<u>Leading the Pack</u>
The Effect of "FanBoost" on Formula E Race Performance

by

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Abstract

Formula E is a nascent racing league based around electric vehicles. Other racing formats have already allowed for the study of various factors which influence racing strategies such as engineering decisions or track and meteorological conditions. Formula E presents a new avenue for strategic research. "FanBoost," a feature unique to Formula E, allows fans to vote online for their favorite driver, with to top three vote recipients earning five seconds of boosted engine output. The utility of FanBoost has attracted much speculation and even controversy, but to date, little has been done to assess FanBoost empirically. The following research examines the use fixed effects OLS regressions and an instrumental variable, whether or not a driver or team is racing in their home country, to ascertain the effect of FanBoost on performance during a race, or "E-Prix." Though using this instrument initially showed promise, I find that it does not provide meaningful results. Despite this, I discover that when drivers earn a FanBoost, they tend to improve their average race result by just over one position compared to their performance without FanBoost. I conclude that FanBoost appears to work as intended and discuss this result's implications for future research.

Leading the Pack

Introduction

Formula E represents one of the most popular emerging sports of this decade. The sport's founders are seeking to fill a void in motorsport. While other racing formats such as Formula 1 view fuel efficiency and alternative energy production as a secondary, albeit important, consideration, Formula E places sustainability at the center of their competition. In Formula E's words:

> "We are not just a race! We are a technological and sustainable development test bed for some of the leading companies in and out of motor racing to address mobility and environmental issues." (Formula E, 2014)

In the winter of 2011, the idea for Formula E resulted from a dinner between three influential gentlemen; current Formula E CEO- Alejandro Agag, the President of the Federation Internationale de l'automobile (FIA)- Jean Todt, and Vice President of the European Commission- Antonio Tajani ("On the Subject of Power", 2016). Their discussion centered on Tajani's efforts to reduce European CO2 emissions and modernize its transportation infrastructure. The gentlemen concluded that an all-electric racing series presented an opportunity to exhibit current sustainable mobility technology and incentivize the development of future technologies for consumer vehicles. Formula E quickly attracted major sponsors, heavyweight team owners, elite drivers, and top celebrity backers for its inaugural 2014 season.

To succeed in their efforts to promote sustainability, Formula E must translate this momentum into fan engagement, awareness, and, finally, demand for sustainable transportation. Formula E answer to this challenge is an innovative new approach to fan involvement in racing, FanBoost. FanBoost is an online contest in which fans vote for their favorite driver. Once polls close, the top three vote earners receive a five-second boost of an additional 100 kJ for use at the driver's discretion, which is roughly enough energy to enable a driver to overtake one opponent. Formula E employs this tool to encourage teams and drivers to appeal to fans for their support through social media and other interactive outlets. It hopes fans will respond in turn with greater interest in the sport. Formula E seeks to translate this fan engagement into greater viewership, attendance, and eventually demand for sustainable transportation.

FanBoost has been controversial from the start. Formula E faces the challenge of balancing the significance of FanBoost's advantage. Racing purists fear that an outside influence may become more important than driver skill in determining race winners. Teams have already adapted their strategies based on FanBoost. If FanBoost is too significant, teams may make decisions which compromise the spirit or integrity of the competition. In an extreme example of this, some drivers have accused others of cheating the system using sophisticated cyber techniques to inflate their voting numbers artificially (Fischer, 2018).

On the other hand, Formula E touts FanBoost's ability to influence the race. While video footage shows drivers passing their competitors during the five seconds of boost, the question remains, does it matter to the final result of the race? Perhaps the driver would have eventually passed that competitor regardless of FanBoost. Maybe the driver temporarily passes his or her opponent during the FanBoost but loses the position again during the race. If FanBoost does not alter the outcome of the race, fans may come to see it as a gimmick.

