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The College Football Gambling Market An Empirical Approach

Brian McNeil

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Abstract

This study tests the efficiency of the college football gambling market and whether the market allows for profitable wagering. Operating upon the theoretical framework that, at any given time, prices fully reflect all information available in a particular market, I test for the existence of residual information that is not currently incorporated into the market, thus rendering it inefficient. This project expands upon several previous studies performed on sports betting – most notably that of Zuber, Gandar, and Bowers (1985), which examined the gambling market efficiency for National Football League games. The findings prove to be consistent with the conclusions reached in these prior analyses, which suggest that speculative inefficiencies exist within the market.

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Preface

The ensuing work examines the efficiency of the sports betting market with respect to college football through an analysis of the Vegas line. Market efficiency is the driving force behind the study, since existent inefficiencies can easily translate into exploitable and profitable opportunities for the market participant. In analyzing the overall efficiency of the sports betting market, or Vegas line, I will be using the vehicle of college football to gather data, perform tests, and draw conclusions. These conclusions will reflect on the ability of an individual to devise profitable waging strategies from the results obtained, along with the lessons for market efficiency.

Before delving any deeper into the specifics of the study, I would like to take this moment to offer the reader an insight to the origins of the project. Beginning back in the latter part of 2003, I had sat down with an admired professor of economics to discuss the possibility of pursuing an Honors Thesis. As a student-athlete, I was not surprised to see the conversation evolve into a sports debate, as had often been the case when professors discovered I am a member of an NCAA Division 1-A varsity team. Within short order, the professor and I were in complete agreement over the deplorable composition of the Bowl Championship Series (BCS). Before our very eyes, the perfect Honors Thesis topic presented itself for a student eager to fuse his two leading passions – sports and economics. The focus would be on evaluating the efficiency of the Vegas line (VL), while determining the predictive ability of other ranking systems. The predictive ability would, ultimately, be based on the extent to which residual information, not captured by the Vegas line, is incorporated in either the BCS, AP, or ESPN polls.

Further reasons for performing such a study on market efficiency soon revealed themselves. For one, there was the apparent need for a better ranking system to determine which two teams would play for the title of national champion. As it would soon turn out, 2003 would be the year that the BCS finally produced a split national champion – the last straw that broke the camel's back. It was time to think seriously about the future of collegiate football and how the NCAA's desire to preserve the age-old tradition of the bowl system was conflicting with the more important goal of crowning a [single] national champion. I aspire to offer the policy-makers (NCAA) a viable frame of reference in their attempt to strengthen the collegiate football playoff system by providing sound statistical evidence regarding the efficiency of the BCS and other ranking systems.

The project began with the intention of investigating the effectiveness of the BCS system. Ultimately, this end was achieved but through different means. Instead of making the BCS the primary focus of the study, it was found better to lay the spotlight on the market itself – the Vegas line. In doing so, I would indirectly be able to test the effectiveness of the BCS more efficiently than if I had tackled the issue straight on. The reason, of course, is the relation of the BCS to residual market information not incorporated in the Vegas line. Testing for the significance of this residual information within the BCS rankings would enable me to make inferences on the ability of the system to effectively predict the actual outcome in situations where the Vegas line erred.

The study implements a series of ordinary least squares (OLS) regressions as a means of assessing the exogenous variables. This method permits a thorough, yet easily interpreted, analysis of the four independent variables examined (VL, BCS, AP, and ESPN). I found it to be much simpler than adopting a probit model, which some contend allows for the circumvention of potential econometric possesses and is less sensitive to plausible outliers. However, I find that the method poses the considerable weakness of failing to include all relevant market information. In this case, such a weakness could pose devastating effects, since the examination of market information lies at the heart of the study.

The purpose of this study is threefold. First, it is my intention that reader acquires a greater understanding of markets and the characteristics necessary for a market to become efficient. I devote a significant portion of the work to explaining the underlying theoretical framework that links knowledge of efficient markets to the world of sports betting. Secondly, I intend for the reader to be able to extract practical and valuable information that can applied to their current waging strategies for further benefit. Finally, I wish to broaden the area of interest on the issue of market efficiency so that future studies may offer answers that neither my predecessors, nor myself, could fully provide.

For numerous reasons, a study of this nature retains significant meaning. The implications it renders upon the extremely affluent industry of the sports betting market could result in market participants realizing greater returns, while the bookmakers incur a greater loss. A market with such a large volume retains a great deal of importance in the social and political realms. My only regret in performing the study is that I only had the time to gather data and perform tests for a single season. A larger sample size, indeed, would have provided more concrete evidence for the conclusions that were ultimately reached. Nevertheless, the study was performed with acute due diligence and I feel confident in the results that ensued.

This study was created with a wide audience in mind. Economists and scholars, alike, will take interest in the theoretical application of the Efficient Market Hypothesis to the sports betting market. Gambling market participants and sports fanatics will find solace in the conclusions provided, which could potentially enhance their waging strategies. Most importantly, however, this piece is directed towards policy makers of the NCAA and those aspiring to establish efficient markets in new domains. I hope that this work enables you to take a step in the right direction in your unrelenting search for a sensible answer.

Acknowledgements

This piece never would have been made possible without the support and assistance of several key individuals. First and foremost, I would like to formally thank both my parents for encouraging and endowing my attainment of higher education. If not for their support and inspiration over the years, I certainly would not be where I am today. Secondly, this work never would have achieved its full potential without the guidance and motivation provided by Professors Horrace and Lovely – two individuals who have defined the quintessence of Syracuse University through their devotion to their students and to their profession. Finally, I would like to acknowledge the much appreciated patience maintained by two very understanding women – my coach and my girlfriend. Their tolerance of the endless venture of pursuing an Honors Thesis Project did not go unnoticed each and every time it caused an inconvenience in one of their lives. To all of these people, I offer my sincerest gratitude and hope that this study affects you one way or another, just like it affected me.

I. Introduction

For decades, a motivating concern among gamblers and financial investors alike has been the existence of market inefficiencies. The ability to exploit opportunities within various markets and realize above normal profits from provisional inefficiencies is the driving force behind perpetual market activity. In addition, the functional similarity between disparate markets is astonishing. The fact that the stock market behaves utterly congruent to that of the gambling market has produced fascinating and useful literature over the years. Through the application of such literature and financial theory, along with taking a fresh angle upon the gambling market via college football, I intend to test for inefficiencies inherent within the gambling market. If significant inefficiencies are proven to exist, then it can be concluded that investors in the gambling market are provided with a viable opportunity to employ profitable waging strategies. This opportunity is presented to investors through alternative means of reference containing residual market information that has not been incorporated in the Vegas line, or spread. As will be revealed throughout the ensuing proposal, the study I plan to pursue possesses much practical, as well economic, significance. By utilizing the findings of this empirical analysis, an investor in the gambling market will, potentially, be able to sustain a sizeable advantage over other market participants. The following project was selected in an attempt to fuse my two principal passions: sports and economics.

II. Previous Studies of Sports Betting

This study extends a statistical analysis of the gambling market performed by Zuber, Gandar, and Bowers (1985). These economists test for the existence of exploitable market inefficiencies in National Football League (NFL) gambling. This particular study builds upon the work of Vergin and Scriabin (1978), who investigate the existence of potential biases in the setting of point spreads for NFL games. From these biases, Vergin and Scriabin are able to develop distinct betting strategies that enabled profitable wagering to occur. Similarly, Zuber *et al.* test for market efficiency and the ability to earn speculative profits by adopting a stronger, more direct method that utilizes an explanatory model of actual point spreads.

With respect to market efficiency, Zuber et al. contend that the gambling market is deemed to be efficient "when the rate of return to any gambling strategy based on publicly available information approximates the bookmaker's vigorish." (The vigorish, commonly referred to simply as the "vig," is merely the commission earned by bookmakers on all losses.) If significant divergence from efficiency in the gambling market exists, thereby creating market inefficiencies, then the window of opportunity for profitable gambling strategies is believed to be open. Starting with a "weak" model, Zuber and his colleagues tested for efficiency within the market by assessing the ability of the Vegas line to predict point spreads. Then, by applying data on spreads obtained from the first eight games of the sixteen-game NFL season, they are able to construct a stronger, explanatory model that offers predictions on point spreads in the latter half of the season. Through the use of publicly available information on NFL games, Zuber *et al.* devise an explanatory model that contains a number of observable variables. Through the implementation of ordinary least squares (OLS) regression, they use this model to predict future game outcomes. Ultimately, they conclude that speculative inefficiencies are, indeed, present within the gambling market. However, it is not conclusive that these apparent speculative inefficiencies imply *market inefficiency*.

The technique adopted by Zuber *et al.* in their exploration of market inefficiencies within the NFL betting market serves as a model for the implementation of my study, as well. Performing both a weak and strong test of statistical significance with multiple exogenous variables enables one to observe the different implications that each variable possesses. For example, in carrying out the weak test one might find that several independent variables maintain significance at very high levels. Once the strong test is completed, however, one might then conclude that very few, or even none, of the exogenous variables retain their initial levels of significance. Accordingly, the varying degrees of the strength of the tests performed allow for the observance of each variable's significance in diverse scenarios. It also permits the reader to witness the progression of each variable's significance as the level of the test's potency increases.

Over the years, the market efficiency literature has presented two distinct definitions of "efficiency." The first, which takes on a narrow view held by those in academia, suggests that "the return from any betting strategy should be negative and equal in magnitude to the commission of the betting house" (Brailsford, 170). The broader, more practical definition maintains that "no betting strategy should yield significantly positive returns (after commissions) on average" (Brailsford, 170). The definition referred to henceforth, when discussing the topic of efficiency, is the latter or broader view.

