An Examination on NFL Time Management Efficiency

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"It's about strategically giving your team the best chance to win. That's really the essence of it. How to do that? There's 1,000 different ways, based on the situations. Those situations present another set of circumstances that you have to spend a lot of time reviewing, understanding, preparing for. The game is going to happen so quickly, if you're not prepared for it, it could affect you." – Michael Lombardi, NFL Network Analyst and former NFL Player Personnel Executive

ABSTRACT

This paper analyzes the factors contributing to an NFL team's offensive ability to efficiently reach field goal range during the final six minutes of regulation. The data is constructed from 2009 - 2011 NFL regular season games examining various in-game factors that affect an offensive unit's total time taken to reach field goal range. Through regression analysis, the most significant factors discovered affecting total time were the impact of starting time, the number of offensive timeouts used, and the number of offensive timeouts taken. These findings could alter in-game coaching decisions for an NFL head coach.

INTRODUCTION

Time management in the National Football League is a heavily active discussion when the ability to manage the game offensively and defensively affects a team's probability of winning (Branch, 2011). For example, the 2012 Super Bowl featured New England Patriots head coach, Bill Belichick, making the unprecedented decision to let the New York Giants' Ahmad Bradshaw run for a 6-yard touchdown on the Giants' final possession. Belichick dwindled the clock down at the two-minute warning to the 57-second mark because he underestimated the sufficient time he needed to score with one timeout remaining. This mismanagement of time by Belichick and his staff minimized the Patriot's opportunity to respond to Bradshaw's touchdown.

As this issue continues to trend, this study seeks to examine the factors that have an effect on an NFL offense's efficiency to move downfield in an endgame situation. By understanding the impact of a multitude of variables, this information could become more apparent to coaches and possibly allow for game decisions and play-calling to be adjusted given various scenarios. Research done upon this subject is minimal at best, which provides the opportunity to customize and pioneer a model relating in-game variables and the total time an offense needs to get downfield.

Based on the complexity this research could possess, this study is limited and neglects situations where an offense needs a touchdown on the last possession in an NFL game. Instead, the purpose of this research is to seek out and investigate significant variables in determining a team's capacity to reach field goal range. Field goal range should be defined as the optimal location to kick a field goal for the average NFL kicker, which will be determined by other academic research. We believe that team personnel,

starting field position and the number of timeouts available could potentially have a significant effect on the time needed to reach field goal range. This study involves secondary data obtained through content analysis of recent NFL games to determine the effects of specific independent variables on a dependent variable.

LITERATURE REVIEW

The typical NFL season has a fair share of games where the result of the game may come down to the final possession. To maximize a team's chances to tie or win the game in regulation, a head coach must have an efficient understanding of how to manage the clock in the NFL. With all the play-calling duties head coaches have, the biggest adjustment that a new head coach will have is managing the game and its efficiency on both sides of the ball. Most new NFL head coaches had previously been position coaches and coordinators, so rookie NFL head coaches most have never had the opportunity to gain time management experience.

Coaches must possess the ability to operate the team efficiently on offense, defense and special teams, which comes from experience. Efficient coaching could potentially account for three to four additional wins in one's season and makes a statistically significant contribution (Hadley, Poitras, Ruggiero & Knowles, 2000, p. 63). Hadley et al., said that as management has a multifunctional purpose, it is the head coach's duty to utilize all information on-hand to influence their play-calling decisions to give their teams the best chances of winning. Hadley et al. indicated the mean performance index, which analyzes the winning percentage for an average NFL head coach, for all 32 NFL teams was 0.641. This translates into an average NFL head coach winning 6.41 games in a regular season. Hadley et al., found that the win differential

between the average head coach and the best head coach was 3.5 wins per season. Experience and years of coaching was statistically significant in the regression model when you consider coaches with 14 years experience or greater won 71 percent of games and coaches with no prior experience won 56 percent (Hadley et al., 2000, p. 66-7).

At the end of the game, inferences from research indicate that timeouts might possibly be considered more valuable than the field position of the ball. Prince (2008) provided an example of this in a regular season game between the Tennessee Titans and the Minnesota Vikings. Prince showed that timeouts might heavily impact a team's win probability more so than field position. Trailing six points with 4 minutes to play, Minnesota called their last timeout on their own 2-yard line. According the Prince's model, Minnesota had an 11 percent chance of winning the game once the timeout was taken versus 13 percent if they had taken a delay of game penalty and kept their final timeout. Prince also noted that simply maintaining possession of the ball increases a team's probability of winning (Prince, 2008, p. 30-1).

While NFL coaches believe that winning the battle of time possession is a huge factor in winning the game, there is contradictory research that shows otherwise. Sackrowitz and Sackrowitz (1996) discussed the disadvantages of efficient ball control and make a point that teams should operate as clock-neutral. They suggested that an NFL offense should run its usual offense disregarding the variable of time. However, the group recommended an unconstrained, time-omitting, offense must take into consideration the team's personnel at all times (Sackrowitz & Sackrowitz, 1996, p. 43).

