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Suspense-Optimal College Football Play-Offs

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Abstract

U.S. college football's traditional bowl system, and lack of a postseason play-off tournament, has been controversial for years. The conventional wisdom is that a play-off would be a more fair way to determine the national champion, and more fun for fans to watch. The colleges finally agreed to begin a play-off in the 2014-2015 season, but with just four teams, and speculation continues that more teams will be added soon. A subtle downside to adding play-off teams is that it reduces the significance of regular season games. We use the framework of Ely, Frankel, and Kamenica (in press) to directly estimate the utility fans would get from this significance, that is, utility from *suspense*, under a range of play-off scenarios. Our results consistently indicate that play-off expansion causes a loss in regular season suspense utility greater than the gain in the postseason, implying the traditional bowl system (two team play-off) is suspense-optimal. We analyze and discuss implications for TV viewership and other contexts.

Introduction

National Collegiate Athletic Association (NCAA) Division I football's traditional bowl system, in which the top teams each play one bowl game, with no play-off tournament, has been controversial for years.[1] Historically, the national championship title has been claimed by teams finishing the season ranked number one by various third-party organizations.[2] Since 1998, the champion has been the winner

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of the Bowl Championship Series (BCS) title bowl game. The top 2 teams from the regular season are selected for this game based on input from coaches, journalists, and statistical formulas. Sometimes the title game pits the only two teams that were undefeated in the regular season, and the winner emerges as the undisputed champion. But in many seasons, there are either more than two undefeated teams, just one, or even none. When this occurs, the BCS's choice of teams to play in the championship game can appear subjective and unsatisfying. As a result, many journalists, players, coaches, and fans have argued for the creation of a postseason play-off.[3]

In June 2012, the colleges finally agreed to start a play-off in the 2014-2015 season, but with just four teams. Lobbying for play-off expansion, and speculation that this will occur, has begun already.[4] All other major pro and college sports in the United States have play-offs with more than eight teams. The economic stakes for college football postseason play are substantial and suggest substantial gains from play-off expansion; per season television rights for the BCS without a play-off, which included the title game and just four other bowl games, from 2011 to 2014 were sold for US$155 million, and rights for the new play-off plus a small number of nonplay-off bowl games sold for US$470 million (Salaga & Tainsky, 2013).

A potentially major cost to fans from adding play-off teams, which is often ignored in these discussions, is that it would diminish the significance of regular season games. When only two teams play in a championship game, losing a single regular season game is highly likely to knock a team out of title contention; with four teams, one loss has less of an impact, and obviously with more play-off teams, the impacts of regular season losses become lower still. The importance of the regular season in college football can be seen by the relatively high TV ratings for those games. In 2011, a regular season game between two top teams received 20 million viewers, and the title game that year had 24 million viewers (Nielsen, 2012). In 2012, two regular season games each had 16 million viewers, and the title game had 26 million viewers (Nielsen, 2013). By contrast, title game viewership for other sports is more than double that of even the most watched regular season games.[5]

In this article, we empirically estimate the trade-offs that result from different play-off formats in NCAA football—what is added in the postseason and lost in the regular season—with respect to the significance and excitement from the impacts of games on the championship. We apply the framework of Ely et al. (in press; EFK), who develop a theory of suspense and surprise—a formal model of how anticipated, and actual, changes in beliefs affect utility. The basic idea is that when an event that can change beliefs substantially is about to occur, this creates enjoyable suspense. Adding play-off teams increases postseason suspense but decreases (championship) suspense in the regular season. The net effects are theoretically unclear and must be studied empirically.

We discuss the related literature in the second section. In the third section, we discuss the college football context, the EFK model and results, and their application to this context. In the fourth section, we explain our empirical method. Estimating beliefs, that is, distributions, for teams becoming champion throughout the season under different play-off formats seems to require data for play-off games that of course have not occurred historically. We make two key assumptions that allow us to estimate these distributions: (1) that final regular season Associated Press (AP) ranks can be used to proxy play-off seeds and (2) that historical bowl game results can proxy play-off game results.[6] We discuss these assumptions, and others underlying our empirics, in the fourth section as well.

In the fifth section, we present our main results. They robustly support a two-team play-off being the suspense-optimal format. In other words, the original BCS system, typically not thought of as a play-off, is the suspense-optimal play-off format. There is sufficient uncertainty about the championship at the start of the regular season, and resolution of uncertainty throughout the regular season, to dominate the gain in postseason suspense that results from adding play-off teams and games.

Before proceeding, we note our scope is restricted to suspense from learning about the championship (as opposed to suspense from rooting for particular teams). This may be self-evident, but we provide statistical evidence of the importance of this outcome to fans in the sixth section, showing that championship suspense is strongly associated with TV viewership.[7] To be clear though, the championship suspense-optimal postseason format is not necessarily the *optimal* format.[8] In the seventh section, we discuss issues regarding the interpretation of our results further.

Related Literature

First and foremost, this article relates to the literature on the uncertainty of outcome hypothesis (UOH), pioneered by Rottenberg (1956). The hypothesis is that, in addition to wanting one's favorite team to win, fans value game outcomes being more uncertain. This implies that team owners should prefer to maintain competitive balance, unlike in other markets in which each firm has the incentive to maximize its advantage over competitors. Subsequent literature has clarified the distinctions among outcomes for individual games, season-long outcomes (making the play-offs and winning the championship) and outcomes across seasons (Cairns, 1987; Fort, 2006).[9]

The idea that fans value uncertainty is very similar or perhaps equivalent to EFK's assumption that anticipated changes in beliefs generate suspense utility—in fact, Pawlowski (2013) used the very word "suspense" to ask fans about their preferences for outcome uncertainty. The EFK model can thus be interpreted as a formal extension of the UOH in which uncertainty is partially resolved, and utility is obtained, sequentially over time. Similarly, the application of EFK that we examine can be seen as an extension of the UOH, applied to the effects of the season-long outcome of the college football championship on fan utility throughout the season. EFK essentially point out that utility does not just come from uncertainty, but the way in which uncertainty is resolved—we prefer to get clues about the outcome over time and gradually learn, rather than to learn the outcome all at once. Thus, the question of how to maximize utility from uncertainty of the college football championship depends on how this uncertainty is resolved throughout the season.