The definitions presented above can be further paralleled to the weak and strong tests previously discussed. There exists a profound relationship between the academic definition of efficiency and the weak test for examining market efficiency. Likewise, there is a noteworthy affiliation between the more practical definition of efficiency and the stronger test that can be executed. This connection can be observed upon analyzing the results obtained from an execution of the strong test. Any variables that prove to be statistically significant in this test suggest that sufficient inefficiencies are inherent within the market. The occurrence of such results from the strong test may lead to the exploitation of existing inefficiencies, thereby violating the practical definition of market efficiency.

Analysis of gambling market efficiency was expanded by Golec and Tomarkin (1991), who study not only professional but also college football data. Examining fifteen years worth of NFL and college football results (1973-1987), Golec and Tomarkin find that professional football gamblers over-bet favorites, especially on the road, while the college football market does not. Dare and McDonald (1995) test the college football market using a similar time-series method. However, using data that ranged over a thirteen-year span (1981-1993), the two economists could not reject efficiency within the gambling market.

A related study by Brailsford, Gray, Easton, and Gray (1995) examines the efficiency of the two major Australian betting markets using probit and ordered probit models, in preference to traditional OLS regression methodology that was employed by Vergin and Scriabin and Zuber *et al*. In contrast to OLS, probit employs a (0,1) dependent variable methodology. This probit model is tailored to the unique structures of both the Australian Rugby League (ARL) *FootyTAB* and Australian Football League (AFL) *Footywin* markets. The use of the probit model permits the circumvention of potential econometric problems, while also proving to be less sensitive to plausible outliers, thus making its estimates more robust.

Brailsford *et al*. take market efficiency analysis a step further when they introduce and examine the parameters of home-field advantage and underdog conditions. Like Zuber, they conclude that some betting strategies are able to generate sufficient positive returns [in both the ARL and AFL], but they remain cautious on interpreting these findings as conclusive evidence of market inefficiency. The Brailsford *et al.* study, moreover, concludes that the applied probit model fails to include *all* relevant market information. This is due to the fact that numerous variables with the potential of possessing informational content were excluded from the model. In addition, the probit model assumes normality among distribution errors, which is disadvantageous in analyzing point spreads since the errors not believed to be randomly distributed. Nonetheless, both studies imply that transaction costs are extremely high on account of most states treating gambling as an illegal activity. They further reveal that there tends to be a propensity for the market to over-support low probability teams and under-support high probability teams. This indicates that there is a perception among market participants that favorites fail to beat the spread more times than not.

A more recent application of the Brailsford study performed by Paul, Weinbach, and Weinbach (2003) expands upon the notions of home-field advantage and underdog waging. Using college football data over a twenty-five-year period (1976-2000), they determine that the market is generally efficient; yet certain circumstances prevail that enable for profitable gambling. Their study reveals that when wages are placed on home teams who are underdogs by more than twenty-eight points, sufficient profits are able to be realized. According to the authors, "the strategy of betting home underdogs of more than twenty-eight points rejects the null hypothesis of a fair bet for the entire sample and actually violates the null of no profitability during the last ten years of the sample" (Paul *et al*., 2003). For example, in the five-year span from 1991-1995, home underdogs who were spotted by more than twenty-eight points by the Vegas line held a winning percentage of 73.68. This anomaly suggests that major inefficiencies are present within this particular segment of the gambling market from which sufficient returns can be realized by sharp market participants. Such statistics confirm that considerable inefficiencies are present within this particular sector of the market. Nonetheless, one cannot conjecture from this evidence that the college football market, in its entirety, is inefficient. It simply proves that there exists an exploitable segment of the larger market from which market participants can yield positive returns.

Reasons for the apparent inefficiency within the home/large underdog market are two-fold. For one, there exists a propensity among market participants to place wagers on favorites – especially large favorites. This tendency stems from the prevalence of information asymmetry, in which a greater amount of information is made available via television, the Internet, newspapers, and magazines regarding the more superior teams; while less information tends to be offered on the obscure, smaller-name schools. This leads to a trend of over-betting the favorite in the market (Paul *et al*., 2003). The other reason for the lingering inefficiency with respect to home/large underdog market is due to the relative infrequency of the betting strategy. Within the last five years of the sample, this particular betting condition occurred only 37 times. Regardless, it has still proven to be a viable waging scenario for all market participants.

The aforementioned studies are built upon the economic theoretical foundation established by past literature. Such works discuss the significance of psychological factors with respect to financial markets, such as Hiesler and Thaler (1994). Others expand upon this notion of psychological factors being tied to market activity by commenting on the power of overreaction. The theory of overreaction, as discussed in the works of De Bondt and Thaler (1985, 1987), suggests that the stock market tends to overreact to new information. Clarke and Statman (1994) even speculate that certain stock returns gain "momentum," which poses a unique dynamic upon the market. They contend that these auspicious stocks acquire momentum and, thus, are enabled to continue to realize positive excess returns. Such theories can be easily related to the gambling market, given its striking behavioral similarity to that of the stock market. For example, Clarke's momentum theory can be applied to the betting market to the extent that teams often exhibit winning or losing streaks. These "streaks" pose the same effect upon the market as that of a growth stock which has acquired considerable momentum. One commonality shared by all prior works on the issue of sports gambling is their focus on market efficiency (refer to Table 1). Each study offers a unique dynamic into the world of sports betting, as it relates to the overall market of Vegas. From these studies, I have been able to generate and adopt various ideas in regards to the means in which market efficiency in college football will be examined. By deriving/fusing together several possible approaches from former analyses, in addition to offering my own form of market evaluation, I will be able to formulate my ultimate research question. This, specifically, will require adopting the dual-implementation of the weak/strong test for market efficiency utilized by Zuber; the consideration of home-field advantage proposed by Brailsford; and an assessment of the ever-so-profitable role of the underdog – made renowned by Paul et al. Although the study I intend to perform will differ from my predecessors in the sense that it does not incorporate time-series regression, the test will assimilate a substantial data sample by taking a cross-sectional regression approach to establishing the viability of inefficiency within the gambling market.

Despite the extensive literature on market efficiency with respect to both gambling and financial markets, there still persists an unsettled issue. This issue proves to be whether speculative inefficiencies allow for consistent positive returns *and* whether such speculative inefficiencies imply overall market inefficiency. The studies by Vergin, Zuber, and Brailsford all concluded that profitable gambling strategies could be applied to market inefficiencies in order to generate significant positive returns. *However*, none of the three were able to determine that these meager, speculative inefficiencies translated into market inefficiency. Therefore, noteworthy opportunities for profitable wagering fail to exist on account of the market being predominantly efficient. I intend to contribute to the literature on market efficiency by adopting the same basic economic framework established by my predecessors and applying it to a new sphere of the gambling market: college football. Analyzing this segment of the gambling market poses several advantages. The vast number of teams increases the number of observations, which translates into more accurate results. In addition, college football utilizes numerous polls, or sources of market information. This plethora of information will enable one to effectively test for possible inefficiencies inherent within the market for college football and, more importantly, permit one to determine whether these inefficiencies allow for profitable wagering.

Table 1 – Previous Work on Sports Wagering

Author	Data/Time	Method	Principal Findings
Vergin & Scriabin (1978)	NFL regular season (1983)	OLS	-Speculative inefficiencies exist but do not imply market inefficiency
Zuber, Gandar, & Bowers (1985)	NFL regular season games (1969-1974)	OLS (Weak and Strong Tests)	-Confirms findings in Vergin study, plus introduces possibility of high transaction costs
Golec & Tomarkin (1991)	Collegiate & professional football games (1973-1987)	Time-Series	-Professional football gamblers tend to over-bet the favorite (esp. on the road), while gamblers of college ball do not
Dare & McDonald (1995)	College football regular season (1981-1993)	Time-Series	-Efficiency within the gambling market for college football could not be rejected
Brailsford, Easton, Gray, & Gray (1985)	Australian Rugby League (ARL) and Australian Football League (AFL) games	Probit & Ordered Probit Models	-High transaction costs -Propensity to over-support low probability teams -Probit fails to include all relevant market information
Paul, Weinbach, & Weinbach (2003)	College Football regular season (1976-2000)	Log Likelihood Test Statistics	-Betting on home underdogs of large spreads (more than 28 pts) proves to be profitable

III. The Sports Gambling Market

Before testing for inefficiencies present within the gambling market, it is necessary to understand its institutional structure. Institutional issues that shape my economic approach range from how each spread is determined to the role of the Bowl Championship Series. The efficiency test to be conducted is specifically informative of one segment of the gambling market, the Vegas line. By using the Vegas line and college football data as a vehicle for analyzing the gambling market, I hope to provide the reader with valuable insights into the operations of the sports betting market and with a greater understanding of what constitutes overall market efficiency.

i. Gambling Market

Before placing a wager on a college football game, the gambler first refers to the "spread," or Vegas line, on the contest being considered.[1] A game's point spread can be defined as "a handicap used to even the odds of a particular sporting event" (About.com). The initial line for each matchup is determined by taking into account various opinions regarding the expected outcome of the game in question set forth by established experts, who are usually incorporated in Las Vegas. From there, the spread is continuously updated by the bookmaker and the line shifts as more bets are placed. This occurs in order for the bookmaker to remove himself or herself from exposure to unnecessary risk. As a result, the Vegas line on particular games "moves to reflect the collective judgment of gamblers about its outcome" (Zuber et al., p.801).

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[1] It should be noted that participants within the gambling market use the terms spread, line, and price interchangeably.