In either case, whether FanBoost matters too much or not at all, Formula E stands to lose both revenues and more importantly their position as a powerful advocate for sustainability and technological innovation. Formula E CEO, Alejandro Agag understands the delicate balance Formula E must strike:

> "We do it in a way that it doesn't alter [the race] in a fundamental way—you don't win the race only because you have the FanBoost. If you're good enough, if you're running second, you may eventually win the race because you have the FanBoost (Schrader, 2017)."

Given the novelty of the sport, sufficient data for quantitative analysis of race performance are sparse. We are just now gaining enough data to consider a rigorous assessment of FanBoost. This paper seeks to contribute to the emerging dialogue regarding Formula E and to enable its decision makers, teams, and fans to understand the actual impact of FanBoost.

The following research attempts to answer: To what degree does the award of FanBoost improve driver performance during an "E-Prix?" I employ two techniques to explore this question. First, I conduct a series of fixed effects OLS regressions. Second, I employ an instrumental variable, whether or not a driver is racing in his or her home country, to determine if FanBoost impacts driver performance.

The data set remains relatively small compared to other auto racing formats that have existed in some cases for over one-hundred years. Thus large standard errors are likely to detract from the significance of my results. Despite this, I anticipate that a driver in his or her home country will enjoy a higher likelihood of winning a FanBoost award. Based on the statement by Formula E's CEO, I hypothesize that I will discover a net effect of roughly one position improvement for drivers with FanBoost. This means that if a driver would typically finish in second place, FanBoost will enable him or her to win the race- just like Agog predicts.

Literature Review

Formula E is a relatively new racing format. Therefore very little research exists that specifically addresses this sport. Given this fact, I have expanded my review to encompass the greater literature on Autosport. In my research, I considered the Google Scholar and University of Texas Library databases. In both databases, I used two elements for my queries. The first element consisted of either “Formula E,” to allow me to capture the limited data about this sport, or “Autosport,” which broadened my search results to all of the industry. In the second element, I included one of the following: “sponsorship,” “FanBoost,” “fan engagement,” “strategy,” and “innovation.” Though I found no direct research related to the current questions, these searches allowed me to explore previous research on subjects indirectly related to the effect of FanBoost. The vast majority of literature dealt with specific engineering and technical design questions. I opted to exclude these from my results since they are not particularly relevant to my current line of inquiry.

Sponsorship:

Authors such as Cornwell et al. (Cornwell, 2001), and O’roark et al. (O’roark, 2010) have examined the impact of driver and team performance on sponsors’ outcomes in the NASCAR stock car racing league. The consensus from the literature is that a driver or team winning has very little influence either on a sponsor’s share price or on fan consumption decisions. Instead, the evidence suggests that sponsors logically linked to the automotive industry and those who continue their sponsorship for extended periods do tend to see benefits in both their stock price and consumer loyalty.

Formula E has attracted significant sponsorship, especially from automotive and energy firms seeking to associate themselves with sustainability and "green technology." The implications of sponsorship research are significant because they imply a greater level of freedom for Formula E decision makers. First, previous evidence suggests that any performance improvement from FanBoost will have little impact on sponsor outcomes. This means that league decision-makers can adjust the advantage provide by FanBoost without significant concern for how changes in driver performance may negatively impact revenues associated with sponsorship. Second, research into cheating in NASCAR (Baucus, 2008) recommend leveraging sponsors in shaping team and driver adherence to rules. Ensuring sponsors that a potential drop in performance for their drivers or teams associated with stricter adherence to Formula E's rules regarding FanBoost will not significantly impact their bottom line improves the chances they will choose to cooperate with league officials.

Fan Engagement:

Dransfeld et al. (Dransfeld, 1999) explore earlier initiatives into improving fan engagement for a different racing league, Formula One. Their article explores the potential for interactive television, where viewers can select the specific camera angles and drivers they prefer to watch. Dransfeld identifies several issues associated with adopting this technology including television contract rights and sponsorship/vehicle constructor concerns. In addressing this latter concern, the author discusses concerns raised by Mercedes-Benz which support my use of racing in one's home country as an instrumental variable.