See EFK for discussion of additional related theory work. One especially relevant article is Chan, Courty, and Hao (2009), as they also theoretically analyze suspense in sports. They use a different definition of suspense, based on complementarity between effort and the closeness of a contest. EFK's definition is more suitable for our context, both because the effort of college football teams is difficult to observe, and because, due to the small number of games, it seems reasonable to assume effort is exogenous.[10] The operations research literature on the effects of league format on the importance of different games (Goossens, Beliën, & Spieksma, 2012; Scarf & Shi, 2008) and communications literature on suspense (Comisky & Bryant, 1982) are also related.

Swofford, Mixon, and Green (2009) is the only published article we know of that studies why a two-team college football play-off may be optimal despite it being less likely to award the championship to the "best" team. They point out that since the championship has some properties of a public good, it may increase the welfare of fans to allow multiple teams to make claims to the championship. They do not discuss the topic of the article (impacts on fan utility from regular season games from changing the postseason format).

Background and Theory

College football teams play 11–14 games in the regular season. Each team plays at most one game per week, and almost all games are on Saturdays. The regular season starts in late August and ends by early December. After the regular season, most teams with winning records play in bowl games, (at most) one per team. The bowl system is different from a play-off system in that the winners of different bowls do not go on to play each other, and so all bowls but one are irrelevant to the national championship. Bowl games are played through the second half of December and early January. In our analysis, we consider single elimination play-off formats with 2, 4, 8, and 16 teams. This range of formats is close to the feasible range under consideration. The basic features of the season structure (one game per week, number of regular season games, and timing of postseason) would likely be the same or very similar for any postseason format.

One feature of the NCAA football context that is crucial for our empirical strategy is that the top 25 teams are ranked, once a week, throughout the season. There are now many different rankings, but the AP rankings, which date back to 1936, are the most historically prominent and significant. Rankings are especially important and of interest in college football because of the large number of teams (over 100 in Division I), small number of games, and, of course, historical lack of postseason play-offs. The AP ranks are roughly similar to most other rankings. Despite the AP ranks being less scientific than some others (e.g., the Sagarin rankings), the AP ranks are still likely preferable for our purposes because of their prominence and consistency with mainstream fan perception, which is what we are trying to analyze.

We now review EFK's general theory and results and then discuss implications for the college football context.[11] There is an unknown state ω from a finite state space, with probability in period t of μ_t^ω, and T time periods. The expectation of the posterior is the prior: $E_t[\tilde{\mu}_{t+1}^\omega] = \mu_t^\omega$. EFK define utility from suspense as: $\sum_{t=0:T-1} u\left(E_t \sum_\omega (\tilde{\mu}_{t+1}^\omega - \mu_t^\omega)^2\right)$. They define utility from surprise as $\sum_{t=1:T} u\left(\sum_\omega (\mu_t^\omega - \mu_{t-1}^\omega)^2\right)$. In their baseline case, they assume $u(x) = x^{0.5}$.

Suspense is realized ex ante and surprise ex post. Suspense is the enjoyable tension from knowing something significant is about to happen that could answer some important question; surprise is the utility obtained from learning something new. EFK show the distinction between these concepts. There can even be a trade-off, as the biggest surprises occur when there is little prior suspense. However, EFK acknowledge that the concepts are intuitively similar and their model reflects this; they write "[belief paths that] generate more suspense also tend to generate more surprise."

We henceforth focus our analysis on suspense for three primary reasons. First, as just noted, it is highly correlated with surprise. In fact, for a sports application that EFK examine, suspense and surprise are proportional. Second, since the large majority of the time during the season games are *not* being played and watched, and it is during this time that fans consume news about the sport, make ticket purchase and TV viewing decisions, and so on, it appears that suspense is more relevant to the fan experience than surprise.

Third, we also examine a variant of suspense utility that more directly captures surprise: $\sum_{t=0:T-1} E_t \sum_\omega |\tilde{\mu}_{t+1}^\omega - \mu_t^\omega|$. This version of suspense is exactly equal to expected surprise, when defined analogously (using absolute deviations rather than squares, and linear utility). Thus, if we find that results for the two versions of suspense are similar, this would provide additional evidence that results for surprise, as defined by EFK, would be similar too. We henceforth refer to this variant of suspense as "linear suspense," and EFK's suspense with their baseline assumption as "baseline suspense."

Consider a simple example to illustrate the most basic intuition. Suppose there is just one time period ($T= 1$), the true state is revealed after this period, and ω is binary, A or B To be concrete, suppose ω is the identity of national champion, teams A and B play in a title game and the winner is the champion. So, μ_0^A is the pre-game probability A is champion, $\tilde{\mu}_{t+1}^A$ equals 0 or 1, $Pr(\tilde{\mu}_{t+1}^A = 1) = \mu_0^A = 1 - \mu_0^B$, and the other $\tilde{\mu}_{t+1}^\omega$'s would be defined similarly. Then baseline suspense (utility) is

$$u\left(\mu_0^A(1-\mu_0^A)^2 + (1-\mu_0^A)(0-\mu_0^A)^2 + \mu_0^B(1-\mu_0^B)^2 + (1-\mu_0^B)(0-\mu_0^B)^2\right)$$
$$= (2\mu_0^A(1-\mu_0^A))^{0.5} = (2\sigma_\omega^2)^{0.5}.$$

Linear suspense is

$$\mu_0^A|1-\mu_0^A|+(1-\mu_0^A)|0-\mu_0^A|+\mu_0^B|1-\mu_0^B| \\ +(1-\mu_0^B)|0-\mu_0^B| = 4\mu_0^A(1-\mu_0^A) = 4\sigma_\omega^2.$$

Both baseline and linear suspense are monotone functions of the variance of ω.[12] Clearly both approach zero as μ_0^A approaches either zero or one, and are both maximized when $\mu_0^A = 0.5$. This captures the intuition that as game outcome uncertainty declines, suspense declines, and also shows how baseline and linear suspense are similar (and thus baseline suspense is highly correlated with expected baseline surprise).

EFK find several properties of suspense-optimal information revelation. We review these and briefly discuss their relevance to the college football play-off context. The first sentence in each numbered point, in italics, is drawn directly from EFK.