If gamblers are efficiently utilizing the available market information, it can be expected that the final point spread on each game will be the most accurate, unbiased forecast of said game's outcome. The possibility exists, however, for lingering market information to be excluded from the Vegas line. This residual information not considered by the spread could be included in such rankings as the BCS, AP Poll, or Coaches' Poll. The occurrence of such a scenario would render the gambling market (i.e. Vegas line) inefficient, in that it provides gamblers with the opportunity to pursue lucrative waging strategies.

As previously mentioned, the principal reason for the constant evolution of the spread prior to the commencement of a sporting event relates to the bookmaker's desire to avoid exposure to unnecessary risk. The inherent force that ultimately shifts the line on a particular game is dependent on the overall money volume. The spread will not change with each additional bet placed, but the bookmaker will adjust the line accordingly if he or she notices an imbalance in the placement of wagers. The ideal situation for a bookmaker is to have fifty percent of total bets fall on each side of the line at the time of the event. By achieving this goal, the bookmaker reduces all risk associated with issuing returns because the capital collected off the losses will be enough to cover total cash disbursements, or the amount paid out to winners, while also leaving him or her with a profit obtained through the vigorish. Therefore, when a gambling market participant incurs a loss on a bet, that person is required to pay the full amount wagered plus the vigorish, which is usually a percentage of the actual bet.[2]

ii. Legal Issues

Similar issues related to sports wagering involve the matter of legality. To this day, placing a wager on a sporting event remains illegal in many states. Legally speaking, gambling (on sports) is currently prohibited in forty-six of the fifty states within the U.S. The Professional and Amateur Sports Protection Act (PASPA) of 1992 outlawed sports wagering in all states with the exception of Nevada, Oregon, Montana, and Delaware (Perterson, 12/25/04). Atlantic City, located in New Jersey, was only recently (end of year 2004) granted permission for their 12 casinos to accept bets pertaining to sporting events. Thus, sports wagering was illegal in Atlantic City at the time of the study, since I am examining the college football season for year 2000.

Despite the illegal nature of sports betting, the ease with which one can place a wager on any given day is remarkable. With the rise of technology, gambling market participants need not even leave the comfort of their own home to place a bet on a sporting event. Hundreds of websites enable people to check spreads and place bets within minutes. It proves easier and more entertaining than purchasing shares or bonds in the financial market, which has perhaps fueled the sports gambling market's rapid growth in recent years. Although online gambling was only in its infancy at the time of this study, there were nearly 4.5 million online gamblers in the year 2000. Total

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[2] A typical vig on a wager placed in the sports gambling market is 5% or 10% of the actual bet placed. [Commission] rates vary among bookmakers within the market; they establish the vigorish as they see fit.

sports betting accounted for 43% of the gambling market in 2001, raking in $15 billion in revenues – second in the market only behind that of online casinos (Microgaming.com). Within four years the size of the market has doubled and current online sports wagering revenues exceed $7.6 billion. This figure merely reflects those bets placed online and fails to take into consideration the revenue generated by legal casinos, along with other offshore venues. Even if all profits generated by established operators were aggregated to determine the size of the market, the estimate would not be accurate due to the existence of the black market sector of the industry. This makes one realize just how large the sports gambling market truly is.

Aside from submitting wagers online, people can engage in the gambling action by contacting a bookmaker and placing a bet over the phone. The bet can be made at any point before the inception of the sporting event and after the initial line is posted by Vegas. This proves to be the most traditional form of placing a wager, since participants within the market tend to develop a relationship with individual bookmakers and use that same person when placing all future bets. However, many bookmakers in today's society tend to be illegitimate operators. This means that they do not represent any casino or online corporation, but have entered the industry on their own accord in the aspiration of realizing significant profits. Thus, these bookmakers constitute the black market in the sports gambling industry since their operation is illegal and their revenues are not recognized by the government.

Although sports gambling remains illegal in most states, many bookmakers get away with their illicit operations because the money volume is so large. As discussed earlier, the gaming market is immense, pulling in tens on billions of dollars annually. Consequently, it proves to be of little avail for the government to crack down on an illegitimate bookmaker who might be recording revenues in the neighborhood of tens of thousands. This is not to say that the government has not, nor will not, prosecute bookmakers caught for engaging in gambling practices outside the established jurisdictions of Nevada, Oregon, Montana, Delaware, or Atlantic City.

While the government has made diminutive strides in terms of establishing a precedent that punished individuals for participating in the sports gambling market, the NCAA has been working hard to prevent its members from entering the market. Although the association cannot impose any legal penalties upon its members who choose to partake in the gaming market, it has publicized a variety of consequences that will be issued to any violator (NCAA.com). For example, according to the rules of ethical conduct set forth by the NCAA:

> "You are **not eligible** to compete if you knowingly: provide information to individuals involved in organized gambling activities concerning inter-collegiate athletics competition; solicit a bet on any intercollegiate team; accept a bet on any team representing the institution or solicit or accept a bet on any intercollegiate competition for any item (e.g. cash, shirt, dinner) that has tangible value." [Bylaw 10.3]

Despite their inability to prosecute those athletes who participate in sports wagering, the NCAA has found an alternate way to punish those individuals – by taking away their eligibility. However, if it is found that an athlete altered the outcome of any game in order to realize a profit from the unexpected outcome, then that person would be subject to a prison sentence. This act is referred to as sports bribery and is illegal all states, including Nevada. Whenever an individual places a bet on a sporting event in which he or she is participating in, then the market is immediately rendered inefficient. This is due to the fact that there exists conflicting interests and the athlete has the potential to alter the outcome of the game.

Although the government has the power to prosecute individuals who partake in sports bribery, they will not rebuke any athlete who gambles on games in which said individual is not competing in. Much to the chagrin of the NCAA, the strongest penalty that can be imposed on athletes participating in the gambling market is the eradication of the athlete's eligibility. The NCAA has lobbied the government to inflict harsher penalties upon those athletes guilty of sports wagering, but they simply will not do it. Reason being, there is just too much money at stake. The sports gambling market is a thirty billion dollar industry and a significant portion of that amount reaches the government in forms of taxes paid by established gambling operations. If the government were to make gambling illegal for all athletes, they might lose a considerable portion of their tax revenues – a hit that they are not willing to take.

iii. Collegiate Football

Now that the intricacies of the sports betting market have been established, it is necessary to discuss the nature of college football competition and the role of the Bowl Championship Series (BCS). College football in the United States prides itself in honoring the age-old tradition of the "bowl" system. For nearly one hundred years the NCAA has preserved this method, which proves to be extremely dissimilar to most playoff systems. Unlike that of collegiate baseball, basketball, or hockey, the bowl system employed by the sport of football does not rely on a tournament procedure to determine the overall champion. In a tournament system, the top-ranked teams eliminate one another in structured competition until only one team, the victor, remains. In contrast, the bowl system merely selects qualified teams of equal ability to engage in a one game playoff, with the two best teams being placed in a head-to-head matchup. Controversy over which two teams are "best" each year has forced the NCAA to seek out a more objective and impartial post-season system. In desiring to achieve these ends, the association has been extremely hesitant to stray from time-honored tradition of the bowl system. It has been concluded that improvements are necessary, but these improvements will not arise from the abandonment of the bowl system.

In 1998, the BCS was created by Southeast Conference (SEC) commissioner Roy Kramer in an effort to enhance the bowl system by presenting an innovative method for determining the national champion in college football (bcsfootball.org). The BCS is simply a formula used by the

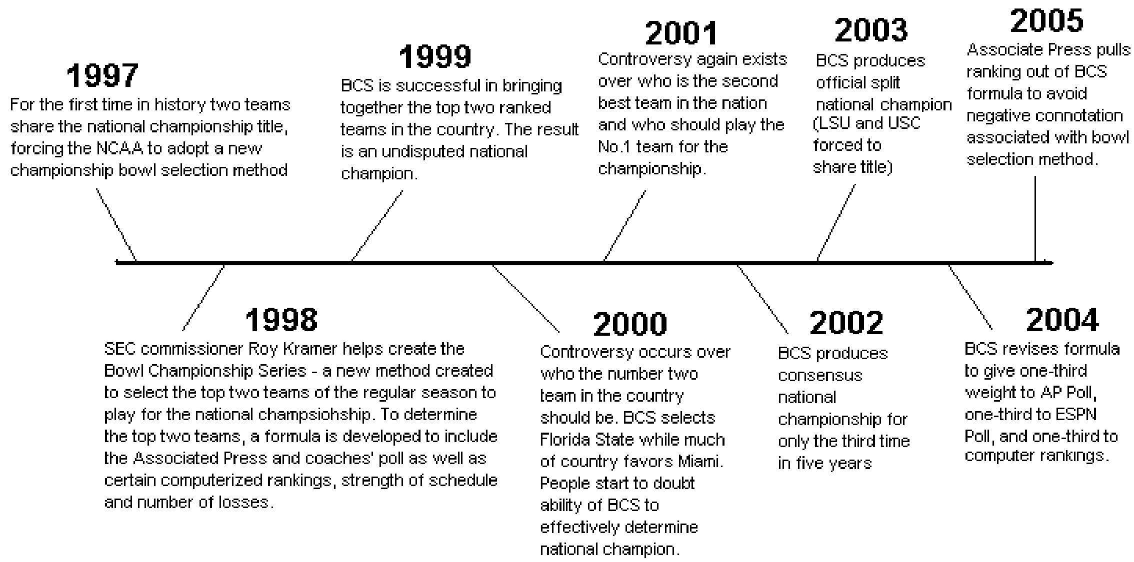
NCAA in an attempt to have the two best teams compete against one another at the end of the season. This formula incorporates rankings from the Associated Press Poll and ESPN/Coaches' Poll, six computerized rankings, strength of schedule, and number of losses. The formula then produces a standing known as the BCS ranking. This ranking is not revealed until the seventh week of each season, however, due to the fact that data need to first accumulate before being inserted into the BCS formula. Following the 1997 season, in which two teams (University of Michigan and University of Nebraska) split the national championship title, it was apparent that change was imperative. This gave rise to the formation of the BCS, which would be implemented the following year and maintain an eight year contract with six partnering conferences (ACC, SEC, PAC-10, Big 12, Big Ten, and Big East).