A German automaker, Mercedes-Benz had two English drivers at the time of this publication. On the other hand, the German drivers in Formula One at the time drove for competitor teams, McLaren and Ferrari- a British and Italian team respectively. Mercedes-Benz was concerned that interactive television would result in German racing fans tuning in to watch their countrymen rather than the team from Germany. Fans preferences for the drivers would present a twofold challenge as Mercedes-Benz would lose exposure to German fans no longer watching the traditional broadcast and their direct competitors, such as McLaren and Ferrari, would gain greater exposure as German viewers watched their fellow Germans. Their concerns suggest that fans are particularly drawn by national identity to support specific drivers, supporting my argument that a driver should stand to earn FanBoost at a higher rate in his or her home country.

The Baucus article mentioned in the sponsorship section also highlights the potential impact of cheating on fan engagement. Baucus first makes the argument that fan loyalty and league history may have influenced the rise of cheating in NASCAR culture. She goes on to recommend leveraging the fan base as a means to correct this culture. Baucus states that NASCAR, with a cheating permissive culture, exposes itself to the risk that fans may disengage with the sport in ways experienced by bicycle racing or baseball during their respective steroid scandals. By addressing cheating in the sport, she argues that NASCAR stands to broaden its appeal to fans who demand ethical competition. This expansion would have a cyclical benefit of then promoting teams who have a reputation for fair competition. If we take her argument as correct, Formula E may also find itself in a similar position about cheating allegations surrounding FanBoost.

Strategy:

Racing strategy has a long tradition and is nearly universal in all motorsport formats. Typically, this consists of deciding between various technical specifications or when to make a pit stop to load up on fuel and install new tires. The inclusion of FanBoost in Formula E demands teams' attention as they consider their on track strategies. An MIT thesis exploring machine learning opportunities for NASCAR strategy development by Christopher Choo presents a compelling view of emerging technology and application (Choo, 2015). If successful, my results stand to benefit the greater motorsport community similarly as I am among the first to empirically assess the impact of FanBoost on Formula E racing performance.

Design

In designing this assessment, I find it helpful to illustrate my base model up front and follow with a discussion of some of the constraints I face and my techniques for addressing them.

$$Final\ Position = \beta_0 + \beta_1 FanBoost + \beta_2 Driver\ Home + \beta_3 Driver + \beta_4 Team + \beta_5 Race + \beta_6 Starting\ Positon$$

In this model, my dependent variable, *Final Position*, is defined as the position the driver finishes in the race (i.e., first place, second place). *FanBoost* and *Driver Home* are dummy variables identifying drivers who earn a FanBoost and race in their home country respectively. *Driver, Team,* and *Race* are indicator variables which account for the individual, time-invariant characteristics of each driver, team, and race event. Finally, *Starting Position* is the position in which the driver qualifies. This controls for the fact that a driver towards the front of the pack is more likely to finish in a higher position than a driver in the rear.

Several considerations prevent me from concluding that a simple linear regression of FanBoost on racing results provides a causal linkage. Primarily, the reverse narrative provides a sensible alternative explanation. A more successful driver will likely become more popular with fans. These fans, in turn, may be more likely to vote for previously successful drivers in the FanBoost poles. Therefore, a more successful driver is both likely to perform better on the race track and earn the FanBoost, which may overestimate the effect of FanBoost.

I employ two techniques to resolve this issue. First, the model employs fixed effects for each driver, which controls for unobserved differences in each driver's performance that persist over time. Similarly, I control for each Team- the group of engineers, financiers, and other administrative/logistics personnel who support two drivers, and each race- which accounts for geographic and weather considerations, number of participants, and other event anomalies. As a result, my fixed effects regression's results compare a driver's performance with FanBoost to their performance without FanBoost rather than comparing all instances of drivers with FanBoost to all instance of drivers without it.

