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Technology Innovations and Consumption of Formula 1 as a TV Sport Product

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Abstract

Drawing upon the technology acceptance model, the aim of this study was to describe the effects of technology innovations in Formula 1 (F1) on fans' satisfaction and commitment to consumption of F1 as a TV product, controlling for identification with F1 and specific teams and drivers. We surveyed F1 fans ($N = 449$) contacted via web-based forums. Results of a structural equation modeling showed that positive perceptions of technology innovation lead to satisfaction with F1 as a TV product, which in turn leads to commitment to consumption. Highly identified fans are committed to consuming the sport on TV, but they do not necessarily accept F1 new technologies. Technology changes that increase predictability and competitive unbalance are not well received and may lead to less consumption of F1 on TV. F1 managers need to make careful analysis before introducing new technology, which might decrease the TV audience for F1 races.

Keywords: commitment; satisfaction; sport spectatorship; TV product

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Introduction

Since the introduction of TV broadcasting in 1978, Formula 1 (F1) has enticed millions of TV viewers across the globe (Dewhirst & Hunter, 2002; Judde et al., 2013). However, from 2014 to 2017, F1 experienced a reduction in 100 million TV spectators (Mourão, 2017). From 2018 to 2019, F1 lost 8.6 million in Europe and 20 million around the world, partially due to exclusive transmission contracts signed between *Fédération Internationale de l'Automobile* (FIA) and cable television providers dropping broadcast transmission (Sylt, 2020). Despite being a sport that attracts highly committed fans to different racetracks around the world, F1 depends heavily on the revenues generated by a large TV audience, which justifies multimillion sponsorship contracts (Budzinski & Müller-Kock, 2016). TV rights are F1's biggest revenue stream. Globally, in 2021, F1 TV contracts were worth $587 million (Watson, 2021).

In F1, technology innovations have explained periods of clear dominance of specific teams and drivers (Jenkins, 2010). For example, from 2010 to 2013, Red Bull with Sebastian Vettel completely dominated F1, winning four constructors' and drivers' championships in a row. Most of that success was attributed to the Renault engine that blew exhaust gases even when the driver was off-throttle (Benson, 2015a). A similar situation happened with Mercedes and Lewis Hamilton, winning all championships from 2014 to 2020 (except in 2016). Much of their success has been associated with a unique turbo engine, which reduced the engine capacity from 2.4- to 1.6-liter and the number of cylinders from eight to six (Benson, 2014). Therefore, it seems that technological innovations have had some negative impacts on the competitive balance and unpredictability of the sport (Ballouli et al., 2016). With the exception of Ballouli et al. (2016), no comparable research has been conducted to investigate how technology changes may

affect F1 fans' attitudes and behaviors. While their research focuses on attendance at F1 races, we aim to analyze whether technological changes introduced in recent years affect the TV audience.

The aim of this study was to describe the effects of technology innovations in F1 on fans' satisfaction and commitment to consumption of F1 as a TV product, controlling for identification with F1 and specific teams and drivers. The fluctuation in TV viewership figures poses a significant risk to the sport, especially financially. Technology changes may have influenced the drop in TV viewership. In the short run, this has made the sport more predictable, with dominant teams. In the long run, technology may create some unpredictability, helping new teams to win races and championships. However, this has not been empirically investigated. Investigating how fans' perceptions of technology innovation have affected the attitudes of fans toward F1 viewership can provide fundamental information for managers, who need to understand the effect of future technology innovations and the effects such innovations have on viewership.

Theoretical Background

Previous research developed the technology acceptance model (TAM) based on the theory of reasoned action (Davis et al., 1989). The model outlines that attitudes towards technology being used affects the individual's behavioral intention to use the technology. Because F1 consumers are not end-users of technology, we apply a hedonic approach of TAM, where the acceptance of technology innovation used to create a product affects the attitudes and behaviors of consumers (Ibrahim, 2014; Kwak & McDaniel, 2011). Using this model to inform our research, we investigate whether positive attitudes on technology changes may lead to the satisfaction of F1 as a TV product. For instance, fans who appreciate and approve of the recent technological innovations may enjoy watching F1 races on TV. Positive attitudes toward technology innovation should indicate acceptance and may play an important role to mitigate negative aspects related to competitive unbalance generated by technology in the sport. Fans may appreciate technology outcomes (e.g. faster cars, modern designs, safety of pilots) and place less importance on the fact that one pilot or team dominates the competition during a certain period. Because of their appreciation for technology, they can express satisfaction with F1 as a TV product. Satisfaction can lead them to keep watching F1 on TV because they admire the technology present in the cars, engines, and tires. If this happens, they may develop some commitment to this form of consumption of the sport. On the other hand, those who do not appreciate technology innovations can become less satisfied with the experience of consuming F1 on TV. This may create a noncommitted pattern of consumption, which may lead eventually to not watching F1 on TV anymore. These are assumptions not tested yet. In the current study, we test these assumptions.