The BCS is structured so that each conference champion, plus two "at-large" teams, can compete in one of the four championship bowl games. These four bowls, Fiesta, Orange, Rose, and Sugar, constitute the Bowl Championship Series. In addition, the national championship game rotates annually among the four bowls, in an effort to evenly distribute revenue to each venue and community. The two at-large selections in the BCS are open to any Division 1-A team. These teams, however, must be ranked within the top twelve in the final BCS standings and maintain a record boasting at least nine wins during the regular season.

The ESPN/Coaches' Poll rankings are obtained by collaborative voting efforts of thirty various Division 1-A coaches who are randomly appointed to the committee. The team receiving the most number one votes is, naturally, ranked at the top of the poll and the one receiving the least is at the bottom. The most publicized of the rankings, however, are merely those teams who are fortunate enough to make the top 25. Similarly, the Associated Press (AP) generates its rankings by seeking out the opinions and votes of a committee of established media sportswriters. These rankings are often similar to, but differ slightly, from the analogous ESPN rankings. The most revered AP rankings include those teams included in the top 25, as well.

It is tough to say whether the game of college football has been enriched by the adoption of the BCS system. While effectively preserving the bowl method of post-season play, the BCS has received much criticism for its ineffectiveness in matching up the best two teams. It is often the case that there exists a large gap between the top-ranked team in the country and the remainder of the competitive field. As a result, controversy arises in regards to which team is second best and deserves to compete against the No.1 team in the final game for the national championship. In 2003, the BCS even produced a split national champion proving that this system does not appear to be the definitive answer that college football administrators are looking for in their mission to consistently crown an undisputed champion year-in and year-out. In addition, critics reserve opinions for the inability of the BCS to consistently and efficiently place teams of equivalent ability against one another in the remaining three bowls. The full progression of the BCS since its inception is revealed in Figure 1.

Figure 1 – BCS Timeline



In defense of the system, proponents of the BCS argue that it was devised strictly for the purpose of determining the national champion of college football – the other bowls in the series are purely secondary. University of Nebraska Head Coach Bill Callahan was quoted stating, “I feel very strongly about the BCS format... It allows for great interest and fan following and allows for the great tradition of the bowls to continue” (bcsfootball.org). Aside from merely preserving the bowl tradition, it has been argued that if a sixteen-team, NFL-style playoff system were to be adopted in college football, then regular-season games would be less meaningful. If the regular season were to become less significant, then these games would be less interesting to their fans. This would pose a detrimental effect to universities’ revenue streams nationwide, in terms of reduced ticket sales and lost television contracts (Suggs, 11/17/03).

One organization, in particular, that has expressed utter disappointment in the BCS system is the Associated Press (AP). Their dissatisfaction with the post-season, bowl selection method culminated in late 2004 when the AP pulled its ranking out of the BCS formula. In a cease-and-desist letter, the AP asserted, "BCS has damaged and continues to damage the AP's reputation for honesty and integrity in its news accounts through the forced association of the AP poll with the BCS rankings" (Wharton, 12/22/04). In their defense for retracting the poll, the AP emphasized the fact that it had never officially sanctioned its use by the BCS. This event, undoubtedly, will add even more confusion to the already chaotic method of selecting collegiate football teams to participate in post-season play. Now, with a major component taken out of the equation, the BCS will surely face its most significant reorganization since its inception (Solomon, 12/22/04).

iv. Market Efficiency

The concept of market efficiency, which was presented in the previous chapter, indicates that the spread is designed to incorporate all publicly available and relevant market information. Conversely, the gambling market is rendered inefficient when there is believed to exist residual, or addition, information not incorporated in the spread. Such residual information could accumulate in other sources, such as peripheral ranking systems or articles written by amateur correspondents. These sources may offer information not incorporated in the Vegas line on account of certain variables. These variables include the weight, bias, or confidentiality associated with information being provided. For example, the ESPN/Coaches' rankings are regarded as a legitimate source of market information, but there could exist residual information within the rankings due to the biases of the coaches who participate in the rankings. Vegas recognizes the bias attached to the rankings produced by the coaches' poll and, as such, places less weight on them when establishing placement of the line. However, this is not to say that a market participant could profit from the bias if the residual information captured within the rankings proved to be significant.

Similarly, an undergraduate journalism major may possess certain private information in regards to his or her college's team after conducting an in-depth investigation on the team's no-huddle offense. This story could then be produced in the school's newspaper, revealing significant residual information not reflected by the Vegas line. Although this article would be accessible to the public, the likelihood of market participants reviewing all collegiate publications for residual market information is slim. However, in examining the consistency of a writer's predictions or a ranking's accuracy, one can determine if residual market information indeed exists which would allow for sufficient profits to be realized.

IV. Theoretical Framework

The economic theory upon which the following empirical analysis is constructed is that of the *Efficient Market Hypothesis* (EMH). This theory was made famous in 1970 by Eugene Fama, who affirmed that, "At any given time, prices fully reflect all available information on a particular stock and/or market" (Investopedia.com). This supposition, thus, negates any systematic advantage a particular investor may possess in predicting a return on a stock price. Although this theory was formulated with the financial markets in mind, it can certainly be applied to that of the gambling market. As discussed earlier, there exists a remarkable similarity between the two markets. An investor's ability to predict future stock prices is similar to that of a gambler who wishes to predict the eventual outcome of a sporting event.

i. Gambling Market v. Financial Market

The parallels between the stock and gambling markets can be made on a number of levels. The first comparison can be drawn, as noted above, through an application of EMH. The theory is based on the observation that, "In order for a market to become efficient, investors must first perceive that a market is inefficient and possible to beat" (Investopedia.com). This perception has clearly been adopted by participants in both markets, as evidenced by the time-honored popularity of the NYSE and the inconceivable revenue streams generated by Las Vegas. In each of these markets, investors and gamblers alike hope to capitalize on residual information that has not been incorporated into the market, perceiving it to be inefficient. The ability to generate significant returns from apparent market imperfections is a primary motivation for participants in each market.

Further similarities between the stock and gambling markets can be observed on the most general of levels. For example, in order to participate in either market, one must engage in the organized exchange of buying and selling on the open market. Just as a stock broker trades financial securities on behalf of his client (the market participant) on the floor of the stock exchange, so too does a bookmaker in Vegas; the only difference being that the latter sells various point spreads instead of financial securities. This disparity does not represent a fundamental difference in respective market structures, but rather a distinction in pricing conventions. Furthermore, brokers and bookmakers are both representatives of the market participant and receive commission from the investments set forth by said participant. They represent market participants on each side of the market in order to reduce inherent market risk associated with buying stocks and taking bets, as previously discussed. This risk arises from the uncertain outcome of a given financial security or sporting event. The nature of uncertainty involved with participating in either market contributes to the volatility within those markets.

ii. Properties of EMH

A particular property of EMH that is germane to the activities of the financial and gambling markets is that of *Random Walk*. With its origins set in a financial framework, this theory maintains that, "Stock price changes have the same distribution and are independent of each other, so the past movement of a stock price or market cannot be used to predict its future movement" (Investopedia.com). The same premise can be applied to the gambling market, in which it is recognized that point spreads are completely independent of one another and that historical progress is irrelevant when predicting future outcomes. Advocates of the random walk theory also contend that additional risk is assumed by the investor who tries to outperform the market.

Although the idea of random walk holds true in the financial market, it is met with much protest in the gambling arena. Opponents of the concept maintain that in an area of interest such as sports, one cannot contend that prior matchups and historical data are irrelevant in predicting a team's future success. While a significant aspect of unpredictability in regards to forecasting game outcomes certainly endures, the valuable information offered by past performances speaks volumes about what market participants can expect in the future. For example, if Team A has beaten Team B the past fifteen straight years at home, then this historical data would suggest that the outcome of their next encounter would be in favor of Team A. Such a remarkable streak will certainly be observed by market participants and the availability of market information will be reflected in the placement of the spread. Thus, the gamble becomes *not* will Team A beat Team B, but will Team A beat the spread in beating Team B. Market participants will need to exercise sincere judgment when placing their wagers if they aspire to yield a positive return. This judgment will, undoubtedly, be based upon all the knowledge acquired on each of the two teams – ranging from performances in previous contests to their ability to play in various weather conditions. Such reliance upon past trends, however, will not be enough for the market participant to generate positive returns. This is due to the fact that past outcomes are presumed to be included in the price, or spread, as the random walk conception indicates. Thus, the judgment must be based upon the market participant's mere intuition, or educated opinion, upon acknowledging the random nature exhibited by excess returns.