For my second technique, I employ an instrumental variable- whether or not the driver is racing in his or her home country- to examine the impact of FanBoost exogenously. I hypothesize that a driver racing in his or her home country is more likely to earn a FanBoost due to increased excitement, publicity, and other factors that influence engagement by fans in the host country regardless of the driver's actual on-track performance. As I have seen in the literature, a notion exists that racing fans' loyalty and support tend to follow their fellow countrymen. Thus an increase in engagement in a host country may result in an increased likelihood of a driver receiving a FanBoost when they race at home.

In order to serve as a useful instrumental variable, the variable *Driver Home* must be valid and strong. I will address the strength of the instrument in greater detail in my results section. For now, I argue that the instrument is valid for two reasons. First, beyond the impact of FanBoost, driver performance is generally independent of where Formula E hosts a given race. I verify this by running a fixed effects regression with both a FanBoost and Driver Home dummy variable below.

Second, previous research suggests that "home field advantage" manifests from the fans' influence on referees by way of proximity and crowd noise. (Dubner, 2017) Auto racing, compared to other professional sports, arguably presents the least opportunity for fans to influence the outcome of the event. Fans are behind large protective barriers, physically and psychologically separated from officials, drivers, and other members of the racing crews. Furthermore, any noise generated by fans cheering is unlikely to reach officials or drivers due to engine noise, protective equipment, radios, and other environmental noise generation. One could argue that being closer to home allows drivers to enjoy a better environment in which to prepare- sleeping in their own bed or a home-cooked meal. This is effect should be minimal since being in one's home country does not necessarily mean they are located close to these resources, especially since most drivers maintain a residence in the country their team is headquartered rather than their home country.

None of my techniques allow me to refute the effects psychological conditions such as patriotism or a desire to perform well in front of a home crowd on driver performance. However, my fixed effects regression of driver performance based on being in their home country and earning a FanBoost suggests that these conditions do not significantly impact driver performance.

An additional challenge I face is measuring the impact of FanBoost on driver performance. This design examines how the award of a FanBoost impacts the driver's final position when they cross the finish line. To correctly interpret this result, I include controls for the position in which the driver starts the race. In an average race, between 18 and 22 drivers are competing. Each driver runs a qualifying time-trial before the race and drivers start the race in order with the fastest qualifying driver in first place. A limitation of my design is that the driver in pole position has no opportunity to improve his or her position whereas the driver at the very back has the most opportunity to improve (an average of 17 to 21 if a driver starts in the back and finishes in first place). My inclusion of a driver's starting position controls for this to some degree, but I took further steps to explore this circumstance. Because I hypothesize FanBoost's impact on position improvement to be roughly one, I included a fixed effects regression against a dataset which does not include drivers who qualified in first or second place to start the race.

My dependent variable, *finishing position*, requires that a driver finish the race for inclusion in my data. Drivers fail to complete a race for a wide variety of reasons (most commonly crashes, technical failure, or disqualification for a rules violation). My analysis must consider the fact that my regressions drop these drivers. It may be the case that drivers who earn a FanBoost are more prone to risk. Perhaps drivers who drive aggressively are more popular and tend not to finish races at greater rates. Alternatively, in their attempts to use FanBoost, drivers may attempt more risky maneuvers and crash more often than they would otherwise. I explore this possibility with a Chi-squared test comparing the incidence of finishing the race between drivers with and without FanBoost.

A final challenge facing this design is the relatively small dataset. A total of 57 drivers have competed in 45 total races resulting in 879 data points (note that every driver has not competed in every race). I anticipate large standard errors will reduce the strength of this analysis. The only mitigation for this limitation is patience. As more data become available in the future, researchers can reassess these hypotheses with greater certainty.

Data

Due to the relatively small and well-structured nature of this data set, my assessment includes the entire population of Formula E racing data for this evaluation. Data required for this evaluation include the starting and finishing results for each driver/team in each Formula E race, FanBoost award results for each race, and home country information for the drivers. With a few exceptions, I found the majority of the necessary data from official race reports by the FIA (FIA Results Booklets). These data included starting and finishing positions for each driver, each driver's team, and each driver's home country. I collected FanBoost data from E-Racing.net's Formula E database (Grzelak, FIA Formula E Database. E-Racing.net).