The Use of Technology in F1

A common issue related to change in technology in F1 is competitive balance. Mastromarco and Runkel (2009) demonstrate that regulation changes impact competitive balance, outlining that rule changes can make teams more competitive. However, the effectiveness of rule changes can be questioned by considering the level of competition since the introduction of 1.6 V6 Hybrid Turbo engines. The current dominant competitor, Mercedes GP, secured both constructors' and drivers' championships for four consecutive seasons, leading to less excitement for fans following the sport (Benson, 2019).

Introduced to F1 in 2009 and 2011, respectively, the kinetic energy recovery system (KERS) and the drag reduction systems (DRS) have provided further issues relating to the use of technology in the sport. KERS was a system that provided drivers with approximately 60kw of extra power through reusing stored energy generated by braking and proved extremely effective in races during standing starts, offering a power boost of six seconds. DRS is a system that has been in place since 2011 that offers a driver the ability to adjust the flap of their rear wing when within one-second of the car in front, significantly increasing the car's top speed. Young (2012) posits that some technologies are a step too far. For example, technologies that assist drivers' race crafts eliminate the dependence on the driver's ability. Despite the criticism against the technologies, the introduction of technologies such as KERS and DRS have allowed for more overtakes to take place during races. For example, Red Bull Racing driver Max Verstappen broke the 32-year-old record of most overtakes in a single season in 2016, performing an incredible 78 overtake moves (Barretto, 2016). Interestingly, the FIA announced in May 2018 that as of the 2019 season, rule changes would allow overtaking to increase, aiming to provide more excitement for spectators (Benson, 2018). Excitement has not always translated into competitive balance (Benson, 2014; Jenkins, 2010). However, regarding tires, Jenkins et al. (2016) argue that a sole tire supplier in F1 might provide less competitive advantage for one team to dominate the sport, ultimately creating more competitive balance and excitement for spectators throughout a season. As recent years have proved, the expected competitive balance has not returned to F1,

demonstrating the complexity of the issues associated with tire use in F1 and the importance of understanding its impact on the sport.

The problem of technology and the competitive balance becomes even more complex when one considers the safety of the drivers. Since the 2018 season, F1 cars have a protective head system called the halo, mounted above the driver's cockpit. The recent motorsport fatalities of Jules Bianchi (F1), Henry Surtees (Formula 2), and Justin Wilson and Dan Wheldon (both Indy Car), all caused by head injuries, pressured the FIA to introduce a system that protects F1 drivers' heads (Rosalie & Malone, 2018). It has been argued that safety technology around the cockpit area in F1 needs to be reliable and, importantly, not interfere with the driver in any way (Potkanowicz & Mendel, 2013). There have been concerns that the halo would obstruct the driver from exiting the vehicle as quickly as possible in the event of a severe accident (Boretti, 2013; Young, 2012). While the system has been used in F1 since the 2018 season, fans were not very welcoming as the design violates the nature of the open-cockpit sport. Furthermore, fans appear to be dissatisfied with the technology as it makes it difficult for them to identify the drivers by their helmets as a clear view of the driver's helmets is obstructed by the halo (Galloway, 2018).

Technology Acceptance Model

Davis et al. (1989) developed the technology acceptance model (TAM) to explain beliefs individuals can have towards technology. They ground their model on perceived usefulness and perceived ease of use of technology. Perceived usefulness refers to the utility of technology to improve a certain task within a certain organizational context, while perceived ease of use refers to the ease with which people can understand and use technology. From a utilitarian point of view, TAM was developed to understand the perceptions of technology innovations by the end-users, the ones that try the technology themselves. This utilitarian approach has suffered some criticisms (Ajibade, 2018; Szajna, 1996; Venkatesh & Bala, 2008). Most of those criticisms are related to problems related to actionable guidance to practitioners (Venkatesh & Bala, 2008). Ajibade (2018) has summarized the criticisms against TAM, saying that the model has shown some weaknesses in explaining users' behaviors. We are not applying the utilitarian approach of TAM because F1 consumers are not the end-users of technology. Rather, we have applied a hedonic approach of TAM, as proposed by recent studies (Ibrahim, 2014; Kwak & McDaniel, 2011). These studies propose that TAM should be understood from a hedonic point of view, where innovation in technology used to create a product affects the attitudes and behaviors of consumers. Therefore, we apply the hedonic approach of TAM, which informs that the perceived usefulness of technology in F1 and the ease of understanding its utility may affect fans' attitudes toward the TV product. Davis et al. (1989) summarize this in the idea under the term acceptance. Developed through the theory of reasoned action (Ajzen & Fishbein, 1977), TAM proposes that individuals' attitudes towards technology can lead to other attitudes toward a product (Ibrahim, 2014).