1. *The state is revealed in the last period, and not before.* This is true for all play-off formats under consideration.
2. *Uncertainty declines over time.* This is also likely true for all play-off formats.
3. *Realized suspense is deterministic.* This is likely not true for any of the play-off formats.
4. *Suspense is constant over time.* This indicates that a smaller play-off would be better. Although suspense is almost certainly not constant across time for any play-off structure, it is likely closer to constant when there are fewer play-off teams, since this makes early season games more suspenseful.
5. *The prior that maximizes suspense is the uniform belief.* This point supports a larger play-off format being preferable, since this would make prior beliefs more dispersed and closer to uniform.
6. *The level of suspense increases in the number of periods T.* This also supports a larger format being preferable, assuming the regular season's length is not reduced to accommodate additional play-off weeks.
7. *Suspense-optimal information policies are independent of the stage utility function.* This point does not favor any particular play-off structure, but does indicate that we do not need to examine different utility functions.

EFK also examine several applications. The most relevant is the number of games in a play-off series. National Basketball Association (NBA) play-off series are all best-of-seven (the team to first win four games advances); baseball play-offs include a one game wild card play-off, best-of-five and best-of-seven series; National Football League (NFL) play-offs are single elimination. EFK show the suspense-optimal series length is increasing as the teams are more evenly matched, and the optimal series length is one when the better team has an 80% or higher chance of winning each game.

EFK discuss the intuition for these results briefly; we elaborate somewhat on their discussion here. When a series is longer, there is a trade-off between suspense increasing due to there simply being more games (each involving some suspense), and decreasing due to each game losing significance. When one team is highly dominant, the underdog only has a chance of winning the series if it gets very lucky, which is most likely in a very short series. This is why a very short series is suspense-optimal when one team is dominant.

This basic trade-off is similar to that of college football: Increasing the number of play-off teams means more play-off games, which are relatively highly suspenseful, but also means less significance to regular season games, which are relatively plentiful. As Swofford et al. (2009) point out, the college football season can be thought of as one large tournament with two components, the regular season and postseason (play-offs). Increasing the number of play-off teams effectively puts less weight on the regular season component outcome. EFK's results indicate that this is more costly, with respect to total season-long suspense, when there is more uncertainty throughout the regular season.

Here is a more concrete example. Suppose the two teams ranked best before the season were expected to win each game against other teams with probability .99, while all other teams were of equal (lower) quality, and suppose also that the teams that won the most regular season games advanced to a single elimination play-off. Then, even if only the top 2 teams made the play-offs, the regular season would not involve much suspense, because it would be known ex ante that the top 2 teams would almost certainly be the ones to advance. Even if one of those teams happened to lose a regular season game, this would be insignificant as it would be very unlikely to prevent that team from still amassing more wins over the regular season than the most lucky of the other teams. On the other hand, each play-off game involving one of these top 2 teams would be more significant, because one loss in the play-offs would result in elimination. Thus, for this information structure, it seems increasing the number of postseason teams would increase season-long suspense, since postseason suspense would go up (due to more postseason games), while regular season suspense would not decline since it would be near zero regardless. Conversely, when the ex ante top teams are not much better, in expectation, than other teams, regular season games would be much more suspenseful when fewer teams advance to the postseason. In this case, the greater length of the regular season could imply that it is suspense-optimal to restrict the number of play-off teams.

Thus, it appears that a key factor determining whether it is suspense-optimal to have more play-off teams is the uncertainty of team qualities through the regular season. Another key factor, not captured in the play-off application EFK analyze, is the extent to which uncertainty is resolved throughout the regular season. The fourth point mentioned previously indicates that when uncertainty is resolved more steadily throughout the season, this would favor a play-off structure that puts more weight on the regular season, that is, would favor having fewer play-off teams.

Empirical Method and Data

We use empirical distributions to estimate the distributions necessary to compute suspense, exploiting the information value of weekly top 25 rankings as much as possible. In each time period, suspense is a function of three sets of distributions: the current (prior) probability of each team being champion, the distribution of changes that could occur to each team in the period, and the posterior probabilities of being champion. These priors could potentially be conditioned on large and complex information sets, and the changes could also be modeled in a complex way. Weekly top 25 rankings allow us to avoid much of this complexity. These rankings, while imperfect, whether created by people or formulas, incorporate information on team personnel, strength of schedule, performance, and other factors relevant to future outcomes.[13] Thus, it is a reasonable simplification to condition the distributions *just* on ranks (and the week itself), rather than a more complex set of other factors.

Consequently, for the empirical analysis, we define μ_t^{ω} as the probability that the team ranked ω in week t is the champion (for that season), and so $E_t \sum_{\omega}(\tilde{\mu}_{t+1}^{\omega} - \mu_t^{\omega})^2$ is a measure of the expected changes in the various teams' probabilities of being champion, summed across ranked teams.

Let r_t^i denote a team having rank i at the start of week t. Then

$$\begin{aligned} E_t \sum_{\omega}(\tilde{\mu}_{t+1}^{\omega} - \mu_t^{\omega})^2 = {} & Pr(r_{t+1}^1 | r_t^1)(\mu_{t+1}^1 - \mu_t^1)^2 + Pr(r_{t+1}^2 | r_t^1)(\mu_{t+1}^2 - \mu_t^1)^2 + \ldots \\ & + Pr(r_{t+1}^{24} | r_t^{25})(\mu_{t+1}^{24} - \mu_t^{25})^2 + Pr(r_{t+1}^{25} | r_t^{25})(\mu_{t+1}^{25} - \mu_t^{25})^2 \\ & + Pr(r_{t+1}^{26+} | r_t^{25})(\mu_{t+1}^{26+} - \mu_t^{25})^2. \end{aligned}$$

The empirical distributions of rank transitions can be used to estimate $Pr(r_{t+1}^i | r_t^j)$ for all i, j, and t.[14] Estimating the μ_t^{ω}'s is more challenging, especially for the counterfactual scenarios of four or more play-off teams. Our method for doing this is as follows. We first estimate $Pr(r_{T+1}^i | r_t^j)$, with T denoting the last regular season week, for all i, j, and t. That is, r_{T+1}^i is the rank at the end of the regular season, before the bowl games. We then estimate the probability of being champion conditional on having rank i in $T + 1$, μ_{T+1}^i, for each play-off format, using bowl game results to estimate play-off result distributions. We then calculate the estimate of μ_t^j as $\sum_{i=1:25} \mu_{T+1}^i Pr(r_{T+1}^i | r_t^j)$.