In a further extension of EMH, David Hirshleifer examined the effect of investor psychology in asset pricing. In his study, risk and misvaluation proved to be the leading factors in determining security expected returns. Hirshleifer believed that there exists a "social process by which people form and transmit ideas about markets and securities" (Hirshleifer, 2001). This social process can be similarly viewed in the gambling market, where media agents, reporters, and analysts provide substantial market information to market participants who, then, circulate the acquired ideas to the public. Equally visible within the confines of the gambling market is the concept of overreaction, which Hirshleifer addresses, as well, in his analysis. He attributes this overreaction effect to the arrival of good news, which causes investors to react excessively. This is often seen in the gambling market, for example, when a team reacquires one of its marquee players from injured reserve. Market participants have a propensity to overreact at the news of a star player returning to the lineup; this overreaction takes the form of irrational betting. Such wagering proves irrational in the sense that market participants have failed to fully consider the lingering effects of the player's injury along with the forfeiture of experience that occurred while the player was sidelined. This overreaction leads would eventually lead to profitable opportunities on the other side of the bet and, thus, market inefficiency.

iii. Conditions for Market Efficiency

The concept set forth by Hirshleifer in regards to investor psychology centers upon the notion of **rationality** – a characteristic of market efficiency. In order for a market to be efficient, there must first exist a group of rational participants. If the market is believed to contain any irrational investors (that is, the participant is not utilizing available market information in order to derive positive returns), then inefficiency may result. For example, if a set of market participants were to select games at random on which to place bets and formulate their wagers based upon a coin flip (Team A being heads; Team B being tails) as opposed to market information, then these actions could pose significant repercussions upon the market in which they partake. Such irrational betting strategies would shift the lines on the games in which wagers were placed, rendering the market inefficient and opening the door for rational investors to realize sufficient profits. Market inefficiency and swinging spreads would only occur, however, if the volume of irrational investors is high. The effect irrational betting poses upon the movement of the spread would be lessened if there were only a handful of irrational participants within a sizeable market.

Volume proves to be another necessary characteristic that a market must possess in order to generate efficiency. One assumption of the concept of market volume is that of participation – another characteristic of market efficiency. Before the gambling market is able to attain a high volume of bets there must simply be a desire for people to participate in the market. Therefore, participation [of rational investors] is the first step towards achieving market efficiency. As mentioned above, a market will not become inefficient unless the volume of irrational participants is significant. The same concept holds true for the converse, as well. That is, no market will be able to become completely efficient unless there is a substantial quantity of rational investors. The greater the degree of participation within a market (assuming the investors are rational), the more prices reflect all available information and the closer to efficiency a market will become. A high volume results in the Vegas line being placed in the most accurate position, since the line shifts accordingly as bets accumulate so as to reduce the bookmaker's risk.

The final attribute that a market must possess in order to be efficient relates to **information**. The market price must fully reflect all relevant information that investors employ in an attempt to realize positive returns. The aggregate information is then used to price stocks, securities, spreads, etc. This information must be widely available to all market participants in order for the market to be considered efficient. If private, or inside, information is used by a subset of market participants, then they will undoubtedly sustain an advantage over other investors, thus rendering the market inefficient.

There proves to be a distinct difference between *private* and *residual* information, which many people fail to realize. Private information exists when an investor possesses knowledge about an expected outcome that supersedes the knowledge held by other market participants. For example, an athletic trainer at a major university may be mindful of a concealed injury that one of his athletes is going to play through in an upcoming contest. If this trainer decides to place a bet on the game in question, then the private information that he or she has exclusive access to will put the remainder of the market at a disadvantage. Residual information, on the other hand, exists when a market participant obtains additional information that is not readily available to all investors and, thus, has not been incorporated in the pricing of a financial security or spread. This participant has no particular relation to the organization with whom he or she is investing, but is able to acquire this information through extensive research and investigation. If residual information exists, then speculative inefficiencies within the market can be exploited by the market participant who retrieves it. These exploited inefficiencies result in realizing more consistent positive returns, while sustaining an advantage over other investors. Expectation of these inefficiencies alters the market price and is an essential part of the process by which markets are made efficient.

iv. EMH Applied to College Football Betting Market

As a test of the efficient market hypothesis, I determine whether any residual information exists within the gambling market from which sufficient profits can be realized. To test efficiency, I estimate the relationship between the Vegas line and the actual outcomes of college football to games in 2000. If efficiency obtains in this market, no other information should improve the prediction of the point spread. If the gambling market truly is efficient, however, then market participants can expect to see an extremely accurate placement of the spread week in and week out for the entire duration of the season. If the market is not efficient, I expect that the residual information will be incorporated in one or more of the following: BCS rankings, ESPN poll rankings, or Associated Press poll rankings.

V. Hypotheses

There are a total of twenty-three hypotheses that will ultimately be tested in the following study. These hypotheses are presented below in full, while their execution is described in more detail in the Analytical Method section (Chapter VII). To begin, I intend to test that the Vegas line incorporates all relevant market information, thereby making it an efficient predictor of the actual spread. If this null cannot be rejected, it provides evidence that the spread is, indeed, the culmination of information within the sports betting market. The null hypothesis for this test is that the coefficient for the Vegas line will not be significantly different from one. This initial test is referred to as the "weak" test because of its inability to offer extensive conclusions in regards to the degree of efficiency within the sports betting market. It is merely a means of observing the relationship between the predicted point spreads provided by the Vegas line and that of the actual point spreads provided by the outcomes.

The next nine hypotheses center on a direct comparison between the Vegas line and the remaining modes of information (BCS, AP, and ESPN). In regressing both the Vegas line and an additional exogenous variable against the actual point spread, I hypothesize that the Vegas line possesses a greater predictive significance than the corresponding independent variable in all three cases. This will hold true for each set of data examined – all games, when ranked teams play other ranked teams, and when ranked teams compete against unranked teams – referred to hereafter as *total, ranked vs. ranked,* and *ranked vs. unranked,* respectively. Three variables with three separate scenarios give rise to the nine hypotheses to be tested. Each test within this particular series will be referred to, henceforth, as an “evolved weak test” on account of its simplistic nature comparable to that of the initial weak test with only one notable difference – the inclusion of an additional exogenous variable. Furthermore, the significance level of each variable will be tested by examining the variable’s corresponding adjusted *R*-squared value; the higher the adjusted *R*-squared value, the greater the significance.

The following series of tests involves analyzing the *total* data set. These examinations will differ slightly from the ones previously presented, however. Instead of regressing the independent variables against the actual point spread, I will take the residual term obtained by regressing the actual point spread on the Vegas line and treat it as a new dependent variable. This residual will be regressed on (in turn) rankings from the BCS, AP, and ESPN polls. My hypothesis is that residual information will not be present in any of the remaining modes of information when analyzing the *total* data set. This can be tested by the null that none of the independent variables (BCS, AP, or ESPN) will be significant when being regressed against the residual term. These three claims result in the eleventh, twelfth, and thirteenth hypotheses.

The next three hypotheses require the utilization of a subsample. In this wave of tests, I will examine games that fall in the *ranked vs. ranked* category. In order to be considered a “ranked” team, both participants in a given matchup must be ranked in the top 25 by either the AP Poll or ESPN, or ranked in the top15 by the BCS. Retaining the same independent variable from the *total* subset, I hypothesize that the BCS, AP, and ESPN variables will not be significant when regressed against the residual term in *ranked vs. ranked* matchups. These tests create the fourteenth, fifteenth, and sixteenth hypotheses to be tested.

The subsequent series of hypotheses involves analyzing contests from the *ranked vs. unranked* division. I believe that the Vegas line will prove to be a better standard for placing bets on games including at least one team ranked in the top 25, whereas one of the remaining modes of information (BCS, AP, or ESPN) will prove to be insignificant in this respect. This hypothesis relates to the notion of information asymmetry, in which the Vegas line will prove to be more accurate for games involving higher-ranked teams. The precision of the Vegas line will reflect the magnitude of information offered in reference to the more superior teams. As such, I believe that the AP, ESPN, and BCS variables will all prove to be insignificant when regressed against the residual term in games involving *ranked vs. unranked* teams. This creates the seventeenth, eighteenth, nineteenth hypotheses since each variable will be tested individually.

The preceding nine hypotheses (eleven through nineteen) require utilizing the amassed residuals of the Vegas line as the dependent variable in the regression equations, as noted. The rationale behind this shift from employing the actual point spread as the dependent variable to the residual term can be attributed to need for a stronger test. It is stronger in the sense that cumulative error term of the Vegas line represents the inaccuracy, or inefficiency, of the gambling market. Thus, by regressing the exogenous variable directly against the residual term, I am able to test for levels significance that, if present, would immediately suggest specific inefficiencies exist within the market. Furthermore, this type of test eliminates the possibility of multi-colinearity by extracting the Vegas line from the equation. This stronger test, which is performed in response to each of the previous nine hypotheses, will be referred to hereafter as simply the "medium" test.

The final series of hypotheses reflects the assertion that the Vegas line explains available market information better than a transformed BCS function – a variable created by taking the logarithm of the differential between each team's BCS ranking in a given matchup. This is based on the presumption that the spread incorporates all market information, whereas the BCS is slightly biased. As a result, I contend that the transformed BCS function will be insignificant when regressed in conjunction with the Vegas line against the actual point spread. Similar to the test described above, three separate tests will be run in order to analyze the *total, ranked vs. ranked*, and *ranked vs. unranked* segments of data. Consequently, the twentieth, twenty-first, and twenty-second hypotheses are obtained. Each test performed using the transformed BCS function will be denoted as simply the "strong" test.

Lastly, I predict that the Vegas line will become more accurate over time as the season progresses. This twenty-third and final hypothesis supports the belief that market information accumulates with the passage of time, thus rendering the spread a more efficient predictor of actual outcomes. This involves taking checkpoints at the third, sixth, ninth, and thirteenth week marks in order to test for increased efficiency with respect to the Vegas line. Should any of these nine hypotheses be rejected, it can be concluded that speculative inefficiencies surely exist. The degree of these inefficiencies will, then, determine the presence of overall market inefficiency. If the market is proven to be efficient, however, then there exists no circumstance in which market participants can routinely exploit inefficiencies within the market in order to obtain positive returns.