Most studies in the sport literature test the relationship between technology acceptance and attitudes related to the technological elements of the sport product from a utilitarian point of view. These studies have investigated, for instance, behavioral intentions toward mobile gaming services (Ha et al., 2007), attitudes of spectators who purchased online tickets for the 2010 Men's FIFA World Cup (Dhurup et al., 2011), acceptance of the information provided in sports websites (Hur et al., 2012), and online purchase intentions of licensed sport merchandise (Yoo & Ross, 2014). From a hedonic point of view, Ibrahim (2014) and Kwak and McDaniel (2011) investigated how acceptance of technological innovations affects the consumption of fantasy sport via websites. Results of these studies showed that the more fans accept the technology used to create the products, the more they consume the sport product. The current study follows this approach to investigate how fans' positive perception (i.e., acceptance) toward technology of technology to create the contemporary F1 final product (including mediated viewership) can affect attitudes toward this product. We focus on two attitudes, satisfaction and commitment to F1 as a TV product, because of the importance of these attitudes to the consumption of the final product (Oliver, 1999). This leads to our first two hypotheses:

H1: Fans' positive perception toward technology innovation directly increases commitment to F1 viewership

H2: Fans' positive perception toward technology innovation directly increases satisfaction with F1 on TV

Satisfaction and Commitment to a TV Product

Cronin Jr. and Taylor (1992) define consumer satisfaction as the experience that occurs as a reaction to the service received. This is aligned with Oliver's (1997) argument, which proposes that consumer satisfaction with a product depends on the confirmation or disconfirmation of expectations (Giese & Cote, 2000). This means that if individuals have their expectations of a specific product confirmed (or positively disconfirmed—they get more than they expect), they are much more likely to be delighted and become committed to the product (Trail et al., 2003). Oliver (1997) suggests that among TV spectators, satisfaction with a TV experience

occurs when their expectations of a TV program are met. However, if the experience is unsatisfactory, "their expectations of the subsequent episode may be adversely affected" (Dennis & Gray, 2013, p. 167).

Consumer satisfaction tends to lead to commitment (Oliver, 1999). Lin et al. (2016) propose that commitment refers to "an individual's long-term orientation towards a relationship, including feelings of psychological attachment and intent to persist" (p. 172). They show that commitment toward TV viewing is disrupted by changes to the satisfaction the program brings to viewers. Concerning the current study, it can be claimed that the satisfaction of viewers with F1 as a TV product may influence their commitment to following the sport through TV. This is based on Oliver's (1999) framework, which proposes that the attitude that follows consumer satisfaction is commitment, which precedes loyalty, a deeply held commitment to re-consume a product. Consequently, it can be argued that satisfaction with the TV viewing experience informs other attitudes of consumers, such as commitment.

Regarding commitment to a motorsport TV product, Berkowitz et al. (2011) argue that the consistent use of the same-technology rule in National Association for Stock Car Auto Racing (NASCAR) provides a much larger TV audience commitment. They associate this with the competitive balance created when all cars and drivers have access to the same technology. In F1, some technological advancements are present in all cars (e.g., halo), but others are not, as it depends on the economic power of the teams. Krauskopf et al. (2010) identify that, in the past, a close competition among drivers used to entice F1 fans to follow the sport on TV, creating a large base of committed fans. Schreyer and Torgler (2018) show that F1 has decreased in close competition among drivers (and levels of uncertainty of outcome), leading to a decrease in the commitment to TV viewership. The issue of outcome uncertainty affecting commitment to TV viewership is a recurring theme in various sports. For instance, Alavy et al. (2010) found that football fans are more likely to continue their viewership if the outcome remains uncertain up to the end of the match. Additionally, Tainsky and McEvoy (2012) found that the quality and excitement of matches (usually caused by the uncertainty of results) are positively associated with TV demand for the American National Football League (NFL) matches.

