	Projected Budget	Budget Reduction	Score	Projected Budget	Budget Reduction
2010										
Red Bull 2010	244.9	498	9	20	0.736	180.2	64.7	1.000	244.9	0.0
Mclaren 2010	199.7	454	5	16	0.823	164.3	35.3	0.862	172.1	27.5
Ferrari 2010	375.1	396	5	15	0.382	143.3	231.8	0.396	148.6	226.4
Mercedes 2010	299.3	214	0	3	0.259	77.4	221.8	0.339	101.5	197.8
Renault 2010	172.5	163	0	3	0.342	59.0	113.5	0.512	88.3	84.2
Williams 2010	122.1	69	0	0	0.204	24.9	97.1	0.524	63.9	58.1
Force India 2010	112.3	68	0	0	0.219	24.6	87.6	0.567	63.7	48.5
Sauber 2010	67.5	44	0	0	0.236	15.9	51.5	0.852	57.4	10.0
Toro Rosso 2010	117.9	13	0	0	0.040	4.70	113.1	0.420	49.4	68.4
Lotus Racing 2010	72.2	-	0	0	0.000	0.0	72.2	0.638	46.1	26.1
Hispania 2010	46.1	-	0	0	0.000	0.0	46.1	1.000	46.1	0.0
Virgin 2010	50.5	-	0	0	0.000	0.0	50.5	0.913	46.1	4.40

Source: Own creation based on data from various auto sport magazines and DEA Model results [52]

[52]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

Table 3.8 Mean Efficiency Scores for 3 year Windows

3 year Window	Mean CRS Efficiency	Mean VRS Efficiency	Mean Scale Efficiency
2008 - 2009 - 2010	0.244	0.501	0.518
2009 - 2010 - 2011	0.275	0.555	0.484
2010 - 2011 - 2012	0.330	0.663	0.465
2011 - 2012 - 2013	0.329	0.632	0.468
2012 - 2013 - 2014	0.365	0.693	0.503
2013 - 2014 - 2015	0.361	0.712	0.506
2014 - 2015 - 2016	0.302	0.651	0.462
2015 - 2016 - 2017	0.328	0.689	0.469
2016 - 2017 - 2018	0.353	0.782	0.455
2017 - 2018 - 2019	0.402	0.786	0.506
2018 - 2019 - 2020	0.378	0.767	0.499

Source: Own creation based on data from DEA Model Results [53]

[53]Results from DEA Model computed with budget data taken from Budget Reference N.1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-21-32-33-34-35-36-37-38 (see Budget References under References Section), Inputs and other data taken from official F1 website (F1, *Standings*)

References

2022 FIA Formula One World Championship. (2022, July 06). Retrieved July 18, 2022, from https://www.fia.com/events/fia-formula-one-world-championship/season-2022/2022-fia-formula-one-world-championship

Chachra, T. (2020, August 16). F1 engine suppliers 2020: Who Supplies Engines to Formula 1 teams? Retrieved July 18, 2022, from https://thesportsrush.com/f1-news-f1-engine-suppliers-2020-who-supplies-engines-to-formula-1-teams/

Duxbury, A. (2021, November 11). How much fuel does a Formula 1 car use? F1, WEC & More compared. Retrieved July 18, 2022, from https://www.autosport.com/f1/news/how-much-fuel-does-a-formula-1-car-use-f1-nascar-more-compared-4980266/4980266/#:~:text=Formula%201%20%2D%20110%20kilograms%20per,car%20with%20that%20much%20fuel

Fa̋re, R., Grosskopf, S., & Lovell, C. K. (1985). *The Measurement of efficiency of production*.