VI. Data Description

The data to be used in this study are derived from a variety of sources. The first data series, the Vegas line, requires extracting spreads on NCAA Division 1-A football games from weekly publications of USA Today. These spreads are disclosed in the Friday edition preceding each weekend of competition during the fall season of year 2000, the time-frame in which the observations are made. Each matchup is briefly discussed and the most up-to-date spread is then revealed. In addition, a well-known and reliable website (JimFiest.com) was consulted in order to extract spreads that were not included in the publications of USA Today.

The second data set consists of all current rankings for the relevant week (i.e. BCS, AP Poll, ESPN/Coaches' Poll). This information was obtained through the same issues of USA Today used to extract the Vegas lines, along with the weekly publications of the New York Sunday Times. These publications offer comprehensive results on all the NCAA Division 1-A games that took place the previous day, complete with related ranks and scores. The scores unveiled in Sunday's paper comprise the third data set – the actual point spreads on the games surveyed for each week.

In applying these data sets to the methodology of the project, the actual point spread will prove to be the dependent, or endogenous, variable during the implementation of both the weak and strong tests. The remaining four exogenous variables (VL, BCS, AP, and ESPN) will be used to explain variations in the outcomes. For the medium test, however, the residual term of the Vegas line will be the dependent variable, while the remaining three exogenous variables (BCS, AP, and ESPN) will be used to explain variations in the outcomes. Essentially, the predictive ability of each individual variable will be tested (refer to Table 2 for variable descriptions). As will be discussed in the following section, each one of these explanatory variables will be incorporated within a regression equation that reflects either a *weak*, *medium*, or *strong* efficiency test.

Table 2 – Regression Variables

Variable	Definition	Source
PS	Actual **P**oint **S**pread of D1-A college football games from the year 2000	www.NCAA.org
VL	**V**egas **L**ine or spread on each collegiate football game in the year 2000	USA Today/ www.JimFiest.com
BCS	**B**owl **C**hampionship **S**eries ranking	www.footballfoundation.com
AP	**A**ssociated **P**ress poll ranking	New York Sunday Times
ESPN	**ESPN**/Coaches' poll ranking	USA Today (various issues)

In situations where the *total* sample will be assessed, it is necessary to convert the unranked teams to some quantitative figure. As such, any team that is unranked, or outside the top 25 in the polls, will receive the numerical value of 26 to denote its rank. Therefore, when a ranked team plays an unranked team, the difference between the ranked team's number and 26 will be predicted point spread amount for the corresponding ranking system (AP or ESPN). Similarly, when analyzing the BCS an unranked team will be given number 16 to represent its current rank (since BCS only ranks teams in the top 15). This will facilitate an easy measure of comparison between the actual spread and the remaining modes of information – BCS, AP, and ESPN.

VII. Analytical Method

The empirical analysis to be conducted requires first recording observations for all NCAA Division 1-A contests during the 2000 season. As described above in the Data Description section, statistics from each week include: competing teams with associated rankings (AP and Coaches' Poll for all 13 weeks; BCS for final 6 weeks), the spread (Vegas line) on each individual game, and the actual result of each game. Data from each week of competition was gathered in spreadsheet format and then inputted into MINITAB software to obtain the necessary regression statistics.

In order to evaluate inefficiencies existing within the gambling market I will employ weak, medium, and strong tests. Using an OLS regression equation, the first weak test examines the ability of the Vegas line to effectively predict point spreads. This equation takes the form:

(1) $PS_i = b_0 + b_1 VL_i + e_i$, where i = week; b_0, b_1 = est. coefficient
e = error term; PS = actual spread

The weak test presented above is performed to assess the initial hypothesis, that the Vegas line incorporates all publicly available information, thus permitting it to effectively predict point spreads.

An extension of the weak test requires adding a second independent variable to the equation above. This enables us to observe the significance possessed by the additional predictor variable (BCS, AP, or ESPN) in conjunction with the Vegas line when being regressed against the actual point spread. These equations take the following form:

(2)i. $PS_i = b_0 + b_1 VL_i + b_2 BCS + e_i$ where i = week; b_0, b_1, b_2 = est. coef. e = error term; PS = actual spread

ii. $PS_i = b_0 + b_1 VL_i\ b_2 + AP + e_i$ where i = week; b_0, b_1, b_2 = est. coef. e = error term; PS = actual spread

iii. $PS_i = b_0 + b_1 VL_i + b_2 ESPN_i + e_i$ where i = week; b_0, b_1, b_2 = est. coef. e = error term; PS = actual spread

These equations for the evolved weak test allow for a simple examination of the predictive ability of the ranking indicators by directly comparing the Vegas line to each of the three remaining modes of information. The inclusion of simultaneous dummy variables in the regression equation enables one to contrast the significance of each term with ease. The evolved weak test will be used to evaluate hypotheses two through ten.

The next set of tests takes the basic analysis established thus far a step further by examining the effectiveness of the BCS, AP, and ESPN ranking systems through analysis of residual terms. These residuals are created by regressing the Vegas line against the actual point spread. The exogenous variables (BCS, AP, and ESPN) are then regressed against the residual term to test for significance. The degree of significance will be based upon the resulting p-value of each regression along with the adjusted R-squared value; low p-value and high adjusted R-squared indicate that a variable possesses statistical significance. The equations for this test take the following form:

(3)i. $\varepsilon_i = \alpha_0 + \alpha_1 BCS_i + \eta$ where i = week; α_0, α_1 = est. coefficient
η = error term; ε = residual term

ii. $\varepsilon_i = \alpha_0 + \alpha_1 AP_i + \eta$ where i = week; α_0, α_1 = est. coefficient
η = error term; ε = residual term

iii. $\varepsilon_i = \alpha_0 + \alpha_1 ESPN_i + \eta$ where i = week; α_0, α_1 = est. coefficient
η = error term; ε = residual term

This medium test will be used to appraise hypotheses eleven through nineteen, since all three cases will be examined (*total, ranked vs. ranked,* and *ranked vs. unranked*).

A stronger efficiency test compares the ability of the Vegas line to predict point spreads against that of the transformed BCS function. This test relies on being able to convert the BCS rankings into predicted point spreads, through the use of a log function. Such a conversion allows for an uncomplicated measure of comparability, since both data sets will be in the form of a continuous variable. The strong test will incorporate an OLS regression equation, as well, in the form of:

(4) $PS_i = b_0 + b_1 VL_i + b_2(\log BCS_i) + e_i$, where i = week; b_0, b_1, b_2 = est. coef.
e = error term; PS = actual spread

This strong test is conducted for all three cases (*total, ranked vs. ranked,* and *ranked vs. unranked*). These hypotheses state that the Vegas line explains available market information better than the transformed BCS function in all cases.

The final hypothesis can be examined by using regression analysis in conjunction with periodic checkpoints. This hypothesis asserts that the Vegas line becomes more accurate over time as the season progresses. Several regressions will be performed by using data from various points throughout the season. Since the regular season is thirteen weeks long, three-week intervals will separate the first three checkpoints, while the final interval will be four weeks in duration. Regressions will be run on each individual checkpoint to test for increased efficiency over time. As a result, the data used in these regressions will consist of all regular season games (from week one to week thirteen). This method proves to be an effective technique for analyzing the maturity of the Vegas line over the course of a single season.

VIII. Findings

In examining the results obtained from the regressions performed in this study, implications and inferences can then be made with respect to the primary concern: market efficiency. One must keep in mind that the principle aspiration of this project is practical in nature. As such, I have analyzed the statistical results with the intention of speculating the degree of inefficiencies present within the gambling market. The extent of said inefficiencies will, ultimately, be based upon the significance of the *t*-statistics and p-values produced in the regressions. If these values are significant, then it can be concluded that residual information exists, resulting in speculative inefficiencies with respect to the Vegas line. In order to determine that *market inefficiency* persists, however, the appropriate statistics must prove to be extremely significant.

In testing the initial hypothesis that the Vegas line incorporates all relevant market information, thereby negating the possible existence of residual specifics, I find that the Vegas line is, indeed, extremely efficient (refer to Table 3). This is due to the fact that it produced a *p*-value of zero, as well as a variable coefficient of 1.04, when regressed against the actual point spread for the entire (*total*) sample. Consequently, the null cannot be rejected in this case, since the spread proves to be the culmination of market information within the market of college football. In addition, the Vegas line exhibits undeniable efficiency when examining the remaining two subsets of data – *ranked vs. ranked* and *ranked vs. unranked* (refer to Tables 4 & 5).