For a two-team play-off, estimating μ_{T+1}^i is simple: It is zero for $i > 2$, the empirical probability with which r_{T+1}^2 teams beat r_{T+1}^1 teams in bowl games for $i = 2$, and one minus this probability for $i = 1$. For other play-off formats, we must make some assumptions. For the first round of a four-team play-off, we use the empirical probabilities of No. 1 or No. 2 teams beating No. 3 or No. 4 teams (in bowl games) to estimate the probability of the higher seeded team winning in first round games.[15]

Table 1. Bowl Game Results for Matchups of Teams with Prebowl Rank No. 1–16 (1990-2011 seasons).

Rank Matchup	Pr (Higher Rank Wins)	*N*
No. 1 versus No. 2	0.571	14
No. 1–2 versus No. 3–4	0.700	10
No. 1–4 versus No. 5–8	0.571	14
No. 1–4 versus No. 9+	0.667	18
No. 5–8 versus No. 9–12	0.556	18

We do not use more specific matchups (No. 1 vs. No. 4, No. 2 vs. No. 3) because the sample sizes would be very small. We treat the second round of a four-team play-off as equivalent to a two team play-off. This means we assume that whoever wins the No. 1 versus No. 4 game in the first round has the same chance of winning in the second round. This assumption is helpful for limiting further computational complexity (avoiding reordering of seeds after upset wins) and seems reasonable since if a low seed wins an early round game this is at least evidence it was underrated and is better than higher seeded teams.[16]

We treat the early rounds of 8- and 16-team play-offs in a similar manner. For an eight-team format, we pool bowl results from games between No. 1–4 teams versus No. 5–8 teams, again to preserve sample size. For a 16-team play-off, we pool games between No. 5–8 teams versus No. 9–12 teams, and games between No. 1–4 teams versus all teams ranked No. 9 or higher. It would be ideal to only use games involving opponents ranked 13 or higher, but there are very few of these. We treat later rounds of 16- and 8-team play-offs as equivalent to rounds that start eight-, four-, and two-team play-offs.

The data needed are thus ranks for all weeks of a historical sample of seasons, and bowl game results. We collected data on the top 25 AP ranks for each week of each season, from 1990 to 2011, from http://www.collegepollarchive.com. We drop seasons prior to 1990, as they are less relevant to the distribution of game results and suspense in future seasons than more recent data. The choice of cutoff of 1990 is arbitrary; we also examine more recent cutoffs (which obviously come with the downside of reducing sample size). We have data on scores from bowl games from 1990 on from http://homepages.cae.wisc.edu/ dwilson/rfsc/history/howell/ and collegepollarchive.[17] The data used for estimated play-off game distributions are reported in Table 1. The number of observations for No. 1–2 versus No. 3–4 teams is low because since the start of the BCS the No. 1 has played the No. 2 team almost every year.[18] The distributions all appear reasonable; still, we run and report robustness checks with different distributions.

There are a few key assumptions underlying our method that we should discuss. One is that results from bowl games, and bowl games only, can be used to estimate play-off outcome distributions. We do not use games from earlier in the season because, first, teams do not prepare for them in the same way as postseason games, and second, and more importantly, these games are endogenous to the end of regular season ranking. That is, teams ranked highly at the end of the regular season are very likely to have won most regular season games to attain those high ranks. This does not mean they are just as likely to win postseason games. The assumption that the distribution of play-off game results, conditional on seed, can be proxied by the distribution of bowl results conditioned on rank, while imperfect, seems reasonable in that AP ranks are very similar to other ranks that would be used to seed play-off teams.[19] The major potential problem with this assumption is that in some systems (though not the four team format starting in 2014) play-off spots may be awarded automatically to teams based on their winning their conference, and not their rank. This is likely not too big an issue though as the large majority of teams that win automatic bids would also be ranked very highly, and once teams are admitted to the play-offs they would be seeded based on ranks very similar to the AP's. Perhaps the more significant concern is that the distribution of regular season matchups has changed over time, with more conferences holding conference championship games now in the final regular season week. This implies that top ranked teams may be more likely to face other top ranked teams in the final week now than in the past. We account for this issue with a robustness check using a subsample of very recent seasons, which should better capture the current distribution of regular season matchups.

Another assumption is that the distributions of regular season game results is independent of the postseason format. This means, for example, a team ranked No. 5 puts the same effort into its final regular season game whether two or four teams make the postseason. As mentioned in the introduction, effort in our model is exogenous. We think this assumption is reasonable, at least for the top ranked teams we study, because those teams have strong incentives to perform well even if their chances of contending for the championship are low, because their own fans still care about their performance, and coach and player career concerns are still strong. This point is not inconsistent with our focus on the championship; although fans may be interested in whether their favorite team finishes in the top 5 or top 10, they likely are not interested in which other teams achieve these ranks.

We define the unit of time as a week, but it could also plausibly be defined as a game. Most games that occur in the same week are played on the same day, with many played at the same time and the large majority played in the afternoon, so our definition is a reasonable simplification. Moreover, operationally it would be extremely difficult to account for the effects of each game's results on the suspense of other games in the same week (since ranks do not change within a week). Another approach would be to define the unit of time as a game but to continue to use empirical distributions that only condition on rank and week (i.e., to ignore the effects of one game's results on the suspense of another game in the same week). For linear suspense, this approach would be equivalent to our original approach, and so since our results are similar for baseline and linear suspense, this indicates our results are robust to this issue.

Table 2. Baseline and Linear Suspense.

		Number of Play-Off Teams			
		2	4	8	16
Baseline suspense	Regular season	3.121	2.303	1.516	1.019
	Play-offs	0.700	1.163	1.544	1.808
	Total	3.821	3.466	3.059	2.827
Linear Suspense	Regular season	7.357	6.215	5.034	3.823
	Play-offs	0.980	1.820	2.799	3.730
	Total	8.337	8.034	7.833	7.553

A final issue we should discuss—though not an assumption—is that we do not estimate standard errors of suspense. Since suspense is an ex ante construct, suspense itself is a function of historical data. That is, suspense is a sample statistic, not an unobserved population parameter. This means that if we calculate the statistic correctly—if our model is correct and we use the same data, and estimate distributions using that data in the same way, as fans—then we would calculate fan suspense exactly. Of course, this is almost surely not the case. We account for model and data uncertainty with our range of robustness checks, specifications, and subsamples.[20]

Main Results

Table 2 reports the main results: baseline and linear suspense in the regular season, play-offs, and in total, for the full sample. The pattern is clear: Reducing the number of play-off teams causes an increase in regular season suspense that dominates the decrease in play-off suspense. It is difficult to interpret the magnitudes except in comparison to one another for a given suspense definition; baseline suspense is around 25% lower with 16 play-off teams, as compared to two, and linear suspense is 10% lower for the same comparison.