Formula one racing. (2022, July 16). Retrieved July 18, 2022, from https://en.wikipedia.org/wiki/Formula_One_racing#:~:text=The%20winner%20receives%2025%20points,in%20the%20top%2010%20positions

Gutiérrez, E., & Lozano, S. (2012). A DEA approach to performance-based budgeting of Formula One Constructors. *Journal of Sports Economics*, *15*(2), 180–200. https://doi.org/10.1177/1527002512447629

Gutiérrez, E., & Lozano, S. (2018). Benchmarking formula one auto racing circuits: A two stage DEA approach. *Operational Research*, *20*(4), 2059–2083. https://doi.org/10.1007/s12351-018-0416-z

Inflation rates in the United States. (n.d.). Retrieved July 18, 2022, from https://www.worlddata.info/america/usa/inflation-rates.php

Júnior, S., & João Carlos Correia Baptista Soares De Mello. (2007). Utilização de Modelo dea com Restrições Cone Rattio Não arquimedianas para Avaliação dos pilotos no Campeonato Mundial de Fórmula 1 do ano de 2006. Retrieved April 19, 2022, from https://www.revistasg.uff.br/sg/article/view/SGV2N3A2

Lingeman, J. (2020, September 04). What is oversteer/understeer? Autoweek explains. Retrieved July 18, 2022, from https://www.autoweek.com/news/technology/a1817111/what-oversteer-understeer-autoweek-explains/#:~:text=Generally%2C%20oversteer%20is%20when%20a,lose%20traction%20before%20the%20fronts

Mourão Paulo. (2017). *The economics of motorsports the case of Formula one*. Palgrave Macmillan UK.

Sexton, T. R., & Lewis, H. F. (2003). *Journal of Productivity Analysis*, *19*(2/3), 227–249. https://doi.org/10.1023/a:1022861618317

Tesla. (n.d.). Retrieved July 18, 2022, from https://www.tesla.com/semi

Yang, C.-H., Lin, H.-Y., & Chen, C.-P. (2014). Measuring the efficiency of NBA Teams: Additive Efficiency Decomposition in two-stage DEA. *Annals of Operations Research*, *217*(1), 565–589. https://doi.org/10.1007/s10479-014-1536-3

Output references

F1. (n.d.). *Standings*. Formula 1® - The Official F1® Website. Retrieved July 29, 2022, from https://www.formula1.com/en/results.html

Budget References

1. Autosport. (2017, December 29). *F1 team budgets and spending in 2017mclaren pic.twitter.com/ibxqht3zpD*. Twitter. Retrieved July 28, 2022, from https://twitter.com/autosport/status/946825855434743809
2. Autosport. (2017, December 29). *F1 team budgets and spending in 2017mercedes pic.twitter.com/hr2lQQfCWq*. Twitter. Retrieved July 28, 2022, from https://twitter.com/autosport/status/946814895156318210
3. Benson, A. (2012, October 27). *Martin Whitmarsh says a budget cap in formula 1 is unrealistic*. BBC Sport. Retrieved July 28, 2022, from https://www.bbc.com/sport/formula1/20110248.amp
4. Boxall-Legge, J. (2019, February 11). The last budget Formula 1 car. Retrieved July 28, 2022, from https://www.autosport.com/general/news/the-last-budget-formula-1-car-5111750/5111750/
5. Collantine, A. K. (2008, October 5). *Toyota has biggest F1 budget - $445.6M - 2008 formula teams budgets*. RaceFans. Retrieved July 28, 2022, from https://www.racefans.net/2008/09/22/toyota-has-biggest-f1-budget-4456m/
6. Dhruv, G. (2019, December 20). *Amid budget cap for 2021, how much is the current budget of teams in 2019?* EssentiallySports. Retrieved July 28, 2022, from https://www.essentiallysports.com/what-are-the-budgets-for-all-10-formula-one-teams-2019/
7. Editor. (2017, January 3). *What did formula 1 teams spend in 2016?* GRAND PRIX 247. Retrieved July 28, 2022, from https://www.grandprix247.com/2017/01/03/what-did-formula-1-teams-spend-in-2016/
8. Fair, A. (2019, November 6). *Formula 1: What are current team budgets with $175M cap impending?* Beyond the Flag. Retrieved July 28, 2022, from https://beyondtheflag.com/2019/11/06/formula-1-current-team-budgets-175m-cap-impending/
9. Forbes Magazine. (2012, November 20). *Formula One's Most Valuable Teams*. Forbes. Retrieved July 28, 2022, from https://www.forbes.com/pictures/emdm45kllj/1-ferrari/?sh=3b4db51b2acc
10. Forbes Magazine. (2014, November 12). *Formula One's Most Valuable Teams 2014*. Forbes. Retrieved July 28, 2022, from https://www.forbes.com/pictures/emdm45ekedf/1-ferrari-3/?sh=1a6672932546