If a team is pacing their offense or running a hurry-up offense, it is beneficial for a team to understand when timeouts must be used throughout the game. Sackrowitz and

Sackrowitz (1996) continued by stating that no team can stop games from taking their full time in minutes, but rather in possessions can make attempts to extend or curtail that time of possession. Against that point, timeouts should be considered attempts to control the time of possession as well. They said that a team's chances to score increase if it utilizes an unconstrained style that ignores time. Ultimately, there is an opportunity cost between gains of time control and losing chances to score more points (Sackrowitz & Sackrowitz, 1996, 46).

Romer (2006) suggests that the NFL values winning on a tremendous level. Moreover, the market for head coaches making these decisions is competitive as salaries average approximately $3 million a year and 20 percent lose their jobs annually. In other words, Romer states that six or seven head coaches are fired per season based off of 32 NFL teams (Romer, 2006, 341-2). Essentially, it is difficult for head coaches to gain sufficient experience combining play-calling with time management due to the cut-throat nature of the league especially since the regular season is so short with only 16 games.

Decision-making on third and fourth downs is also a component of time management. Attempting a fourth-down conversion has an effect on time management and as Prince's model stated, maintaining possession of the ball increases your team's chances. Romer (2006) states "teams' choices between punting and attempting a field goal change rapidly around their opponents' 35-yard line" (p. 347). Romer (2006) says that NFL team play-calling tends to be more conservative and labels them as 'risk-adverse'. NFL head coaches rely on experience and intuition as opposed to formal analysis as the root cause of their conservative decision-making (p. 362).

Romer (2006) points out that there are expected point returns in scoring outcomes based on the ball location, the down and distance. Since there are expected point returns, it would be wise for the coach to understand what the expected score of the game is based on his team's present offensive field position. Inversely, Romer (2006) suggests the same for coaches on defense where they can make more efficient play-calling decisions in a time when controlling the clock is unlikely (p. 346). Carter and Machol (1971) also note that there is an expected point return value for 1st and 10's on a given spot on the field. Since one can assume a point value for location on the field, an NFL head coach could then begin managing the game clock based off an adjusted score for field position. This would allow an NFL coach to manage the game clock and deployment of his timeouts more efficiently (Carter & Machol, 1971, p. 542).

For timeout strategy in the last minutes of a game, Carter and Machol point out the Type I error is using a timeout when a timeout should not have been called. For example, a coach of the team on offense calls a timeout and then the team turns the ball over thus giving their opponent the ball and extra time on the clock to score. "The Type II error consists of not calling a time out when none should" (p.543). The result of a Type II error is for time to expire with a team still possessing timeouts they could have called. Moreover, Carter and Machol "recommend that a team that is behind seven points or less should never call a timeout when there are more than 30 seconds to play if it has the ball, or more than one minute to play if the opponents have the ball" (p.544). However, many teams begin using their timeouts when on offense and trailing well before 30 seconds remain in the game and well before one minute remains in the game when on defense and trailing. This may be due to coaches understanding that not only do

they need the ball, but they also need time to drive down the field to get into scoring position. Having around 50 seconds remaining in the game may not give an offense enough time to drive down the field and set up an opportunity to score.

NFL coaches may be more risk adverse in play calling, decisions whether to punt or go for it on 4th down, and whether to attempt a field goal or go for it on 4th down, but in another aspect of the game may be more risk seeking. Tversky and Kahneman (1992) studied behavior in decision-making and found "that those subjects who were more risk averse in one domain tended to be more risk seeking in the other" (Tversky & Kahneman, 1992, p. 307). Tversky and Kahneman also state that, "Overweighting of small probabilities contributes to the popularity of both lotteries and insurance. Underweighting of high probabilities contributes both to the prevalence of risk aversion in choices between probable gains and sure things, and to the prevalence of risk seeking in choices between probable and sure losses" (p. 316). NFL coaches may fall victim to overestimating the impact of failing to gain a 1st down when faced with a 4th and short situation and may also believe they are better served taking the risk seeking mentality of holding timeouts till less than a minute remains in the game.

Urschel and Zhuang (2011) examined if NFL coaches are risk and loss averse by using evidence from coaches kickoff strategies. Romer (2006) had previously assumed that coaches operate in a risk neutral fashion and do not maximize their winning chances. However, Urschel and Zhuang (2011) found that "for scoring gains and losses of equal magnitude they suffer more from a loss than they enjoy from a gain" (p. 24), indicating that NFL coaches are indeed risk averse. Being that an NFL coach does not want to risk the loss of possession or field position on an attempt to go for a surprise onside kick, go

for a 1st down on 4th down instead of kicking, or go for a 1st down on 4th in hopes of later scoring a touchdown instead of kicking a field goal; an NFL coach would benefit from finding a way to increase win probability through better clock management. The reward for proper clock management may not be equal to that of gaining a 1st down on a 4th down attempt. However, the risk of committing a Type I or Type II error in regards to use of timeouts (Carter & Machol, 1971) is less risky than the loss of possession or field position in a coach's mind when attempting a 4^{th} down conversion. Better clock management gives an NFL coach the ability to improve win probability without going against a coach's natural risk-averse tendencies.