Table 3 – OLS Estimates of Equation (1):
2000 NCAA D1-A College Football Regular Season, Total

DEPENDENT VARIABLE: ACTUAL POINT SPREAD				
Explanatory Variable				
Constant	-0.0170 (0.4383)	0.000 (0.9199)	-0.000 (0.5943)	-0.000 (0.5932)
VL	1.0388 (0.0266)***	-	-	-
BCS	-	1.6671 (0.2195)***	-	-
ESPN	-	-	1.0881 (0.0663)***	-
AP	-	-	-	1.1047 (0.0666)***
R^2(adj)	55.4%	11.1%	18.0%	18.3%
F	1519.99	57.67	269.51	274.99
N	612	228	612	612

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 4 – OLS Estimates of Equation (1):
2000 College Football Regular Season, Ranked v. Ranked

DEPENDENT VARIABLE: ACTUAL POINT SPREAD				
Explanatory Variable				
Constant	-0.000 (1.484)	0.000 (2.696)	-0.000 (1.813)	-0.000 (1.799)
VL	1.3590 (0.1899)***	-	-	-
BCS	-	1.7043 (0.3987)***	-	-
ESPN	-	-	0.4980 (0.1774)***	-
AP	-	-	-	0.5643 (0.1857)***
R^2(adj)	38.3%	31.8%	7.8%	9.2%
F	51.22	18.28	7.88	9.24
N	41	19	41	41

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 5 – OLS Estimates of Equation (1):
2000 College Football Regular Season, Ranked v. Unranked

DEPENDENT VARIABLE: ACTUAL POINT SPREAD				
Explanatory Variable				
Constant	-0.0498 (0.7868)	-0.000 (1.658)	-0.000 (1.018)	-0.000 (1.015)
VL	1.0215 (0.0376)***	-	-	-
BCS	-	1.6568 (0.2495)***	-	-
ESPN	-	-	1.1443 (0.0687)***	-
AP	-	-	-	1.1513 (0.0688)***
R^2(adj)	64.3%	23.4%	40.3%	40.6%
F	737.79	44.09	277.09	280.20
N	205	71	205	205

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

On account of the fragility of the regressions presented above, one may note that the other exogenous variables (BCS, AP, and ESPN) possess tremendous significance as well. Although the degree of significance held by these variables is not nearly as impressive as that of the Vegas line (as is noted by the lofty adjusted *R*-squared values in Tables 3 & 5), they still remain quite salient. Reasons for the remarkable significance of the remaining exogenous variables can be attributed directly to the simplicity of the regression equation; hence, it is called the “weak” test. When being regressed against the actual point spread in a rather large sample, these variables will appear to have extensive predictive ability. However, their true significance will not be revealed until the results of the medium test are obtained.

Before analyzing results from the medium test, it is first necessary to examine outcomes derived from the evolved weak test. As one may recall, the evolved weak test is performed in order to assess the next series of hypotheses (two through ten), which assert that the Vegas line possesses a greater predictive significance than the corresponding independent variable in all three cases. The independent variables in this case being those of the BCS, AP, and ESPN ranking systems. I expected that this would hold true for each set of data examined – *total, ranked vs. ranked,* and *ranked vs. unranked,* respectively. Again, the results do not permit a rejection of the null hypotheses but give rise to the conclusion that the Vegas line is, indeed, efficient (refer to Tables 6 – 8).

Table 6 – OLS Estimates of Equation (2):
2000 NCAA D1-A College Football Regular Season, Total

DEPENDENT VARIABLE: ACTUAL POINT SPREAD			
Explanatory Var.			
Constant	-0.0443 (0.7059)	-0.0174 (0.4381)	-0.0173 (0.4383)
VL	1.011 (0.0567)***	1.0665 (0.0333)***	1.0602 (0.0332)***
BCS	-0.0523 (0.1941)	-	-
ESPN	-	-0.0849 (0.0611)	-
AP	-	-	-0.0661 (0.0614)
R^2(adj)	47.6%	55.4%	55.4%
F	207.95	761.54	760.67
N	228	612	612

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 7 – OLS Estimates of Equation (2):
2000 College Football Regular Season, Ranked v. Ranked

DEPENDENT VARIABLE: ACTUAL POINT SPREAD			
Explanatory Var.			
Constant	0.000 (1.648)	-0.000 (1.442)	-0.000 (1.460)
VL	2.1496 (0.2744)***	1.8016 (0.2614)***	1.7107 (0.2623)***
BCS	-0.5826 (0.3803)	-	-
ESPN	-	-0.4777 (0.1999)**	-
AP	-	-	-0.4039 (0.2115)*
R^2(adj)	74.5%	41.7%	40.2%
F	55.14	29.98	28.28
N	19	41	41

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 8 – OLS Estimates of Equation (2):
2000 College Football Regular Season, Ranked v. Unranked

DEPENDENT VARIABLE: ACTUAL POINT SPREAD			
Explanatory Var.			
Constant	-0.132 (1.3670)	-0.0526 (0.7867)	-0.0518 (0.7872)
VL	0.9380 (0.1147)***	1.0793 (0.0650)***	1.0622 (0.0645)***
BCS	-0.1042 (0.2979)	-	-
ESPN	-	-0.1001 (0.0919)	-
AP	-	-	-0.0710 (0.0914)
R^2(adj)	47.9%	64.3%	64.3%
F	65.83	369.66	368.84
N	71	205	205

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

In conducting the evolved weak test, other noteworthy results are revealed in addition to the confirmed significance of the Vegas line. For example, while regressing the ESPN variable in conjunction with the Vegas line against the actual point spread for the *ranked vs. ranked* category, it is found that the exogenous variable proves significant at the 5% level. Similarly, the AP variable possesses significance at the 10% level when performing the same test, as seen in Table 7. The same significance levels did not hold true for results acquired from the *ranked vs. unranked* subset, however. This indicates that while the Vegas line is outright efficient overall, the ESPN rankings prove to be a viable source of information when placing bets on games involving two ranked teams. To a lesser extent, the same is true for the AP rankings as well. However, neither the ESPN, AP, nor BCS variables exhibited significance at any level when analyzing the segment of contests between ranked and non-ranked teams (refer to Table 8).

In reviewing Table 8 for the results discussed able, on may note the extraordinarily high adjusted *R*-squared value (74.5%) possessed by the BCS variable. This figure dwarfs the corresponding adjusted R-squared values for both the ESPN and AP independent variables, despite the fact that the *p*-value of the BCS variable is very high. This suggests that the BCS variable is, itself, incredibly insignificant, but when regressed in conjunction with the Vegas line it exhibits extremely high levels of significance. Such a phenomenon can be attributed to the occurrence of multi-colinearity.

The next sequence of tests, which were performed in order to evaluate hypotheses eleven through nineteen, entailed deviating from the traditional dependent variable – the actual point spread. In adopting a new dependent variable, the residual of the Vegas line, I was able to more effectively test the predictive ability of the BCS, AP, and ESPN systems. These tests, referred to as the medium tests, provide a stronger measure of significance since the exogenous variable is being regressed against the cumulative error terms of the Vegas line.

It is found that neither the BCS, AP, or ESPN variables maintain any level of significance when being regressed against the residual term of the Vegas line for the *total* sample. As a result, the null hypotheses, again, could not be rejected when evaluating the *total* data set (refer to Table 9). The same holds true for those contests included within the *ranked vs. unranked* category (refer to Table 11). However, significant residual information is believed to be present in games confined within the *ranked vs. ranked* grouping with respect to the ESPN variable. This particular exogenous variable proves significant at the 10% level, allowing the null to be rejected for the sixteenth hypothesis (refer to Table 10). This conclusion is strictly limited to the ESPN variable though, since the test reveals that the remaining two independent variables are insignificant. From these results, it can be inferred that some residual information does, in fact, exist within the ESPN ranking system that suggests provisional inefficiencies are present within the market. The low number of observations coupled with the low R-squared value implies that these inefficiencies are merely speculative, however. One cannot conclude at this point whether these particular inefficiencies would result in profitable waging strategies.

Table 9 – OLS Estimates of Equation (3):
2000 NCAA D1-A College Football Regular Season, Total

DEPENDENT VARIABLE: RESIDUAL OF VEGAS LINE			
Explanatory Var.			
Constant	0.000 (0.7052)	-0.000 (0.4381)	-0.000 (0.4381)
VL	-	-	-
BCS	-0.0394 (0.1683)	-	-
ESPN	-	-0.0544 (0.0489)	-
AP	-	-	-0.0425 (0.0492)
R^2(adj)	0%	0%	0%
F	0.05	1.24	0.74
N	228	612	612

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 10 – OLS Estimates of Equation (3):
2000 College Football Regular Season, Ranked v. Ranked

DEPENDENT VARIABLE: RESIDUAL OF VEGAS LINE			
Explanatory Var.			
Constant	-0.000 (1.657)	-0.000 (1.458)	0.000 (1.467)
VL	-	-	-
BCS	-0.2392 (0.2450)	-	-
ESPN	-	-0.2380 (0.1427)*	-
AP	-	-	-0.2049 (0.1514)
R^2(adj)	0%	2.2%	1.0%
F	0.95	2.78	1.83
N	19	41	41

Note – Figures in parentheses represent standard errors.
*Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 11 – OLS Estimates of Equation (3):
2000 College Football Regular Season, Ranked v. Unranked

DEPENDENT VARIABLE: RESIDUAL OF VEGAS LINE			
Explanatory Var.			
Constant	0.000 (1.363)	0.000 (0.7865)	0.000 (0.7866)
VL	-	-	-
BCS	-0.0497 (0.2051)	-	-
ESPN	-	-0.0335 (0.0531)	-
AP	-	-	-0.0242 (0.0533)
R^2(adj)	0%	0%	0%
F	0.06	0.40	0.21
N	71	205	205

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

In order to take the current analysis further, a stronger, more efficient test must be employed. This test requires reverting back the original method of utilizing the actual point spread as the dependent variable. It also entails converting the BCS rankings into point spreads by taking the log of the ranking differential. This approach aborts the establishment of any linear correlation between ranking differentials and point spreads by incorporating a logarithmic function. This transformed BCS function will then be paired with the Vegas line as dummy variables in an ordinary least squares regression against the actual point spread. Upon executing this strong test, it can be determined that the Vegas line outperforms the transformed BCS function and is wholly efficient. In all three instances (*total, ranked vs. ranked*, and *ranked vs. unranked*), the transformed BCS function proves insignificant when regressed in conjunction with the Vegas line against the actual point spread (refer to Tables 12-14). Thus, we cannot reject the null that the Vegas line possesses a greater predictive ability for hypotheses twenty to twenty-two.