Figure 1 presents linear suspense for each of the top six ranked teams, for each week of the regular season, for the different play-off formats. The graphs look very similar, but much more crowded, when we include more ranks. We present linear suspense because it can be disaggregated by rank directly, but the most closely analogous figure for baseline suspense is very similar.[21] The figure shows that suspense in the first week with a two team play-off is substantially greater than suspense in even the last week with a 16 team play-off. The figure also shows that suspense generally increases throughout the season for all formats (though it declines at the end for No. 5–6 teams with two play-off teams), but the increases are much greater when there are fewer play-off teams.

The figure does not show play-off linear suspense; the totals for each round can be backed out of Table 2, and are 0.93 for the first round of a 16 team play-off, 0.98

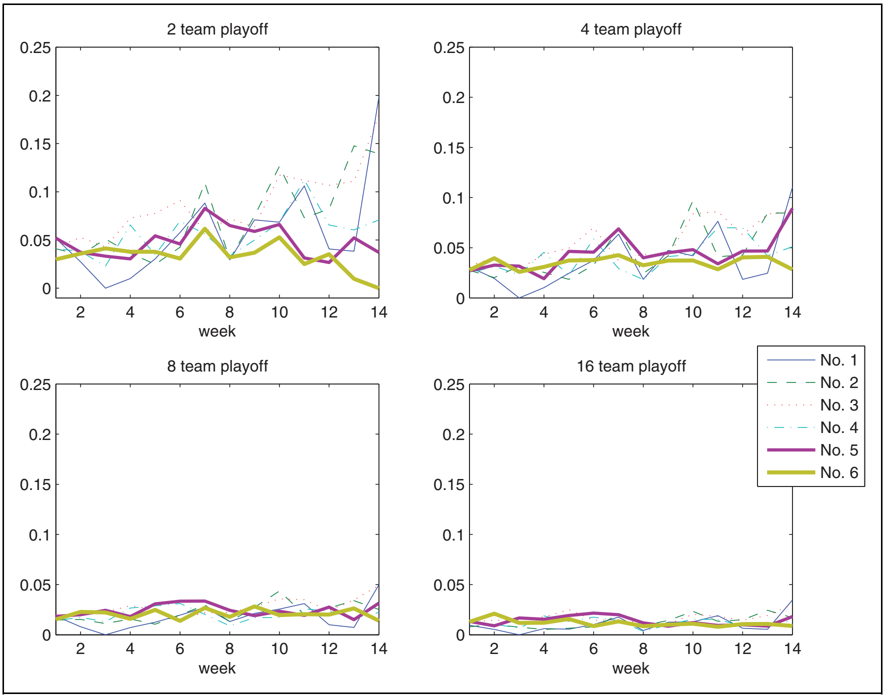

Figure 1. Linear suspense (*y*-axis), by rank, for top six ranks in each week of regular season, for different play-off formats.

for the second round, 0.84 for third round, and 0.98 for final.[22] The figure indicates that, with a two team play-off, there is an average per team of about 0.05 units of linear suspense for the first 8 weeks of the season, and for the last 6 weeks there is an average of nearly 0.1. This adds up to 6, which clearly outweighs the extra linear suspense from the first 3 rounds of play-offs with 16 teams (about 3).

In other words, there is significant suspense throughout the season with a two team play-off. When we sum up linear suspense across all teams in the regular season, there is on average (per week) just over half the suspense of a play-off week. With a 16-team play-off, the linear suspense in a typical week is just under a quarter of a typical play-off week. Given that the regular season lasts 14 weeks and the play-offs at most four, it is clear how the extra regular season suspense with a two-team play-off dominates the extra suspense from a few extra rounds of play-offs.

To relate these results more directly to the theory discussed previously, the fact that each week in the regular season has substantial suspense suggests there is substantial uncertainty at the start of the season and that it is gradually resolved week to week. This is implied by Figure 1 and shown more explicitly in Figure 2. This figure shows the estimated probability of the No. 1 and No. 4 (chosen arbitrarily as

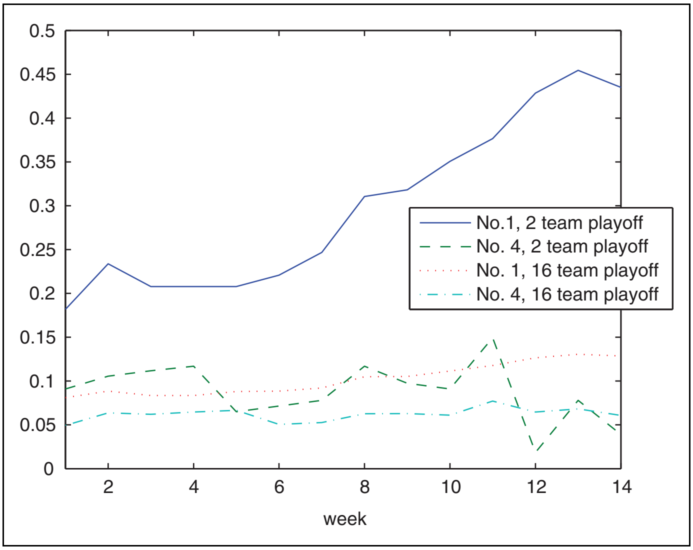

Figure 2. Estimated probability of being champion (*y*-axis) for No. 1 and No. 4 ranked teams at start of each week of regular season, for play-off formats with two and 16 teams.

a contrast) teams' chances of being champion at the start of each regular season week, for 2- and 16-team play-offs. There is some noise, but the No. 1 team's probability of being champ increases from 20% to 45% through the regular season, while the No. 4 team has a probability that declines from 10% to under 5%, with a two team play-off. With a 16 team play-off, the probabilities do not change much throughout the season. This figure shows it is the gradual resolution of uncertainty throughout the season, and not just preseason uncertainty, that drives the smaller play-off format's dominance.