Effective clock management and usage of timeouts on offense will also affect the defense's end of the game strategy. Goldschmeid, Nankin and Cafri (2010) discussed utilizing unused timeouts to debunk kickers on tying or game-winning field goal attempts. New York Giants placekick Lawrence Tynes believes that kickers might be more anxious without a timeout and that dumping a timeout will only allow kickers to judge the spot, the distance, and the elements (Goldschmeid, Nankin & Cafri, 2010, p. 300). However, the trio found that the deployment of timeouts did limit the conversion rate for kickers and that iced kickers only converted on 64.4 percent of their attempts (p. 307).

Goldschmeid et al., looked at 'pressure kicks', which they defined as a kick performed in one minute or less behind three points or less, and overtime games (p. 301). Also, they were seeking to find out if kickers had higher conversion rates on scenarios where the opposing team had a timeout available or if they did not have any direct control over the kick. Interestingly when the opposing team had a timeout at their disposal,

kickers converted 74.3 percent of their attempts versus 76.2 percent who did not have a timeout available. While the percentage made with no direct control over icing the kicker was higher, it was not as statistically significant as they perceived. Conversion rates were contingent upon game location whether it was home or away, the score differential and experience of the kicker (p. 306).

Now, NFL teams utilize their coaching staffs and have added positions known as 'quality control coaches.' Many former quality control coaches including Lane Kiffin, Eric Mangini, Mike Munchek, Mike McCarthy and Raheem Morris have worked tirelessly up from this rank to become head coaches in the league. Edmund (2007) suggests that quality control coaches have become a necessity on offense, defense and has dribbled down to special teams play. Personnel staffs have made decisions to hire analysts to spend an immense amount of time preparing for opponents and developing a game plan (Edmund, 2007, p. 30-2). NFL teams and head coaches incorporate assistants to utilize statistical analysis and 'make a science out of football' (Edmund, 2007, p. 34).

Without evidence to contradict a coach's decision to hold timeouts or deploy timeouts, there is little incentive for a coach to change his ways. If a coach knew the average time needed to allow his offense to get into field goal range, a coach could better allocate his timeouts in order to give his team the proper amount of time to drive down the field. Pompei (2004) adds that teams begin in the offseason and training camp to figure out the particular philosophies that suit their offensive personnel best (Pompei, 2004, p. 54). All these various pieces illustrate how time management is an effective component of good coaching and decision making from an NFL staff. Thus, time

management is a thought process for coaches and their staffs, which makes it a primary focus in sustaining success for their teams and gaining a higher win percentage.

METHODOLOGY

The methodology being implemented for this study includes compiling relevant information and data, and using this information to establish a model regarding final possessions for NFL teams. This study will discover a more complete answer about end-of-the-game time management by an NFL head coach. The NFL Time Management Efficiency model will run a multiple regression analysis and investigate what variables impact the total time taken to reach the 35. The main assumption is that the mean time taken will grant a stronger chance to create an opportunity, so our dependent variable will set a benchmark of time needed on the last possession. To clarify, a potential 'last possession' will be defined as a possession under six minutes to play within regulation and the game is either tied or within a three point differential.

Hadley, Poitras, Ruggiero & Knowles (2000) used a regression model to investigate performance in the NFL based on offensive and defensive variables that including statistics such as passing percentage, fumbles, field goal percentage, and total first downs. The study also correlated head coach experience to team performance, which was based on wins, and found a causal relationship between the number of years as a head coach and winning percentage. Goldschmeid, Nankin and Cafri (2010) examined the usage of timeouts on pressure kicks with descriptive statistics summarizing means and standard deviations with scoring differentials, game location, and deployment of timeouts between teams. There were many studies with a qualitative background including Romer (2006), Tversky and Kahneman (1992) and Carter and Machol (1971)

that studied coach play-calling behavior and expected point return. Thus, Hadley et al., was the main study to utilize a regression analysis and to look at team performance as a dependent variable when compared to offensive and defensive statistics as independent variables.

The research design implemented for this study is an experimental design due to measuring the independent variables' effects on the dependent variable. This design provides the ability to use quantitative data, due to the necessity to utilize a regression model to explain the causal relationships between variables within. This model seeks to determine the significance of how the independent variables affect the dependent variable. The NFL Time Management Efficiency regression model is as follows:

$$\text{Total Time Taken to Reach} = \beta_0 + \beta_1 \text{StartTime} + \beta_2 \text{ScoreOff} + \beta_3 \text{ScoreDef} + \beta_4 \text{Start} + \beta_5 \text{Reached} + \beta_6 \text{TOSAvail} + \beta_7 \text{TOSused} + \beta_8 \text{DEFTOs} + \beta_9 \text{TwoMinute} + \beta_{10} \text{trail0} + \beta_{11} \text{trail1\_3} + \beta_{12} \text{HOME} + \beta_{13} \text{QBRating} + \beta_{14} \text{Stars} + u,$$

where the variables are defined below.