From these raw data, I created further variables for the analysis. To enable fixed effects analysis and control variables, I created identification numbers for each driver, team, and race. Finally, I created dummy variables indicating whether a driver was competing in his or her home country and whether or not the driver finished the race.

Results

Table 1. Analysis of FanBoost and Driver Home Effect on Driver Performance

Dependent Variable	*Final Position*	*Final Position*	*Final Position*	*Final† Position*	*Final Position*
Regression Technique / Independent Variable	*Fixed Effects for Driver, with Team, Race, and Starting Position Covariates*	*F.E. for Driver, with Team, Race, and Starting Position Covariates*	*F.E. for Driver, with Team, Race, and Starting Position Covariates*	*F.E. for Driver, with Team, Race, and Starting Position Covariates*	*Instrumental Variable Analysis*
Driver Home	*-1.42** *(0.74)*		*-1.28* *(0.80)*	*-1.15* *(0.79)*	
FanBoost		*-1.24**** *(0.46)*	*-1.17*** *(0.47)*	*-1.42**** *(0.40)*	*-11.70* *(7.67)*

† Data excludes drivers who start in first or second position

* Denotes statistical significance at the 10% level

**Denotes statistical significance at the 15% level

*** Denotes statistical significance at the 1% level

Table 1 summarizes the regressions in this assessment. In each case, I examine the dependent variable, *Final Position*, and include controls for time-invariant covariates associated with individual drivers, teams, and races. Starting from the left-hand side of the table, I include two regressions to examine the effect of driving at home and earning a

FanBoost separately. In both cases, I find a statistically significant result, racing at home and earning a FanBoost both correlate with improved driver performance between one and two positions.

For my next fixed effects regression, I included the FanBoost and driver home variables together while controlling for driver, team, race, and starting position. The results of this regression are in the third column of Table 1. In this regression, the FanBoost coefficient remains roughly constant and statistically significant, but the driver home variable becomes insignificant. This result suggests that a driver with FanBoost will tend to improve his or her race outcome by one position compared to when they drive without FanBoost. While this matches my hypothesis, this design does not necessarily support a causal conclusion; I will revisit this fact in my conclusions. This result does support my claim that a driver racing in his or her home country is a valid instrument for analysis since it appears the advantage of driving in one's home country manifests through the FanBoost and is not a statistically significant predictor of driver performance otherwise.

Previously, I identified a weakness in my analysis in that top qualifying drivers do not have the opportunity to improve their positions. This effect would lower the estimated impact of my independent variables. To explore this effect, I ran the same fixed effects regression as in column three of Table 1, but this time, I dropped all drivers who qualified in the top two positions for a given race. I decided to drop first and second place because the estimated coefficients from my previous regressions indicate an effect size between 1 and 2. Therefore dropping the top two qualifiers from each race should account for lack of opportunity to improve. My regression coefficients are as expected. My home country variable remained statistically insignificant, and my FanBoost variable increased in both magnitude and statistical significance. The results are reported in column four of Table 1.

Finally, I conduct an instrumental variable regression to examine the impact of FanBoost on position improvement through the instrument of the driver racing at home. The first step in this regression is to assess the relationship between the independent variable, FanBoost, and the instrument, whether or not the driver is racing at home. I have included a visualization of this relationship in Figure 1 and the results of this first step in Table 2 below. The relationship is positive and significant, suggesting that drivers are roughly 12% more likely to earn FanBoost when driving in their home country.

Figure 1. Are Drivers More Likely to Earn FanBoost in Their Home Country?