Table 3 presents checks of robustness to variation in the distributions of game results in the play-offs, for baseline suspense (results are similar for linear suspense). The table shows the main pattern appears very robust to this issue. The difference expands somewhat when the higher and lower seeds are equally likely to win each play-off game. This reduces regular season suspense substantially when there are many play-off teams, because the only significance of the regular season then is to determine which teams make the play-offs (since seed does not matter), and even this is not that exciting since the probability of being champion conditional on making the play-offs is low. Note that the assumption of higher win probabilities for higher seeds may better capture a scenario in which higher seeds are awarded home field advantage. Note also that if the championship game's distribution is held constant, then suspense for any number of play-off teams converges to two team play-off suspense as the higher seed win probability in earlier rounds converges to one.

Table 3. Robustness Checks: Baseline Suspense With Different Play-Off Game Result Distributions.

		Number of Play-Off Teams			
		2	4	8	16
Pr (higher play-off seed wins) = 0.5	Regular season	3.123	2.115	1.338	0.843
	Play-offs	0.707	1.207	1.561	1.811
	Total (suspense)	3.830	3.322	2.899	2.654
Pr (higher play-off seed wins) = 0.7	Regular season	3.270	2.408	1.731	1.256
	Play-offs	0.648	1.142	1.518	1.804
	Total (suspense)	3.918	3.550	3.248	3.060

Note. In the bottom three rows, it is assumed the higher seeded team wins the game with probability .7 in each first round game, the winner of the prior game with a higher seed has a .7 probability of winning in the next round, and so on. In the first three rows previously mentioned, it is assumed that each team has a .5 probability of winning each play-off game.

Table 4. Robustness Checks: Baseline Suspense Based on Recent Season Subsamples.

		Number of Play-Off Teams			
		2	4	8	16
1998-2011 sample	Regular season	3.400	2.535	1.689	1.131
	Play-offs	0.700	1.163	1.544	1.808
	Total (suspense)	4.100	3.698	3.232	2.938
2005-2011 sample	Regular season	4.093	2.990	1.994	1.358
	Play-offs	0.700	1.163	1.544	1.808
	Total (suspense)	4.793	4.153	3.538	3.166

Note. Play-off distributions estimated using original sample (1990-2011).

Table 4 presents results using recent season subsamples; this checks robustness to two issues. One is the distribution of regular season matchups—the possibility that the order and/or frequency of matchups between high- and low-quality teams has changed in more recent seasons, which could change patterns in suspense. Another is that fans may simply remember better or put more weight on more recent seasons when forming beliefs for other reasons. We continue to use the bowl game results to estimate play-off distributions because the number of observations for these would be very small with the subsamples, and we do not know of reason to be concerned that these distributions have changed in recent years. The table shows that, again, the main pattern is robust. Again there is a negative, monotone relation between play-off teams and total suspense. The table also illustrates the upward bias in suspense that results from using a smaller sample with a smaller number of distinct seasons, referred to in Note 20.

TV Viewership

In this section, we present a limited analysis of the relationship between suspense and television viewership. We do not have access to the ideal data for this analysis and want to stress that the results here should be interpreted with caution. A more complete analysis of viewership effects is beyond the scope of this article. Still, the available data are sufficient to provide evidence of fan utility increasing in championship suspense, as we show it is strongly associated with viewership, and for making rough estimates of: (1) the viewership elasticity of suspense and (2) how viewership throughout the NCAA football season would be affected by changing the play-off format.

Suspense as we define it—expected changes in beliefs about the eventual champion—exists in all levels of all competitive sports. To increase sample size for this analysis, we collect data from NCAA football, pro football (the NFL), pro basketball (the NBA), and NCAA basketball on game viewership, factors determining suspense, and other determinants of viewership. Using these four contexts allows us to have a substantial number of observations (70), with a sample still limited to just two sports, with both college and pro levels for both sports.

Most of our viewership data are from Nielsen's (2011; 2012; 2013) publicly available annual reports on sports media from 2010, 2011, and 2012. All three reports include average viewership of the NFL's semifinal and final play-off games (conference championships and Super Bowl), and regular season games on Thanksgiving and the season opener, NBA semifinal and finals series (both best-of-seven), and regular season games on Christmas day (and the season opener for 2010) and all-star games, and each round of the NCAA basketball tournament after the "first four." The reports also have data on average regular season viewership, by conference, of NCAA football and basketball games in 2011, the NCAA football championship game in each year, and selected bowls and regular season games for NCAA football in each year. We also obtained average regular season viewership for NFL and NBA games in 2012 from adweek.com and NBA.com, for 101 and 52 telecasts, respectively.

To calculate suspense for these games, we assume for simplicity that each nonplay-off game, for contexts other than NCAA football, has suspense of 0.001 (marginally positive so the log is defined), and each team has a 50% chance of winning each play-off game. The latter assumption will bias suspense calculations upward since in reality in most situations one team is more likely to win; this bias would weaken our estimated suspense–viewership association. We average the suspense values for each game of the NBA play-off series, taking into account the series score before each game. We calculate suspense numbers for regular season NCAA football games using recent historical game results to approximate the ex ante probabilities of each team winning, and results on the ex ante and ex post probabilities of being champion from the main analysis.[23]

Table 5. Regression Results: Estimated Effects of Suspense and Other Variables on TV Viewership.

	(1)	(2)	(3)	(4)
Baseline suspense	42.486*** (3.561)		0.301*** (0.022)	
Linear suspense		30.028*** (2.523)		0.281*** (0.021)
Basketball	−2.855 (2.078)	−3.532* (2.068)	−1.194*** (0.223)	−1.252*** (0.225)
Pro	13.942*** (2.201)	13.279*** (2.193)	1.324*** (0.242)	1.290*** (0.244)
Pro basketball	−13.003*** (2.406)	−12.329*** (2.394)	−0.859*** (0.258)	−0.802*** (0.260)
Holiday	10.413*** (2.743)	10.146*** (2.744)	1.156*** (0.304)	1.137*** (0.307)
Season opener	5.415 (4.131)	5.411 (4.138)	0.470 (0.459)	0.466 (0.463)
Log-log			√	√
Adjusted R^2	.868	.867	.895	.893
N	70	70	70	70

Note. Standard errors in parentheses. "Log-log" models use log viewers and log suspense. All models estimated with ordinary least squares (OLS) and dependent variable in millions, and include year fixed effects. *, **, *** denote 10%, 5%, and 1% significance, respectively.