Starttime = the number of seconds remaining on the game clock when the offensive possession being measured began.

ScoreOff = the offensive score before the start of the last possession drive.

ScoreDef = the defensive score before the start of the last possession drive.

Start = the yard line where the ball began at for the offensive possession being measured.

Reached = the number of seconds remaining in the game when the offensive team reached the 35-yard line

TOSAvail = timeouts available to the offense upon the commencement of the offensive drive being measured.

TOSused = timeouts used by the offense during the offensive possession in which the timeout is used not in period where the clock is stopped.

DEFTOs = timeouts used by the defense during the offensive possession in which the timeout is used not in period where the clock is stopped.

TwoMinute = 1 if the possession measured was impacted by the two-minute warning

Trail0 = 1 if the game is tied.

Trail1_3 = 1 if the offense is trailing between 1 to 3 points on the possession being measured

HOME = 1 if the offensive unit in the last possession was operating the drive at home

QBRating = the end of season quarterback rating for the QB of the offense for the season in which the possession takes place.

Stars = number of players on the offense who were elected to an all-pro team for the season in which the possession takes place.

The 14 independent variables in this regression model will seek to measure any significance or insignificance between the dependent variable, total time taken, which is defined as the differential between the starting time and the time reached. Thus, this is the time it took to reach the 35-yard line and put the offensive units in position to kick a tying or game-winning field goal. The weaknesses of the data collection include omitting certain factors such as the weather conditions, field conditions, offensive style, strength

of defense, kicker range and failed attempts. These omitted factors that the NFL Time Management Efficiency model omits are covered in the 'u' variable, which is the error residual term and encompasses the unobserved factors in a model (Wooldridge, 2009, p. 23).

The model utilizes starting field position, which will determine the efficiency of ball movement when comparing it to the average time moving downfield. In addition, this study will determine the mean time taken through various descriptive statistics and could bring light to the tendencies of coaches in the last possession. This study will solely include those results where an offense reached the target of the 35-yard line and how many seconds taken to reach the marker. Defensive timeouts, timeouts used, and the impact of the two-minute warning are utilized to acknowledge any clock stoppages. Timeouts available allows the model to address the peace of mind a team may have as they drive down the field due to the number of timeouts they possess. This peace of mind may allow the team to play with better composure and make better decisions. The model accounts for whether a team is in a situation where they could attempt to win the game in regulation without suffering a loss if they do not score with the 'Trail0' variable. The 'Trail1_3' variable indicates that the team needs a field goal for a win or tie.

The data collection process will come from the NFL gamebooks and play-by-plays from NFLMedia.com. The study will look at the scorelines going into a potential last possession and record all the specific independent variables. The play-by-plays include down and distance, time of the snap, stoppage of the clock and whether a timeout was used. This process is more accurate with gamebooks providing specific numbers while watching the games would make the study more qualitative. Plus, with the

abundance of games, getting tapes of those games would be an obstacle to the study. This study will provide quantitative explanations using descriptive statistics and running a regression analysis to examine relationships between the independent variables and total time taken.

The sample for the model will be all NFL regular season games from the 2011 – 2012, 2010 – 2011, and 2009 – 2010 seasons. This sample totals 768 games (n=768). However, all the games that do not have the last possession or an offense failed to reach the 35 yard-line are not incorporated into the model. The sample includes all NFL teams and not a specific group of teams as the model wanted to serve as a representation to the entire efficiency of all 32 teams in the league. Also, the study looks at only regular season games simply because of the league changes in the overtime rules beginning in the 2010 – 2011 season. NFL Time Management Efficiency being a new subject of study forces the study to be conducted with the most recent data available, which is why the last three seasons of NFL regular season play were selected. Moreover, it would be very difficult to find NFL gamebooks from over 10 years ago, so it is in the best interest of the study to utilize the most recent information. Below is an example of the raw data collected in Microsoft Excel and is called the NFL Time Management Efficiency Table 1.1.