Commitment to sport as a TV product is related to viewers' identification (with sport, team, or athletes) and their experience during consumption (Devlin et al., 2017). A consumer who identifies with a sport and has a satisfying experience consuming it on TV is more likely to re-consume it in the future (Devlin et al., 2017; Hwang & Lim, 2015; Madrigal, 2000). Sport TV consumers usually signal an emotional commitment to a specific team or player, indicating that commitment to sport as a TV product should be affected by fan identification (Gantz et al., 2006). Taking all the information from the literature together, we designed an original partially-mediated model to test the relationship between a positive attitude toward technology innovation and the satisfaction and commitment to F1 as a TV product, controlling for fan identification.

In the context of F1, fan identification with different points of attachment (e.g., driver, team, sport) is likely to affect TV viewership and attitudes toward it. Rosenberger III and Donahay (2008) argue that F1 fans show different levels of identification. Ballouli et al. (2016) describe that identification with an F1 driver or team leads to the development of a relationship with the sport. They found that fan identification with different points of attachment and motives can explain large portions of the variance in attitudes toward F1 (e.g., intentions to attend a Grand Prix, intentions to buy merchandise and support of teams). The current study uses fan identification as a control variable. We control for fan identification to avoid finding spurious relationships between our variables of interest. We test how much of attitudes toward F1 as a TV product can be explained by fans' positive perception of technology while controlling for the level of fan identification. From the model, we propose two additional hypotheses:

H3: Satisfaction with F1 on TV directly increases commitment to F1 viewership, controlling for fan identification.

H4: Fans' positive perception toward technology innovation indirectly increases commitment to F1 viewership via satisfaction, controlling for fan identification.

Method

Procedures and Participants

The online questionnaire was created using Online Surveys' (former Bristol Surveys) website. The questionnaire has two sections. In the first section, we measured: (a) fans' positive perception toward *technology innovation* in F1, using three items adapted from Ballouli et al. (2016), (b) *satisfaction with F1 on TV*, using three items adapted from Brady et al. (2005), (c) *commitment to F1 viewership*, using three items adapted from Lin et al. (2016), and (d) *fan identification* with F1 (one item), team (one item), and specific driver (one item) identification, using items adapted from Wann and Branscombe (1993). We found support in the sport consumer behavior literature to use single items to measure fan identification (Kwon & Trail, 2003, 2005). We also got some support for using

Table 1. Scales, Items, Factor Loadings (λ), Average Variance Explained (AVE), Cronbach's α, Means (*M*), and Standard Deviations (*SD*)

Factors and Items	*λ*	AVE	*α*	*M*	*SD*
PERCEPTION OF TECHNOLOGY INNOVATION		0.851	0.764	4.75	1.42
Recent technologies have made the racing more exciting	0.908				
The technology changes introduced in F1 have made it more interesting	0.992				
I would welcome future innovative technology in F1	0.862				
SATISFACTION WITH F1 ON TV		0.565	0.942	4.44	1.68
I am satisfied with F1 as a TV product	0.793				
I am happy with F1 as a TV product	0.905				
I am delighted with F1 as a TV product	0.496				
COMMITMENT TO F1 VIEWERSHIP		0.790	0.915	5.85	1.51
I am committed to watching F1 on TV	0.838				
I would feel very upset if I had to stop watching F1 on TV	0.855				
I feel very attached to watching F1 on TV	0.968				
F1 ID					
I am a Formula 1 fan regardless of what teams are racing				5.81	1.53
TEAM ID					
My favorite F1 racing team being successful is important to me				5.24	1.51
DRIVER ID					
My favorite F1 driver being successful is important to me				5.27	1.58

single items for social identification outside sport (Postmes et al., 2013). We shuffled the items to avoid potential memory bias from rating a block of items. The stem for the first section reads, "Please, express your level of agreement with the following sentences." The items were answered on a 7-point Likert scale, ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Table 1 shows item wordings and scales. In the second section, we asked for demographic characteristics of respondents (i.e., sex, age, nationality, and highest education received).