To estimate the suspense–viewership relationship, we regress viewership on suspense, using various controls and specifications. The regressions are weighted by the number of telecasts for the average viewership observations, and by one for all other observations that represent just one game. The controls are dummies for basketball, pro, an interaction of these two (pro basketball), year, holiday (Christmas, Thanksgiving, or New Year's Day) and season opener.[24] The specifications are suspense and linear suspense, both in levels and logs (of both suspense and viewership). For the log-log models, coefficients can be interpreted as elasticities. We exclude the observations for Super Bowls and all-star games, because they are unique events with higher viewership for reasons unrelated to suspense.

Results are presented in Table 5. Baseline and linear suspense are both significant at the 1% level in all models. The elasticities are estimated to be 0.30 and 0.28 (linear). This implies viewership is responsive to suspense, but still inelastic, and also implies that, again, results are robust to how we define suspense. Fit and precision for suspense and linear suspense are also very similar, and are very good, for all models.

Potentially important omitted variables include media market, and time and day of telecast. Teams with larger media markets are relatively likely to have regular season games nationally televised, increasing viewership for reasons other than suspense; this would bias the suspense coefficients downward. But one might argue the coefficients are biased upward because more suspenseful games are shown at times when more people tend to watch television anyway. This is not true for NFL or NBA play-off games—they are in general scheduled for the same days/times as regular season games. Around half of NCAA basketball regular season games are played weekday evenings, and about half are on the weekends, which is similar to the distribution for late round play-off games. Many early round NCAA basketball play-off games do occur Thursday and Friday during the day, which could lower their viewership; however, this effect is likely counteracted by the greater interest in these games due to their significance in tournament betting pools.[25] Another omitted variable is team quality; one might also claim viewership is higher in more suspenseful games in part because the teams playing in those games are higher quality and play harder. Most regular season games that are televised involve top quality teams, so the variation in quality is not too high; still, to properly address this issue we would need more data on regular season games.

We close this section by presenting rough estimates of the viewership trade-offs caused by suspense effects of play-off expansion. We restrict attention to linear suspense here to simplify the calculations. The estimated coefficient is approximately 30, and total linear suspense with a two-team play-off is around 0.5 per week in the regular season, and around 0.25 per week with a sixteen team play-off, so the weekly loss in linear suspense would be 0.25. Thus, the predicted decline in regular season viewership per week from this play-off expansion would be $30 \times 0.25 = 7.25$ million viewers. By comparison, 17 million viewers watch regular season games for top conferences each week (Nielsen, 2012). The predicted viewers for play-off games, using the 2012 year effect, are 8.2, 12.0, and 19.5 million for Rounds 1, 2, and 3 of a sixteen team play-off, respectively. Since there would be eight, four, and two games in each of those rounds, this yields around 150 million viewers of non-championship play-off games. The net increase in the postseason would be reduced somewhat by the elimination of (nonplay-off) bowl games. Still, these results make it clear that there would be sizable gains and losses in viewership resulting from the play-off format change. It is also worth noting that even if season-long suspense declines, season-long viewership could increase due to an increase in the number of play-off games, since suspense is not the only factor driving their viewership.

Discussion

Our analysis supports a two team play-off being suspense-optimal. This may help explain the historical resistance to introducing a larger play-off. Although this resistance may have seemed illogical to some and the bowl system had obvious problems, it was also obvious that the sport overall was wildly popular and successful. It may have been difficult for defenders of the status quo to explain why it deserved defending; our analysis may be helpful for understanding the BCS system's benefits. Other benefits of the traditional bowl system include that it allows fans of many teams to each have a type of smaller scale, psychological championship (their bowl game), ending the season on a winning note, with substantial time to make travel plans to attend the sole game. Many defenders of bowls have also stressed their rich historical traditions (e.g., the Rose Bowl's ties to the Big 10 and Pac 12 conferences date back to 1961), and that a longer season with more play-off games would impose a greater physical and academic burden on the players.[26]

Again, we note the suspense-optimal play-off format is not equivalent to either the utility or profit-maximizing format. This may help explain why pro sports leagues choose longer regular seasons, and larger play-off formats, than what might be suspense-optimal. Major League Baseball's progression of formats over time is particularly interesting, and perhaps revealing. The World Series is a best-of-seven (final) series between the champions of the two leagues. Up until 1969, these league champs were the teams with the best records after the 162 game regular season. In 1969, an additional play-off round, with two extra teams, was added, in 1994 a third round, with four more teams, was added, and in 2012 an extra round, with two more teams, was added. These changes suggest adding play-off teams increased demand and profits. However, "pennant chases"—long, suspenseful stretches at the end of the regular season, in which top teams fight to advance to the postseason—have essentially disappeared. Although the term is still used in reference to late season games, it is really a misnomer now (since winning a pennant means winning the league championship, which now requires winning multiple play-off series) and the games involved are much less dramatic.

Another important consideration, mentioned in the introduction, that seems to favor a larger play-off structure is fairness. This has been the crux of the argument in favor of a play-off system for many proponents.[27] It was even the topic of congressional hearings in 2009.[28] In the previous (2008) regular season, Boise State was undefeated but ranked No. 9 by the BCS, which pitted two teams with one loss each in the title game (Florida and Oklahoma). Even an eight-team play-off may not have been sufficient to give Boise State a chance to win the title that year, implying a play-off may need at least 10 teams to guarantee all teams a chance at the title.