NFL Time Management Efficiency Table 1.1

off team	d team	START	TOSavail	TOSused	TwoMinute	trail 0	trail 1_3	stars	total time taken	start time	reached	defTOS	score off	d score	HOME	qb rating
TB	MIN	39	3	0	0	0	1	0	99	252	153	0	17	20	0	74.6
WAS	AZ	36	3	1	0	0	1	0	84	260	176	1	19	21	1	72.4
DAL	SF	26	2	2	1	0	1	0	184	243	59	0	21	24	0	102.5
CIN	DEN	5	0	0	1	0	1	0	82	145	63	0	22	24	0	80.4
BUF	NE	20	2	0	1	1	0	0	102	205	103	0	31	31	1	79.1
DET	MIN	53	3	0	0	1	0	1	8	253	245	0	20	20	0	97.2
MIN	DET	17	3	1	1	0	1	0	64	150	86	0	20	23	1	70.1
AZ	SEA	31	3	0	1	0	1	1	60	177	117	0	10	13	0	81.1
PIT	IND	20	3	1	1	1	0	1	56	129	73	0	20	20	0	90.1
DAL	WAS	14	2	0	0	0	1	0	79	224	145	0	15	16	1	102.5
DET	DAL	60	3	0	0	0	1	1	35	254	219	0	27	30	0	97.2
CIN	BUF	19	2	1	0	1	0	0	104	108	4	0	20	20	1	80.4
DET	SF	20	3	0	0	0	1	1	32	111	79	0	19	22	1	97.2
NE	DAL	20	1	0	1	0	1	3	69	151	82	0	13	16	1	105.6
BAL	AZ	56	2	0	0	1	0	3	10	52	42	0	27	27	1	80.9
CAR	MIN	24	2	0	1	0	1	1	89	158	69	0	21	24	1	84.5
SD	KC	52	3	0	0	1	0	0	134	299	165	0	20	20	0	88.7
NYG	NE	20	2	0	0	0	1	1	51	96	45	1	17	20	0	92.9
STL	AZ	36	1	0	0	1	0	0	39	51	12	0	13	13	0	70.5
AZ	PHI	13	3	0	0	0	1	1	182	306	124	0	14	17	0	81.1
ATL	NO	6	0	0	0	0	1	0	67	115	48	0	20	23	1	92.2
DEN	NYJ	5	1	0	0	0	1	0	203	354	151	0	10	13	1	72.9
DAL	MIA	36	3	0	0	0	1	0	18	179	161	0	17	19	1	102.5
NYJ	BUF	18	2	0	0	0	1	1	211	344	133	0	21	24	1	78.2
CIN	CLE	45	2	0	0	1	0	0	53	111	58	0	20	20	1	80.4
DEN	SD	26	3	0	0	0	1	0	121	327	206	0	10	13	0	72.9
DEN	MIN	20	3	0	0	0	1	0	23	186	163	0	29	32	0	72.9
DAL	AZ	32	2	1	1	1	0	0	166	174	8	0	13	13	0	102.5
GB	NYG	20	1	0	0	1	0	2	14	58	44	0	35	35	0	122.5
DEN	CHI	20	0	0	0	0	1	0	48	56	8	0	7	10	1	72.9
CHI	DET	44	3	0	1	0	1	0	81	201	120	2	13	14	1	86.3
NO	SF	30	2	2	0	1	0	2	60	79	19	0	22	22	0	90.9
NO	ATL	37	2	2	1	0	1	2	176	212	36	0	21	24	1	90.9
OAK	ARI	20	1	1	1	0	1	0	158	213	55	1	23	24	0	66.3
CHI	GB	46	1	1	1	1	0	0	19	138	119	2	17	17	1	86.3
WAS	GB	20	2	1	0	0	1	0	111	238	127	0	10	13	1	77.1
GB	WAS	21	1	1	0	1	0	0	41	67	26	0	13	13	0	101.2
HOU	KC	20	2	1	1	0	1	3	34	142	108	0	28	31	1	92.0
NYJ	DEN	20	1	0	1	0	1	1	159	235	76	0	17	20	0	75.3
BUF	BAL	9	1	1	1	0	1	0	137	204	67	1	31	34	0	81.8

RESULTS

The regression model included all the following variables: Starting time of the possession, score of the game, starting yard line of the possession, seconds remaining when the offense reached the opponent's 35-yard line, timeouts available to the offense at the start of the possession, timeouts the offense used during the possession, timeouts the defense used during the possession, whether the two minute warning impacted the overall time of the possession, if the game was tied, if the offense was trailing between one and three points, whether the offensive team was home, the quarterback rating of the offense's quarterback for that regular season, and the number of players on the offense who were elected to the NFL All-Pro team for that particular season. The final 92 NFL Regular Season games examined were drawn from an original sample size of 756 games over the 2011, 2010 and 2009 NFL Regular Seasons. The descriptive statistics found that

33 of the 92 games (36 percent) contained a situation where the game was tied compared to the other 59 games holding a one to three point deficit.

The descriptive statistics containing standard deviation, mean, median and mode for the independent variables and dependent variable are listed in the table below:

NFL Time Management Efficiency Descriptive Statistics Table 1.1

Dependent Variable	Standard Deviation	Mean	Median	Mode
Total Time Taken	52.73	79.91	70	60
Independent Variables				
Start Time	89.1	168.89	154.5	145
Score Off	6.3	18.95	19	17
Score Def	6.2	20.55	20	20
Start	17.8	30.3	24.5	20
Reached	65.1	87.17	74.5	8
TOSAvail	1.0	1.84	2	2
TOSUsed	0.7	0.52	0	0
DEFTOs	0.8	0.53	0	0
TwoMinute	0.5	0.46	0	0
Trail_0	0.5	0.36	0	0
Trail 1_3	0.5	0.64	1	1
Home	0.5	0.52	1	1
QB Rating	12.9	84.5	85.8	102.5
Stars	0.9	0.84	1	0

The multiple regression analysis was run with the dependent variable set as total time taken to reach the 35-yard line and the 14 other independent variables listed above. The results from this regression are in the NFL Time Management Efficiency Model 1.1 below:

NFL Time Management Efficiency Model 1.1

Regression Statistics	
Multiple R	0.988388492
R Square	0.976911811
Adjusted R Square	0.960243266
Standard Error	15.77354874
Observations	92

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Start Time	0.9074	0.0373	24.3454	**0.0000**
Score Off	1.6882	2.8433	0.5938	0.5544
Score Def	-1.5221	2.8621	-0.5318	0.5964
Start	-0.0009	0.1230	-0.0072	0.9942
Reached	-0.8307	0.0523	-15.8681	**0.0000**
TOSAvail	-4.1961	2.2352	-1.8773	0.0642
TOSUsed	5.8878	2.9590	1.9898	**0.0501**
DEFTOs	-0.7133	2.2622	-0.3153	0.7534
TwoMinute	4.0721	3.4745	1.1720	0.2448
Trail_0	2.7852	14.3360	0.1943	0.8465
Trail 1_3	5.4869	15.4397	0.3554	0.7233
Home	1.5818	3.3958	0.4658	0.6427
QB Rating	0.0231	0.1489	0.1555	0.8768
Stars	-6.7877	2.0529	-3.3063	**0.0014**

The regression has an R-Squared of .9769 which indicates that close to 98 percent of the sample variance is accounted for by the independent variables in relation to the total time taken. This regression indicates that the significant variables, variables with P-values equal to or below .05, are in bold in the table and would be starting time, the time reached, timeouts used and the number of star players. The model indicates that for every one star player added to the offense, there is a 6.788 second reduction in time taken to reach the opponent's 35-yard line. Also, the model indicates that for every timeout used on the drive, there is a 5.8878 increase in time taken to reach the opponent's 35-yard line. Furthermore, for every one-second increase in starting time of the possession, there is a .907-second increase in the time taken to reach the opponent's 35-yard line. For every one-second increase for the time the offense reached the opponent's 35-yard line, there is a .083 reduction in time taken to reach the 35-yard line.

As the information above demonstrates, the model produces significant variables with beta coefficients that contradict our thinking on the subject aside from the star player variable. Therefore, we conducted a Variance Inflation Factor (VIF) test to test for

multicollinearity between the independent variables. The VIF is equal to the standard deviation squared multiplied by the number the observations then multiplied by the standard error squared, all divided by the squared residual.

$$VIF_j = \frac{S_{x_j}^2 (n-1) SE_{b_j}^2}{S^2}$$

The VIF test shows multicollinearity to be a problem when the VIF is above 10 (Wooldridge, 2009, p. 99).

NFL Time Management Efficiency Model 1.1 with VIFs

ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	14	821143.2225	58653.1	235.73933	3.9917E-57	
Residual	78	19406.77751	248.805			
Total	92	840550				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*VIF*	*Stan Dev*
Start Time	0.9074	0.0373	24.3454	0.0000	4.0820	89.1
Score Off	1.6882	2.8433	0.5938	0.5544	**117.6242**	6.3
Score Def	-1.5221	2.8621	-0.5318	0.5964	**118.0520**	6.2
Start	-0.0009	0.1230	-0.0072	0.9942	1.7675	17.8
Reached	-0.8307	0.0523	-15.8681	0.0000	4.2921	65.1
TOSAvail	-4.1961	2.2352	-1.8773	0.0642	1.9195	1.0
TOSUsed	5.8878	2.9590	1.9898	0.0501	1.4571	0.7
DEFTOs	-0.7133	2.2622	-0.3153	0.7534	1.3080	0.8
TwoMinute	4.0721	3.4745	1.1720	0.2448	1.2178	0.5
Trail_0	2.7852	14.3360	0.1943	0.8465	**17.6736**	0.5
Trail 1_3	5.4869	15.4397	0.3554	0.7233	**20.4996**	0.5
Home	1.5818	3.3958	0.4658	0.6427	1.0757	0.5
QB Rating	0.0231	0.1489	0.1555	0.8768	1.3612	12.9
Stars	-6.7877	2.0529	-3.3063	0.0014	1.2993	0.9

The offensive score, defensive score, tied game, and offense trialing by between one and three all had VIFs above 10. Therefore, we eliminated those independent variables, except for the variable that indicated if the game was tied (Trail_0), from the model. We also eliminated the variable for what time the offense reached the opponent's 35-yard line due to this variable being a component of the dependent variable rather than

influencing as an independent variable. The variable Trail 1_3 was eliminated due to it representing an improper use of a dummy variable, which causes multicollinearity in a multiple regression.