We applied a chain-referral sampling technique to reach a large, purposive sample of F1 fans. The online questionnaire link was posted on three web-based F1 fan forums (the official FIA forum – F1 Fan Voice, Auto Sport Forum, and F1 Race Fans). The option for a purposive sample is justifiable based on the aim of the research, which targets a specific population. Our population of interest is F1 fans who have knowledge about current technology innovations in F1. Not all F1 fans have this type of knowledge. In general, F1 fan forums gather moderately to highly identified fans who like to discuss the sport, including technology changes. They tend to be better informed about technology because they share and discuss this in the forums. The link stayed available in the forums for three weeks. At the end of that time, 459 fans returned their answers. Three questionnaires were eliminated due to incomplete answers (no answers for the items of the constructs under investigation) and seven because of unreliable responses (i.e., all answers were identical). That led to a final sample of 449 usable responses. Most respondents were male (83.7%), British (48.8%) or American (10.9%), achieved a higher education degree (59.1%), and were aged between 18 and 77 (*M*=40.1; *SD*=17.3). The sample characteristics match recent reports of F1 fans. For example, F1 fans are still majorly males, aged between 16-69, and located in ten countries, which include the UK and the US (Kalinauckas, 2021; Nielsen, 2018).

Data Analysis

A covariance-based structural equation modeling (SEM) analysis was conducted, following the two step-approach (Anderson & Gerbing, 1988), using Mplus 7.11. In the first step, the measurement model was tested using the confirmatory factor analysis (CFA) technique. In the second step, the structural model, using SEM. In both steps, we used four fit indices: root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR). From the CFA, we tested the constructs' internal consistency (Cronbach's alpha – α), convergent validity (average variance extracted – AVE), and discriminant validity (each construct exceeded the squared correlations between that construct and any other) (Fornell & Larcker, 1981; Nunnally & Bernstein, 1994).

Competing Models

The original model is a partially mediated model, where the positive perception of technology innovation in F1 (antecedent) affects commitment to F1 viewership (criterion) directly and indirectly via satisfaction with F1 on TV (mediator). To deal with the problem of equivalent models (MacCallum et al., 1993), we compared the partially mediated model with two additional models: a fully mediated model (where the positive perception of technology innovation can affect commitment only indirectly, via satisfaction) and a direct-effects model (where both positive perceptions on technology innovation and satisfaction affect commitment directly, with no mediation). In all three SEM models, we control for identification with the sport, specific teams, or specific drivers as having direct impacts on the criterion—commitment to F1 viewership. In the mediated models, we estimate indirect effects using the product-of-coefficients strategy (Sobel, 1982) with the multivariate delta method (Preacher & Hayes, 2008), available in Mplus 7.11.

Results

Measurement Model

Results of the measurement model showed close fit (RMSEA [90% CI] = .060 [.042; .078]; CFI = .986; TLI = .980; SRMR = .037). Descriptive statistics (*M* and *SD*), factor loadings (λ), average variance extracted (AVE), and internal consistencies (Cronbach's α) are presented in Table 1. Means and standard deviations showed that, on average, respondents were moderately/highly identified fans of F1 (*M* = 5.81; *SD* = 1.53), specific teams (*M* = 5.24; *SD* = 1.51), and specific drivers in F1 (*M* = 5.27; *SD* = 1.58). They reported somewhat positive attitudes to technology changes (*M* = 4.75; *SD* = 1.41). They are also somewhat satisfied (*M* = 4.44; *SD* = 1.68) and committed to F1 viewership (*M* = 5.85; *SD* = 1.51). All items except for one were loaded above .707 on their assigned factors, indicating that the common variance of the items was larger than their unique variance. The AVE for all constructs was above .50, indicating good convergent construct validity. Additionally, the AVE of each construct was larger than the squared correlations of this construct with all other variables, supporting discriminant validity among constructs. Overall, the model showed very good psychometric properties. This allowed us to continue and test the structural models.

Structural Model

The three structural models fit the data very well and present similar fit indices. The fully mediation fit the data slightly better (RMSEA [90% CI] = .051 [.038; .064]; CFI = .980; TLI = .975; SRMR = .074) than the partially mediated model (RMSEA [90% CI] = .052 [.039; .065]; CFI = .980; TLI = .974; SRMR = .073) and the direct-effects model (RMSEA [90% CI] = .052 [.039; .065]; CFI = .980; TLI = .974; SRMR = .074). Additionally, the fully mediated model seems to better represent the relationship among the variables because the path from positive perception on technology innovation to commitment to F1 viewership was not significant in either the partially mediated model (γ = 0.010; *p* = .849) or the direct-effects model (γ = 0.010; *p* = .849) (Figure 1). This leads to the rejection of H1. Considering that no new information was gained by adding this path, we opted to keep the more parsimonious model. In the fully mediated model, positive perception on technology innovation affects satisfaction with F1 on TV (γ_1 = 0.372; *p* < .001), leading to the acceptance of H2. Satisfaction with F1 on TV affects commitment to F1 viewership (β_1 = .149; *p* < .001), leading to the acceptance of H3. Positive perception on technology innovation indirectly affects commitment to F1 (via satisfaction). This indirect effect was significant (IND = 0.055; *p* = 0.003), which leads to the acceptance of H4.