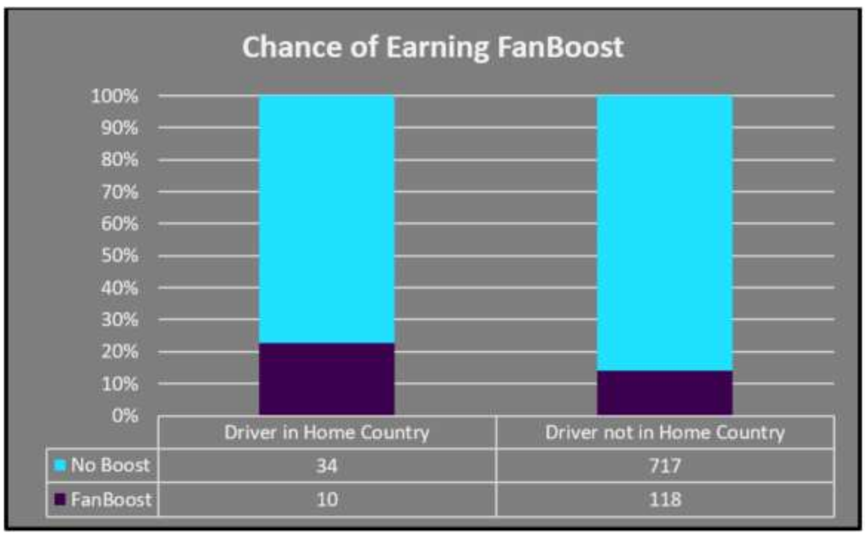

Table 2. The Effect of Racing in One's Home Country on the Likelihood of Earning a FanBoost.

	Likelihood of Earning FanBoost
X Variable	Fixed Effects for Driver with Team and Race Covariates
Driver Home	0.12** (.06)
Constant	0.10 (.11)

** Denotes statistical significance at the 5% level

The second step of the instrumental variable regression assesses the impact of FanBoost on Final Position. I have included the results of the second step in the far-right column Table 1. The P-Value of this regression is 0.158, which means I can only reject the null hypothesis at the 84% confidence interval, below generally accepted thresholds. I assess this is likely due to two factors. First, the small population size is driving up the standard errors in my analysis- based on the assessed impact of FanBoost (just over one position improvement), I would require a data set approximately ten times larger than my current one before I could potentially find a statistically significant result. Second, though the relationship between a driver racing at home and earning FanBoost is significant, the model only produces an R^2 value of 0.026 suggests that the driver home variable does not serve as a sufficiently strong instrument to produce a statistically significant result in the second step of the instrumental variable regression.

As previously addressed, my regressions exclude instances where drivers fail to finish a given race. As a result, my analysis may have issues of bias if it is the case that drivers who earn FanBoost are either more likely or less likely to finish the race. To examine this possibility, I conducted a Chi-Squared test comparing the likelihood of completing the race between drivers who received FanBoost and those who did not (included as Table 3). I also capture this result as a visualization in Figure 2.

Figure 2. Does FanBoost Encourage Riskier Driving?