The regression analysis was re-run with the following independent variables: starting time of the possession, starting field position, offensive timeouts available, offensive timeouts used, defensive timeouts used, whether the two minute warning stopped the clock on the possession, if the game was tied, whether the offensive team was home, the end of season QB rating of the quarterback, and how many players on the offense were elected to an all-pro team at seasons end. The revised model will be called the NFL Time Management Efficiency Model 1.2:

NFL Time Management Efficiency Model 1.2 with VIFS

Regression Statistics	
Multiple R	0.947909
R Square	0.898531
Adjusted R Square	0.875199
Standard Error	32.25095
Observations	92

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	10	755259.844	75525.98	72.612491	3.4E-36
Residual	82	85290.156	1040.124		
Total	92	840550			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*VIF*	*std dev*
start time	0.4929	0.0478	10.3014	**0.0000**	1.6074	89.1
TwoMinute	7.8410	7.0815	1.1073	0.2714	1.1089	0.5
START	-0.4211	0.2273	-1.8524	0.0676	1.4483	17.8
TOSavail	-14.0637	4.3648	-3.2221	**0.0018**	1.6851	1
TOSused	24.9151	5.5286	4.5066	**0.0000**	1.3248	0.7
stars	-4.8961	4.0113	-1.2206	0.2257	1.1528	0.9
HOME	-4.2478	6.8410	-0.6209	0.5364	1.0349	0.5
defTOS	-0.2869	4.3584	-0.0658	0.9477	1.0753	0.8
qb rating	0.2742	0.1361	2.0141	**0.0473**	0.2728	12.9
trail 0	2.8982	8.1447	0.3558	0.7229	1.4669	0.5

This revised model had an R-squared of 0.9479, which indicates that close to 95 percent of the sample variance in the dependent variable, the total time taken, is accounted for by the independent variables. The revised model gave significant variables, variables with P-values less than .05, of the starting time of the possession, the quarterback rating, the timeouts the offense used during the drive, and the number of available to the offense when the possession begins. The beta coefficient for starting possession time indicates that for every one second increase in the starting time of the possession, there is about a half-second increase in the amount of time for the offense to reach scoring position. Also, for every one point increase in the quarterback rating, there is a .27 second increase in the total time taken to reach scoring position. This is a counterintuitive result that will be covered in more detail in the discussion section.

The NFL Time Management Efficiency Model 1.2 demonstrates that for every one timeout the offenses uses on the drive, there is an increase of 24.9 seconds in the time taken to reach the opponent's 35-yard line. The beta coefficient for timeouts available represents that for every increase of one timeout available to the offense at the start of the possession, there is a decrease of 14.06 seconds for the total time taken to reach scoring position. At a 90 percent confidence interval, starting field position would be a significant variable. The beta coefficient for starting field position indicates that for every one yard increase towards the opponent's territory, there is a decrease of .42 seconds in total time taken to reach scoring position. The insignificant independent variables in this model are defensive timeouts, whether the offense was at home, whether the two-minute warning stopped the clock, the number of star players on the offense, and if the game was tied.

DISCUSSION

There were many things found in both NFL Time Management Efficiency Models 1.1 and 1.2 that contradicted our thinking. We originally believed that the score differential would have a significant impact on the overall pace of the drive and the majority of the games we looked at were when the team was trailing late on the last possession, but the findings did not suggest that. Sackrowitz and Sackrowitz's (1996) theory about clock-neutrality and operating one's offense omitting time constraints is very difficult to analyze in the model because there is an unequal number of games tied and games between a 1 to 3 point score differential.

Romer (2006) discussed that the 35-yard line was the spot where a teams' choice to punt or kick a field goal changes. Ultimately, a goal of ours is to seek an average time for the games examined of approximately how long an NFL coach needs to maximize its chances of getting into field goal range. These findings suggest that the average NFL team needs at least 80 seconds, or one minute and 20 seconds, to produce a successful drive to the target of the 35-yard line. The mean quarterback rating was 84.5 (SD = 12.9; min = 50; max = 122.5) and the mean starting field position was at the 30-yard line, though the mode was the 20-yard line. The data suggests that a run from the 30-yard line, a quarterback with a passer rating of 84.5 and 80 seconds on the clock would get an offense in field goal range. Also, the mean for timeouts available is 1.83 timeouts and suggests a team would require almost two timeouts to make a run in 80 seconds from the 30-yard line.

Offensive timeouts used, as we had predicted, played a big role in impacting the drive. However, offenses that were within a 1 to 3 point score differential did not use all

their available timeouts. Only 10 of the 59 games featured instances where the team used all their timeouts and there were 21 games were the offense had two or three timeouts and didn't utilize them. Prince (2008) had had discussed how timeouts were placed at a great value and contributed heavily to the probability of winning. It is interesting how these timeouts were not used in over 35 percent of the games examined and suggests that offenses could be running 'clock-neutral', unconstrained styles of offenses. In a sense, it takes the team a bit longer to reach the 35 when they take a timeout and might even provide an advantage to the defense. While offenses face situations where a quarterback or coach must stop the clock, but it could provide the defense time to analyze the offense's intentions more thoroughly.

Model 1.1 showed a lot of insignificant variables for a model that has an R-squared of .9769. R-squared, as defined by Wooldridge (2009), is "the proportion of the total sample variation in the dependent variable that is explained by the independent variables" (Wooldridge, 2009, pg. 40). The R-squared explains how much of a correlation the entire model explains the dependent variable's relationship with the independent variables in a multiple regression analysis. In the case of Model 1.1, the overall model explains about 98 percent of the sample variance in the total time taken and its relationship with the independent variables in the multiple regression analysis.