Discussion

The aim of this study was to describe the effects of technology innovations in Formula 1 (F1) on fans' satisfaction and commitment to consumption of F1 as a TV product, controlling for identification with F1 and specific teams and drivers. This is the first study in the literature that investigates the relationship between positive perception of technology innovation and fan attitudes toward F1 as a TV product. We apply the hedonic approach of TAM, where the positive perception of technological innovation used to create a product affects the attitudes and behaviors of consumers (Ibrahim, 2014).

An important theoretical contribution of the current study comes from new insights on how positive perception of technology innovation can significantly affect fans' satisfaction with F1 as a TV product. Some previous studies in sport marketing have shown that satisfaction with sport products on TV is influenced by a variety of factors, such as the quality of a match, the level of the competition, and the excitement of the audience (Lim et al., 2010; Rodríguez-Gutiérrez & Fernández-Blanco, 2017). Other studies found that TV consumer satisfaction is crucial for future consumption (Dennis & Gray, 2013). Specifically, in the case of F1, Schreyer and Torgler (2018) reported that satisfaction with TV viewership leads to increased consumption. In the current study, we expanded that knowledge by

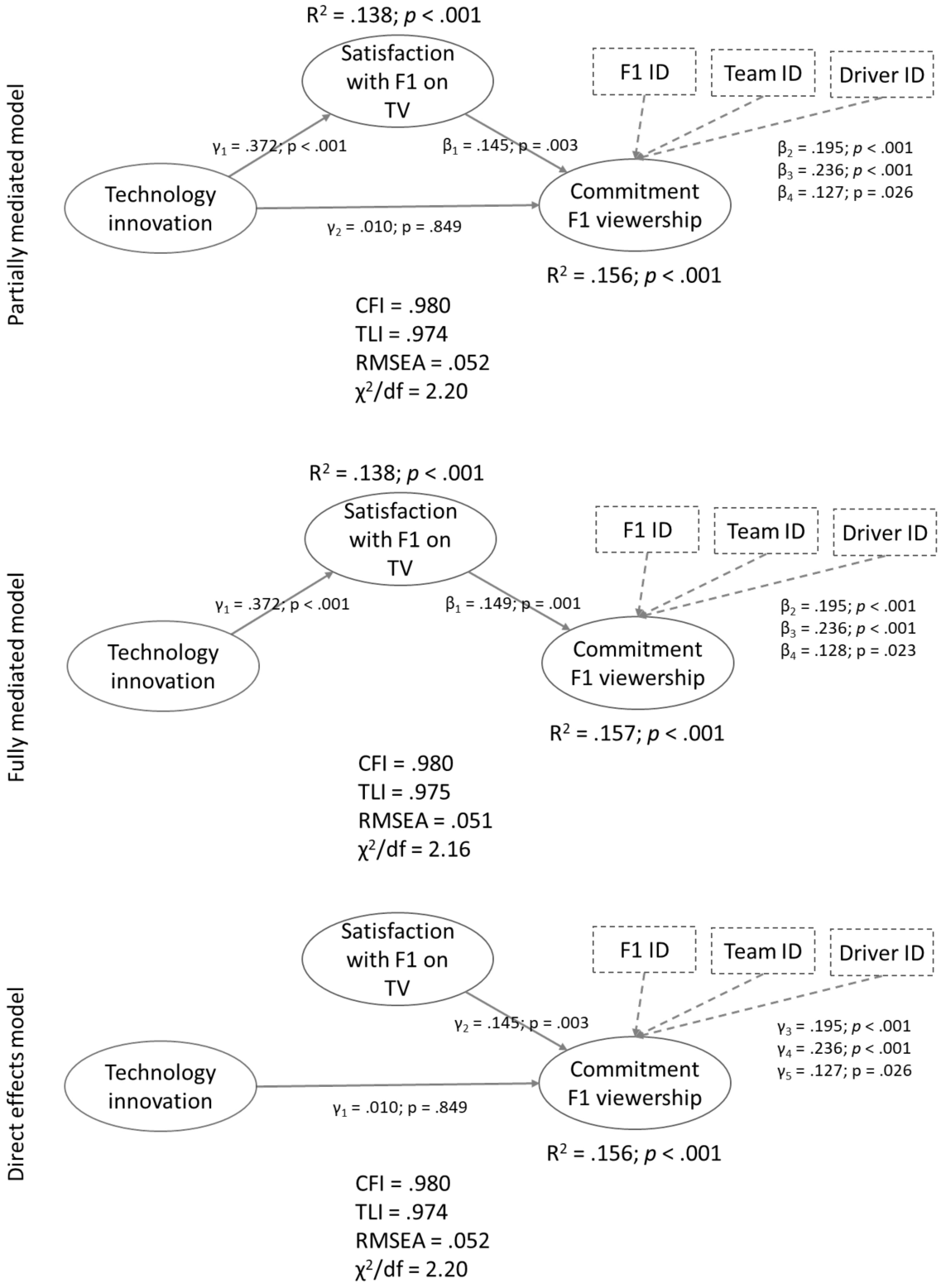

Figure 1. Three structural models to test the relationship between positive perception of technology, satisfaction with F1 on TV, and commitment to F1 viewership

showing that F1 fans are currently not highly satisfied with the TV product and that such satisfaction may depend on their positive attitudes toward technology innovation. Contrary to Mastromarco and Runkel (2009), current results indicate that rule changes in F1 do not guarantee more excitement for fans, as the most recent technology changes are not favored by F1 fans. The sport has been lacking excitement and close competition for a while. Currently, Mercedes dominates the championships, and only a few teams have managed to win a Grand Prix since 2014.

The model may offer some explanations for the reduction in F1 TV viewing figures (Mourão, 2017). Results show that satisfaction with F1 on TV directly affects TV viewership commitment. Oliver's (1999) framework proposes that commitment is the attitude that immediately follows consumer satisfaction. A positive relationship between satisfaction and commitment was found in general management (Mbango, 2018; Rather & Sharma, 2017) and in sport management (García-Fernández et al., 2018; Suh et al., 2019). Few studies, however, have investigated this relationship in the context of TV products. This is another important theoretical contribution of the current study. In the context of sport TV viewership, Suh et al. (2019) found that satisfaction can lead to loyalty to sports broadcasting. While the current research did not investigate loyalty, our findings partially support Suh et al.'s, based on Oliver's (1999) statement that commitment precedes loyalty (or a deeply held commitment to re-consume a product).