11. Forbes Magazine. (2015, December 14). *Formula One's Most Valuable Teams 2015*. Forbes. Retrieved July 28, 2022, from https://www.forbes.com/pictures/emdm45emfmk/1-ferrari/?sh=2bea97e758a8
12. Gmm. (2012, October 24). *Red Bull spent EUR 245M for 2011 title*. Motorsport.com: F1 News, MotoGP, NASCAR, Rallying and more. Retrieved July 28, 2022, from https://www.motorsport.com/f1/news/red-bull-spent-eur-245m-for-2011-title/428148/
13. GPToday.net. (2022, July 23). *Budgets for the formula 1 teams for 2018*. GPToday.net. Retrieved July 28, 2022, from https://www.gptoday.net/en/news/f1/236949/budgets-for-the-formula-1-teams-for-2018
14. Hardy, E., Tobin, D., Sport, M., & Gupta, E. (2019, July 20). *Team budgets crash as the recession bites Fl*. Motor Sport Magazine. Retrieved July 28, 2022, from https://www.motorsportmagazine.com/archive/article/march-2010/13/team-budgets-crash-as-the-recession-bites-fl
15. Jacobs, C. (2018, December 28). *Top 3 formula 1 teams spent over $1.1 billion in 2018: Report*. The Drive. Retrieved July 28, 2022, from https://www.thedrive.com/accelerator/25691/top-3-formula-1-teams-spent-over-1-1-billion-in-2018-report
16. Kubiccia. (2011, April 30). *Formula 1 teams' budgets - racing comments archive*. The Autosport Forums. Retrieved July 28, 2022, from https://forums.autosport.com/topic/147057-formula-1-teams-budgets/#entry4994505
17. motorsport-total. (2017). *Fotostrecke: Die budgets der formel-1-teams 2017 - foto 2/21*. Motorsport. Retrieved July 28, 2022, from https://www.motorsport-total.com/formel-1/fotos-videos/fotostrecken/die-budgets-der-formel-1-teams-2017/welchen-etat-die-teams-haben-wie-viele-mitarbeiter-sie-beschaeftigen-und-was-sie-ein-wm-punkt-bisher-gekostet-hat/s1/c40/d0/p1/z0/2/1720
18. Reid, C., & Sylt, C. (2010, December 13). *2010 F1 Business Review: Red bull wins the money championship*. ESPN UK. Retrieved July 28, 2022, from http://en.espn.co.uk/f1/motorsport/story/36348.html
19. Rencken, D. (2016, December 29). *How much did formula 1 teams spend in 2016?* Autosport. Retrieved July 28, 2022, from https://www.autosport.com/f1/news/how-much-did-formula-1-teams-spend-in-2016-5109312/5109312/
20. Rencken, D. (2021, March 30). *2018 formula 1 team budgets revealed: Part One*. RaceFans. Retrieved July 28, 2022, from https://www.racefans.net/2018/12/19/how-much-f1-teams-spent-race-2018-part-one/
21. Rencken, D. (2021, March 30). *2018 formula 1 team budgets revealed: Part Two*. RaceFans. Retrieved July 28, 2022, from https://www.racefans.net/2018/12/26/the-cost-of-f1-revealed-how-much-teams-spent-in-2018-part-two/
22. Rencken, D. (2021, March 30). *The cost of F1 2019 part Two: What the top teams spent · Racefans*. RaceFans. Retrieved July 28, 2022, from https://www.racefans.net/2020/01/02/the-cost-of-f1-2019-part-two-what-the-top-teams-spent/
23. Rencken, D. (2021, March 30). *The cost of F1 2019: Team Budgets analysed - part One · Racefans*. RaceFans. Retrieved July 28, 2022, from https://www.racefans.net/2019/12/27/the-cost-of-f1-2019-team-budgets-analysed-part-one/