Moreover, Model 1.1 produced a lot of insignificant variables for a model with an R-squared explaining almost 98 percent of the sample variation in the model. The variables that we perceived to maintain a high-level of significance were quarterback rating, whether the game was at home for an offense, the number of star players and starting field position, but they were all heavily insignificant at a 95 percent confidence

interval. This model also had timeouts available and timeouts used during the drive insignificant, which is contradictory to what Prince (2008) believed in teams caring more about timeouts than field position. Sackrowitz and Sackrowitz (1996) believed in player personnel as a critical component to the unconstrained offense, but the NFL Time Management Efficiency Model 1.1 found quarterback rating was insignificant ($p = 0.8770$) (Sackrowitz and Sackrowitz, 1996, p. 43). It is contradictory when the number of star players, which estimates NFL All-Pro players on a roster by season, is significant at 95 percent and the quarterback's passer rating is highly insignificant. Thus, it is strange when there is a large string of variables that are heavily insignificant with an R-squared at almost 98 percent.

The NFL Time Management Efficiency Model 1.1 falls captive to economic phenomena known as multicollinearity. Wooldridge (2009) defines multicollinearity where two or more independent variables have an excessively high correlation in a multiple regression model (Wooldridge, 2009, p. 96). Multicollinearity is perceived as bad due to the fact that it interferes with the model and affects the impact of similar independent variables within the model. Willams (2012) reports that multicollinearity can stem from improperly using dummy variables, incorporating variables into a model that is computed from other variables within, and using two highly correlated variables (Williams, 2012, p. 2).

There are three ways to rid the model of multicollinearity:

(1) Test the VIFs for each independent variable in the model

(2) Regress one independent variable on all the other variables and if the R-squared = 1, then there is multicollinearity in that particular variable

(3) Joint-Hypothesis Testing: do an F-Test of a hypothesis for two or three variables that appear highly correlated in a model

The NFL Time Management Efficiency model can be cleaned up and reduced to include the most correlated variables to the model. It is difficult to explain the reasons why Beta-coefficients and p-values were abnormal because a regression analysis will not explain the specific causal effects, but just the relationships between the dependent variable and independent variables.

The model only took into account the successful attempts to the 35-yard line and not the failed attempts. The fact that all 92 observations had success in reaching the 35-yard line might make a difference in why independent variables such as the score differential, defensive timeouts, whether the game was at home and the quarterback rating are insignificant. The significance of these variables could be better captured if observations were used that were failures, where the offense did not reach the opponent's 35-yard line. The home-field advantage factor could be correlated with the competitive advantage gained on the actual success or failed attempt of the kick, but this would be an entirely separate study to undertake.

The NFL Time Management Efficiency Model 1.2 cleans up the multicollinearity that was previously in Model 1.1. Model 1.2 excludes the offensive score, defensive score, whether the game was within a 1 to 3 point score differential and the number of seconds remaining when the offense reached the 35-yard line. Starting time was highly significant, which indicated that the number of seconds remaining in the game had a strong influence on the time taken to reach the 35 yard-line. In addition, both timeouts available and timeouts used were significant and if an offense used a timeout, it would

slow down momentum and allow the defense to plan. It takes an offense 25 seconds longer to reach the 35-yard line if a timeout is used, which allows substitutions for defenses to matchup to an offensive personnel package better and enhance the defense's playcalling.

The quarterback rating was significant, but the beta coefficient contradicted reasonable expectations of a successful NFL quarterback. The results suggested that a more inefficient quarterback would reach the 35-yard line quicker than a quarterback with a better passer rating, which is a result that most coaches would strongly question. This could be due to a small, misrepresented sample size and could be rectified if the study incorporated failures while possibly expanding the study to include more years of data.

CONCLUSION

Fortunately, the NFL Time Management Efficiency Model 1.1 did not disregard many factors. However, the limitations of the entire study include game weather conditions, placekicker abilities, opposing defenses, overtime games, and looking at the overall success rate of each drive. Some of these limitations are covered in the error term, which Wooldridge (2009) said that error term, often called the *u,* contains unobserved variables that affect the dependent variable (Wooldridge, 2009, p.23). Our study made a couple of mistakes in developing the original model by including so many correlated variables, but the test of Variance Inflation Factors cleaned this problem to an extent.

The most important thing that the overall study would include is testing the failed drives where a team and their offense do not reach the 35-yard line. The result of this

might put a greater emphasis on the team's personnel including the number of star players and the quarterback rating. In addition, the expansion of this study might not make multicollinearity an issue in a different model due to a higher number of observations to test. It would be interesting to analyze the number of timeouts specifically on the total time taken and gauge how many timeouts an offense needs to be successful, given a certain number of seconds on the game clock.

All these limitations and recommendations aside, the study incorporated a lot of variables and still is a great reference in understanding what an offense must have to provide the best opportunity to score in a final possession. This study looks at the precedent analyzing successful trips to the 35-yard line and interpreting specific factors that a coach and his staff should consider on the way down the field for a game-winning or tying field goal.

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