The results of the current study indicate that a positive perception of technology innovation in F1 does not significantly predict commitment towards F1 viewership directly. An explanation for this is that technology innovation does not have enough power by itself to promote commitment in the context of F1 on TV. We found some similarities between this finding and Ballouli et al.'s (2016) proposition that technology can be linked to spectator motives, but it is not enough to explain attachment to either racing or F1. Although commitment and attachment are different constructs, they are both attitudes that tend to precede loyalty to sport products (Mahony et al., 2000).

Indirectly, through satisfaction with F1 as a TV product, positive perception of technology innovation does affect commitment to F1 viewership. This indicates that F1 managers need to mind the effects of technological innovation. From the hedonic point of view of TAM (Davis et al., 1989), a positive perception of technology innovation (or technology acceptance) has informed the consumption of products through media outlets (Ibrahim, 2014; Jung et al., 2009). Ibrahim (2014) found that technology acceptance influences not only sport TV consumption but also other elements of sport products, such as revisiting sites and consumption of online sport fantasy. Our results indicated that a positive perception of technology innovation also informs commitment to TV viewership via satisfaction. Using the case of F1, we provide an important advancement for the use of the TAM model in sport studies because we have not investigated the acceptance of technology in general but rather the positive perception of technology innovation (or the acceptance of specific technology innovations) directly related to the sport itself.

In summary, the current study provides some theoretical contributions to the literature around technology acceptance in sports. Prior to the study, we did not know how fans' positive perception of technology innovation might affect commitment to F1 viewership. Although we knew that technology could be a motive for consumption (Ballouli et al., 2016), we did not know if a positive perception of technology innovation might affect other attitudes, such as commitment. Results showed that this relationship is not direct; rather, this is an indirect relationship that depends on satisfaction with the TV product. Based on the current study, we have also learned that the indirect effect of positive perception on technology innovation to commitment through satisfaction is significant even after controlling for fan identification. This is another important contribution to the field because of the major importance of fan identification to explain sport fans' attitudes and behaviors (Lock & Heere, 2017). That is, the relationship tested in our model can hold for fans with different levels of identification.