24. *Report reveals team budgets fell 10% in 2009*. Pitpass. (2010, February 14). Retrieved July 28, 2022, from https://www.pitpass.com/39944/Report-reveals-team-budgets-fell-10-in-2009
25. Sylt, C. (2018, April 8). *Revealed: The $2.6 billion budget that fuels F1's 10 teams*. Forbes. Retrieved July 28, 2022, from https://www.forbes.com/sites/csylt/2018/04/08/revealed-the-2-6-billion-budget-that-fuels-f1s-ten-teams/?sh=2953500d6595
26. TF1C. (2017, December 29). *F1 team budgets and spending in 2017 Ferrari PIC.TWITTER.COM/EAUEDA1EDL https://t.co/iztfggtixa*. Twitter. Retrieved July 28, 2022, from https://twitter.com/TF1C_Ferrari/status/946767282163691521
27. TF1C. (2017, December 29). *F1 Team Budgets and spending in 2017 Renault Pic.twitter.com/jqeeaup9hl https://t.co/fk5tpncf3s*. Twitter. Retrieved July 28, 2022, from https://twitter.com/TF1C_Lotus/status/946744628115521537
28. TF1C. (2017, December 29). *F1 Team Budgets and spending in 2017 Sauber pic.twitter.com/ZqXsJFyjLr https://t.co/netmj7bz9y*. Twitter. Retrieved July 28, 2022, from https://twitter.com/TF1C_Sauber/status/946785652367962113
29. TF1C. (2017, December 29). *F1 Team Budgets and spending in 2017 Toro rosso pic.twitter.com/asonmpx7jp https://t.co/dktiu4oumh*. Twitter. Retrieved July 28, 2022, from https://twitter.com/TF1C_ToroRosso/status/946812573017563136
30. TF1C. (2017, December 29). *F1 Team Budgets and spending in 2017 Williams pic.twitter.com/aclporyoxl https://t.co/9ldgl8yyhv*. Twitter. Retrieved July 28, 2022, from https://twitter.com/TF1C_Williams/status/946790186288951297
31. TF1S. (2017, December 29). *F1 Team Budgets and spending in 2017 Force india pic.twitter.com/wcfhd4syje https://t.co/3wdyrmjqkz*. Twitter. Retrieved July 28, 2022, from https://twitter.com/TF1C_ForceIndia/status/946768039097221122
32. treehunter8. (2018). *F1 budgets 2017*. Steemit. Retrieved July 28, 2022, from https://steemit.com/formula1/@treehunter8/f1-budgets-2017
33. Verlin, K. (2017, January 20). *What did formula 1 teams spend in 2016?* The News Wheel. Retrieved July 28, 2022, from https://thenewswheel.com/what-did-formula-1-teams-spend-in-2016/
34. Walthert, M. (2013, December 5). *Red Bull and Lotus got the most value for their money in the 2013 F1 season*. Bleacher Report. Retrieved July 28, 2022, from https://bleacherreport.com/articles/1875408-red-bull-and-lotus-got-the-most-value-for-their-money-in-the-2013-f1-season
35. Walthert, M. (2014, November 27). *Mercedes and Williams were the most efficient teams in the 2014 formula 1 season*. Bleacher Report. Retrieved July 28, 2022, from https://bleacherreport.com/articles/2281654-mercedes-and-williams-were-the-most-efficient-teams-in-the-2014-formula-1-season
36. wheels. (2019, March 11). *The cost of F1 SUCCESS: Big three racing giants are also biggest spenders*. Wheels. Retrieved July 28, 2022, from https://www.news24.com/Wheels/the-cost-of-f1-success-big-three-racing-giants-are-also-biggest-spenders-20190311
37. Withnail. (2013, March 17). *McLaren's finances [split] - page 8 - racing comments*. The Autosport Forums. Retrieved July 28, 2022, from https://forums.autosport.com/topic/182862-mclarens-finances-split/page-8
38. Yahoo! (n.d.). Flickr. Retrieved July 28, 2022, from https://www.flickr.com/photos/44928941@N02/8609030843/sizes/o/in/photostream/