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Notes

1. Arguments for change date back at least to White (1967).
2. See http://www.ncaa.com/history/football/fbs for a list of historical champions and "selecting organizations," which are mainly polls by journalists and coaches.
3. See, for example, http://collegefootball.procon.org/ for more background on the controversy and arguments for a play-off. Even President Obama has spoken up on the issue, expressing support for a play-off (http://sports.espn.go.com/ncf/news/story?id=3704864).
4. See, for example, http://sports.yahoo.com/blogs/ncaaf-dr-saturday/doc-five-ways-college-football-final-four-perfect-211738159–ncaaf.html for an argument for expansion, http://www.cbssports.com/collegefootball/blog/eye-on-college-football/22343037/michigan-state-ad-4-team-playoff-is-short-term-answer, which says Michigan State athletic director predicts "an expansion of the playoff beyond four teams" or http://www.insidehighered.com/quicktakes/2013/06/19/keep-college-football-playoff-4-teams-faculty-group-pleads.
5. For example, the most watched college basketball regular season game in 2013 had four million viewers (http://espnmediazone.com/us/press-releases/2013/03/mens-college-basketball-most-viewed-regular-season-ever-on-espn/) and the championship had 23 million (http://www.nytimes.com/2013/04/10/business/media/bump-in-ratings-for-mens-college-basketball-final.html). The pro football championship receives over 100 million viewers and regular season games have at most 30 million (Nielsen, 2012), Nielsen (2013). The importance of the college football regular season is not always ignored; Kevin O'Malley, a sports marketing executive, called college football's regular season "possibly the most exciting and competitively meaningful in all of sports" (http://www.nytimes.com/2009/09/06/sports/football/06bcs.html).
6. To be more precise, our assumptions are as follows: (1) the distribution of attaining play-off seed X in the regular season for a given information set is the same as the distribution of attaining final regular season AP rank X for that information set; (2) the distribution of play-off game results between teams of seeds X and Y is the same as the distribution of bowl results between teams of ranks X and Y.
7. Another piece of statistical evidence supporting this idea is Pawlowski (2013), which found the majority of German professional soccer fans agreed with the statement "the fight for the title is exciting."
8. There are of course many factors that we cannot address. To briefly discuss just one, adding play-off teams may also have ambiguous effects on the suspense from rooting for one's favorite team. More teams would have a chance of making the play-offs, which would increase this type of suspense, but adding play-off teams may also reduce the prestige and suspense when one's favorite team plays in a nonplay-off bowl games. Again, the net effects are unclear.
9. See, for example, Borland and MacDonald (2003), Coates and Humphreys (2011), Leeds and Sakata (2012), Rodenberg (2012), or Salaga and Tainsky (2013) for examples of the large empirical literature on the UOH, which includes findings of evidence both for and against the hypothesis.

10. More specifically, we could assume top teams, which are the only ones we study, exert "full" effort in all games.
11. We omit several technical details from EFK that are not relevant to our analysis.
12. Both expressions can be written using just μ^A due to the symmetric nature of σ_ω^2 with respect to the prior.
13. See Stone (2013) for evidence and discussion of related literature. An even more efficient source of information would be gambling odds, but these data are not available for each week of the season for a large sample of seasons. Moreover, we require rank data for the analysis of counterfactual play-off scenarios, as we refer to in the introduction and explain further subsequently.
14. We ignore the probabilities associated with ex ante unranked teams because their chances of winning the championship, both ex ante and ex post in each week, are very low, and so including them would have a negligible effect on suspense.
15. We assume that matchups are based on seed in the same way as the NCAA basketball tournament, with the matchup in each round favoring the ex ante better seed as much as possible, for example, with four teams, the No. 1 plays the No. 4, and so on.
16. This assumption does cause the relation between probability of winning the tournament and seed to not always be monotonic; we conduct a robustness check in which these probabilities are smoothed and find results are very similar for suspense and actually qualitatively strengthened.
17. The number of weeks in which teams were ranked in each season varies somewhat and we made a few minor adjustments to standardize this number in our sample. We drop the second weekly ranking of the 1990-2002 seasons, excluding 1997, because there were very few games between the first and second ranking in those seasons. We also drop the 16th regular season ranking, for those seasons that had one, for all seasons, again because there were an irregular and relatively small number of games in the week before that ranking, so that each season in our sample has 15 regular season rankings.
18. In 2000, the BCS matched the AP's No. 1 and No. 3 teams, and in 2001 and 2003 the AP's No. 1 and No. 4 teams. Recall the BCS began in 1998.
19. The correlation of AP and BCS ranks for 2009-2011 is 0.97; see, for example, Martinich (2002) for additional evidence and discussion.
20. We could directly estimate standard errors by bootstrapping; however, due to the nature of the procedure, this distribution appears to be upward biased. Repeating observations effectively causes uncertainty to be resolved faster during the regular season, which increases early regular season suspense. This upward bias is shown in our robustness check using smaller samples. But, for the reasons described previously, this would not be the appropriate way to describe our empirical uncertainty regardless.
21. That is, the sum of linear suspense for each rank in each week is equal to total linear suspense in that week. For baseline suspense, the analog for a single rank would be the standard deviation of beliefs just for the team with that rank, which if summed across ranks would not equal total suspense for the week.

22. Recall that, by assumption, suspense in a round only depends on the number of teams remaining in the round, and not what occurred in previous rounds, so linear suspense in the first round of an eight team play-off is 0.84, and so on.
23. The regular season games in the Nielsen reports were Alabama-Georgia in 2012, Notre Dame-USC in 2012, Notre Dame-Michigan in 2011 and 2010, Alabama-LSU in 2011, Alabama-Auburn in 2010, Auburn-South Carolina in 2010, and Boise State-Virginia Tech in 2010. We code suspense for both Notre Dame-Michigan games as 0.001, as both teams were ranked outside the top 10 in both games. We assumed win probabilities were 0.5 for Alabama-Georgia (No. 2 vs. No. 3 at neutral location), Alabama-LSU (No. 1 at No. 2), and Boise State (No. 3 at No. 10), and researched game results from 2000 to 2009 to approximate the other probabilities (0.9 win probability for No. 1 Notre Dame at unranked USC; 0.6 for No. 2 Auburn at No. 9 Alabama; 0.67 for No. 2 Auburn vs. No. 18 South Carolina). Regression results were similar when we used other plausible probabilities for these games.
24. We also code January 2, 2012, as a holiday because it was a federal holiday due to January 1 being a Sunday that year.
25. Interest in the early round games is likely especially high because all participants are still in contention at that stage.
26. Swofford et al. (2009) discuss these points as well.
27. For a good summary of the issues, see http://www.realclearsports.com/lists/top_1O_cliches_foragainst_the_bcs/cliches_foragainst_the_bcs.html?state=stop
28. See http://www.judiciary.senate.gov/hearings/hearing.cfm?id=e655f9e2809e5476862f735da14c6156

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