Practical Implications

We found that a positive perception of technology innovation is a key antecedent for satisfaction and, then, for commitment to F1 viewership. Knowing this, the FIA and F1's owners and managers should carefully analyze the impacts any technological innovation may have on consumers' satisfaction. Technology innovation that increases predictability and competitive unbalance has not been well received and may lead to less consumption of F1 on TV (Mastromarco & Runkel, 2009). Another concern of F1 managers should be increasing satisfaction with the product on TV because it can lead to commitment viewership. Satisfaction with F1 on TV has been linked to excitement and drama created by close racing (Schreyer & Torgler, 2018). Therefore, from a practical point of view, the sport managers should consider ways to increase excitement and drama, for example, by reducing the time of the races. On average, an F1 race lasts 90 minutes. In the current scenario, with unequal access to

technology, it is possible that after 30 minutes or less, a pilot is far ahead, dominating the race and decreasing drama and excitement.

In the impossibility of changing the current business model and reducing the gap among teams, F1 managers can think about shorter races, which can create better opportunities for pilots who are not in top teams because, in shorter races, they might risk more and push their car to the limit. The FIA has considered making changes to the format of grand prix weekends, but plans have not advanced so far. We would suggest, for instance, a new grand prix format with short sprint races introduced and starting grids formed in reverse order of championship standings to replace the traditional form of qualifying on Saturdays and racing on Sundays. This format is similar to that in use in lower racing categories such as Formula 2 (Saunders, 2019). This may increase the unpredictability of the results and give back the excitement and drama, which are missing in F1 races. We are aware that this may have an impact on attendance because people who pay to watch live events in person may prefer longer races. However, from a TV-product point of view, shorter races have the potential to increase the satisfaction of fans.

From a traditional approach, a practical suggestion would be for F1 managers to work in order to increase identification among fans because this has the potential to increase commitment to TV viewership. This is based on Mullin et al.'s (2014) escalator concept, which suggests that sport organizations should be more concerned about caring for moving existing fans up to the identification ladder rather than attracting new ones. However, recent studies have shown that sport managers should care not only about highly identified fans but also about other fans who may form an important mass of spectators (Rocha & Fleury, 2017). This highlights the importance of the current study because the relationship between positive perception of technology innovation, satisfaction, and commitments holds after controlling for fan identification. Therefore, from a non-traditional approach, F1 managers can think about attracting new fans to experience the sport on TV. If they enjoy it, they can develop some level of commitment to the TV product. Even if they do not develop high fan identification with either the sport or specific pilot or team.

Limitations and Future Studies

Previous research in F1 analyzed the impact of competitive balance on the sport, suggesting that competitive balance in F1 has a direct impact on TV demand among F1 fans (Budzinski & Müller-Kock, 2016; Schreyer & Torgler, 2018). Based on the literature, we assumed some relationship between competitive balance and satisfaction with F1 on TV, but we did not investigate it. Therefore, future research could add perceptions of competitive balance to the proposed model. For instance, competitive balance can be a mediator between a positive perception of technology innovation and satisfaction with F1 on TV.

Another limitation of the study is self-selection bias. As a result of the survey being posted on social media and online F1 community forums, it is not possible to guarantee that everyone received notification of the survey, leading to a systematic selection bias among respondents. Although we have reached our population of interest, future investigations may want to try to get access to a random sample of F1 TV viewers, budget permitting. We would have liked to compare the views between highly, moderately, and lowly identified F1 fans. However, descriptive statistics show that almost 70% of participants rated their identification with F1 as 6 or higher (on a 7-point scale), which indicates a homogeneous group of respondents regarding identification. It would be interesting to analyze a more heterogeneous group of fans who watch the sport on TV.

As F1 frequently introduces new technologies to the sport, further investigations surrounding the effects of the technology innovation need to be conducted. In the current study, technology innovation was measured in a generic way, and it would therefore be important to analyze specific technology changes. For example, F1 has recently introduced significant technological innovation with the aim of increasing excitement during races and likely to improve F1 TV viewership (Benson, 2018). Future studies can be conducted after each respective season, controlling for specific innovations. This should provide an interesting comparison to the current research and advance our knowledge on how technology innovations have affected the consumption of F1 on TV.

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