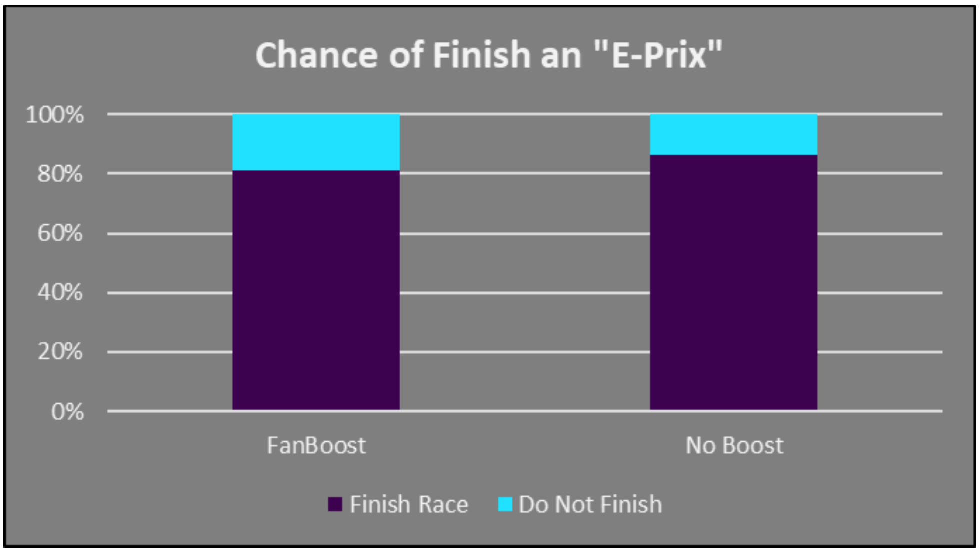

Table 3. Chi-Squared Test Results

Key
frequency *expected frequency*

finish	fan_boost 0	1	Total
0	103 108.5	24 18.5	127 127.0
1	648 642.5	104 109.5	752 752.0
Total	751 751.0	128 128.0	879 879.0

Pearson chi2(1) = 2.2429 Pr = 0.134

From this test, I see that though there is a tendency for drivers with FanBoost to fail to complete the race, my P-Value of 0.134 suggests that this relationship does not meet conventional standards of statistical significance. Therefore I conclude that I do not need to address any bias associated with drivers who fail to finish the race. My relatively small data set requires that we continue future research with caution. As more data become available, we must reexamine this possibility to verify that no statistically significant trend has emerged.

Conclusion

I have conducted an econometric analysis of the effect of Formula E's innovative FanBoost on driver performance in electric car racing. I discover that earning a FanBoost is correlated with an improvement in final race results by just over one position. This relationship is statistically significant at the 1% level. Exploring the impact of whether or not a driver is racing in his or her home country suggests that drivers at home are about 12% more likely to earn a FanBoost. When I examined the two independent variables separately, both driving in one's home country and earning a FanBoost appear to have a statistically significant impact on driver performance. When examined together, FanBoost remains robust, but driving at home no longer seems to influence race outcomes.

Attempts to assign a causal direction to this finding using instrumental variable analysis were unsuccessful. Though using driving at home as an instrument for FanBoost's impact on performance seems valid, my results are inconclusive, primarily due to my limited data population size and the relative strength of the instrument. Further exploring a causal relationship with this instrument will require many more years of competition. With more data, we may be able to use this instrument during a revisit of this question and get a different result.

Despite this, I am cautiously optimistic that we can still make an argument for causality — the fact that drivers tend to perform better when driving at home in Formula E suggests some advantage. Moreover, the direction of this relationship is clear. While a driver may perform better because he or she in his or her home country, the reverse argument does not make sense. A specific driver's performance cannot feasibly be among the factors considered by Formula E's leaders when selecting race locations. Doing so would not only be impractical but compromise Formula E's integrity as a sport, leaving it and its sponsors exposed to unnecessary financial and reputational risk.

My analysis demonstrates that drivers are more likely to earn FanBoost in their home country than otherwise. I also show that FanBoost explains the performance improvement associated with driving in one's home county. Therefore, I conclude that FanBoost causally improves driver performance by approximately one position. The magnitude of this result matches Formula E's goal to create a means for fans to meaningfully interact with races in a way that alters the outcome but does not dominate the competition.

Two follow-on questions require further exploration. Allegations of cheating suggest that teams are attempting to hack FanBoost for an advantage. If this proves true, fans may call the integrity of Formula E into question. A nascent sport like Formula E must continue its positive momentum to attract viewers, sponsors, and drivers if it is to accomplish its objectives of promoting sustainable technology. If viewers, sponsor, and drivers no longer trust the quality of the product on the track, the effect will be a flight from the sport, likely spelling its demise.

Most importantly of all, we must ask if any of this even matters. Formula E's creators sought to establish a racing format which displayed the value, performance, and future of sustainable energy technology. Further analysis should look into whether or not the old NASCAR adage of "win on Sunday, sell on Monday" applies to Formula E. Are firms investing in sustainable consumer technology as a result of these races? Are fans making purchasing decisions based on the demonstrated performance of these electric cars? In their pursuit to lead the pack, are Formula E's drivers forging ahead into the future or driving down a road to nowhere?

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