Table 12 – OLS Estimates of Equation (4):
2000 NCAA D1-A College Football Regular Season, Total

DEPENDENT VARIABLE: ACTUAL POINT SPREAD	
Explanatory Variable	
Constant	-1.825 (5.842)
VL	0.7984 (0.2228)***
logBCS	4.894 (7.607)
R^2(adj)	24.3%
F	9.36
N	53

Note – Figures in parentheses represent std. errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 13– OLS Estimates of Equation (4):
2000 College Football Regular Season, Ranked v. Ranked

DEPENDENT VARIABLE: ACTUAL POINT SPREAD	
Explanatory Variable	
Constant	-6.660 (5.640)
VL	2.1597 (0.3805)***
logBCS	2.383 (8.595)
R^2(adj)	74.6%
F	23.0
N	16

Note – Figures in parentheses represent std. errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 14 – OLS Estimates of Equation (4):
2000 College Football Regular Season, Ranked v. Unranked

DEPENDENT VARIABLE: ACTUAL POINT SPREAD	
Explanatory Variable	
Constant	3.188 (8.260)
VL	0.6239 (0.2754)**
logBCS	1.356 (9.773)
R^2(adj)	10.3%
F	3.07
N	37

Note – Figures in parentheses represent standard errors.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

The final test performed in this study evaluates the maturation of the Vegas line over the entire 2000 season. It essentially examines the ability of the gambling market to become increasingly efficient over time, as the season progresses. Given the greater volume of market information available with the passage of time, one would expect the market, or Vegas line, to grow increasing efficient from week one to week thirteen. However, the results show that that market actually became less efficient as the season progressed (refer to Table 15). Accordingly, the null hypothesis that market information accumulates with the passage of time, thus rendering the spread more efficient, can be rejected.

Table 15 – OLS Estimates of Equation (1): Progression of Vegas Line during 2000 Season

CHECKPOINT	*T-STAT*	*P-VALUE*	*STD ERR*	*VL COEF*	*R-SQ(ADJ)*	*F*
1	22.25	0.000	0.047	1.04	64.2%	495.00
2	18.88	0.000	0.054	1.03	54.8%	356.34
3	19.27	0.000	0.055	1.06	55.7%	371.39
4	17.52	0.000	0.059	1.03	46.1%	306.78

Sensible reasons can account for the decreasing efficiency of the gambling market over time. For example, it is typical for most teams to commence their season by playing a low-caliber opponent. Many coaches feel that it is important to start the season off on a positive note with a win. As a result, the gambling market is presented with a slew of uneven matchups for which the spread can easily be determined. Then, as the season progresses, there occurs more inner-conference play and a greater number of rivalry matchups are seen. These contests prove more difficult to place an accurate line on due to increased volatility. Consequently, the bookmakers issue a low spread so as to minimize their risk in the close matchup games. In the end, however, a good number of these games prove to be not so close after all. The bookmakers then try to compensate and adjust for their prior inaccuracies, but end up overcompensating in some instances. This leads to an increased inefficiency within the gambling market as time passes. Figure 2 reveals the evolution of the t-statistic from checkpoint 1 to checkpoint 4, while Figure 3 exhibits the diminution of the adjusted *R*-squared value over the same time period. In both cases, the values are decreasing from checkpoint 1 to checkpoint 4, suggesting that inefficiencies, with respect to the Vegas line, are increasing during this time.

Figure 2 – Evolution of T-Statistic

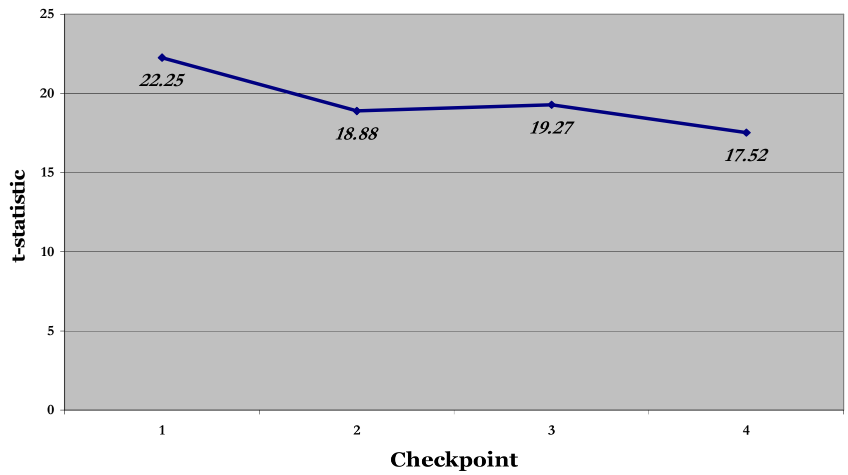
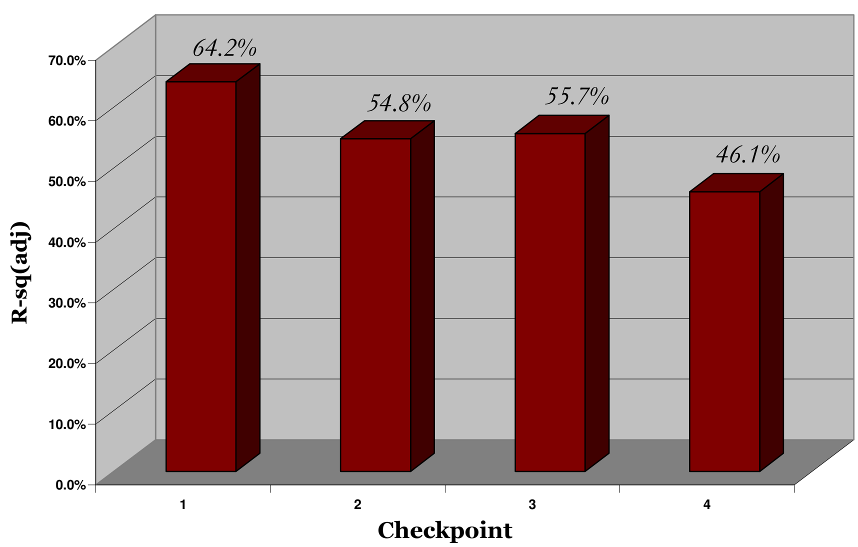


Figure 3 – Diminution of Adjusted R-Squared Value



The **economic magnitude** of the findings can be measured by using results from prior studies on market efficiency as a benchmark. The preceding results suggest that my findings are consistent with those attained by past economists and scholars. Most notably, congruence between this study and previous works is observed through the conclusion that speculative inefficiencies are indeed present within the sports betting market. However, due to a limited sample size and moderate significant levels, it is indeterminable at this juncture as to whether these inefficiencies will give rise to profitable betting strategies. It is understood that such inefficiencies could potentially be exploited in order for a market participant to derive positive returns; but in no way do the results suggest that the Vegas line, or sports betting market, is completely inefficient. This implies that the economic significance of my study possesses a credence equivalent to those inquiries preceding it.

IX. Conclusions

Through the implementation of this study, light has been shed upon a shadowy area of economic interest. It has been nearly twenty years since Zuber and his colleagues tested for market efficiency within the National Football League. In addition, there proves to be no documented research that examines the ability of peripheral modes of information (BCS, AP, and ESPN) to capture residual information in the college football gambling market. The popularity of this sport, along with the size of the current gambling market, suggests that conclusions and inferences derived from this study will be highly valued and greatly appreciated. Any information extracted from this project by a market participant, undoubtedly, has the potential to enhance that individual's present gambling strategies.

i. Interpreting the Results

As revealed in the previous chapter, the Vegas line proved to be extremely significant when regressed against the actual point spread for the *total* sample (*p*-value of zero; adjusted *R*-squared value of 55.4%). This suggests that the sports betting market, as a whole, with respect to college football is incredibly efficient. Similarly, the Vegas line exhibited exceptionally high levels of significance when conducting the evolved weak test for all three scenarios. Only when assessing the *ranked vs. unranked* subsample, however, was it found that any of the remaining exogenous variables (BCS, AP, and ESPN) revealed significance. In this regression, the ESPN variable proved significant at the 5% level, while the AP variable exhibited significance at the 10% level.

Before concluding, at this point, that speculative inefficiencies are present within the sports betting market, it is necessary to analyze the results acquired when executing the medium tests. Findings from these tests remain consistent with those obtained while performing the evolved weak tests. For instance, the ESPN variable maintained its high level of significance when being regressed against the residual of the Vegas line. It showed significance at the 10% level, whereas the AP variable no longer exhibited any significance. These findings allow one to conclude that the ESPN poll ranking is a viable source of information when placing bets on games between *ranked vs. ranked* teams. Although there were a low number of observations for this subsample, the high level of significance implies that inefficiencies may certainly exist within this particular segment of the market.

Upon examining the regressions performed as part of the strong tests of efficiency, it can be determined that the Vegas line outperforms the transferred BCS function in all three instances (*total, ranked vs. ranked,* and *ranked vs. unranked*). This comes as no surprise, however, since the transformed BCS function is merely an extension of the original BCS variable which proved insignificant in all prior tests. Thus, it can be concluded that the BCS ranking system fails to contain any significant residual information from which a market participant would be able to derive a profitable waging strategy if pursued.

Finally, the findings indicate the Vegas line, or sports betting market, becomes *less* efficient as the season progresses. The practical application of this observation entails that it would be more advantageous for a market participant to place a bet at the end of a season than at its commencement. Contrary to what one would expect, the results show that the sports betting market for college football is most efficient in the first three weeks of the season, and least efficient in the final four weeks (refer to Figures 2 & 3). *Therefore, placing a wager on a contest between two ranked teams in the final stages of the season, while referring to the ESPN poll rankings, would provide the market participant with the best opportunity for realizing a positive return.*

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ii. Lessons for Market Efficiency

- Developing countries' stock markets
- Necessary characteristics
    - Volume/Size
    - Rational Investors
    - Information

iii. Message to Policy-Makers