Economic Value of Celebrity Endorsement:
Tiger Woods' Impact on Sales of Nike Golf Balls*

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Abstract

We study the economic value of celebrity endorsement. Despite the size and the long history, few have attempted to quantify the economic worth of celebrity endorsers because it is terribly difficult to identify an endorser's effect on a firm's profit. By developing and estimating the consumer demand model for the golf ball market, we find that after controlling for brand advertisement level and taking into account the inherent quality of the endorser, the endorsement effect leads not only to a significant number of existing customers switching toward the endorsed products but also has a primary demand effect.

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1 Introduction

Celebrity endorsements are ubiquitous and are a multimillion dollar business. Corporations scour the likes of movie stars and professional athletes in search of the perfect celebrity to effectively endorse their products and increase sales; and in return celebrities receive millions of dollars.[1] While tens or even hundreds of millions of dollars in endorsement contracts are a relatively recent phenomenon, endorsements have been around for over 200 years.[15] The long historic practice reveals that celebrity endorsements are accepted as an effective strategy to increase sales and profit. However, this begs the question of just how profitable are they?

Few have attempted to quantify the economic worth of celebrity endorsers. Those that have, have done so only in an indirect manner using the event study methodology.[2] Identifying and measuring the extent to which an endorser affects firms' retail sales is difficult for two major reasons. First, the endorsement variables must be properly defined and the researcher must identify the endorsement effect amongst many other confounding events. Thus, the researcher must distinguish from other phenomena that may give rise to the same outcome.[3] Second, to attribute the endorsement effect to changes in consumer preferences, the interpretation of the estimate is only valid under the condition of a stationary customer base. In a market that has rapid change in demographics, a researcher can erroneously conclude that there exists a significant effect when in fact the natural evolution of customer base has resulted in the outcome.

We have unique golf dataset that satisfy both conditions.[4] Studying the golf industry in the context of celebrity endorsement is fitting because golf has been the leading sports industry

[1] For instance, in 2000 and again in 2005 Nike signed professional golfer Tiger Woods to a 5-year $100 million dollar contract to endorse its then nascent Nike Golf division. Other such examples include the current Miami Heat superstar LeBron James earning $28 million from the likes of Coca-Cola and State Farm and Indianapolis Colts' quarterback Peyton Manning securing roughly $13 million from Sprint, MasterCard, Reebok and Gatorade in 2008 alone.

[2] See literature review for detail

[3] The firms that are able to afford the large endorsement contracts and use it as part of the marketing strategy are often complex in structure with numerous endorsements and advertisement campaigns occurring simultaneously.

[4] Direct data that satisfy both condition is typically unavailable to the researcher, which is why previous studies had to resort to the event study analysis methodology.

in the endorsement business.[5][6] [29][30] Structurally, the golf industry is a relatively insulated industry that has had a steady number of participants. It is estimated that over the past 10 years, the number of golfers remained steady at 26 to 30 million.[26] The avid golfers[7] make up only 23% of all golfers yet account for 63% of all golf related spending in 2002.[8][19] In terms of the endorsement variables, we are presented with favorable circumstances in which the Nike firm is a new entrant in the industry that decides to sign just one endorser.[9] This presents us with several advantages in answering our research questions. First, the newness of Nike Golf takes care of other past advertisement events or endorsements that can potentially affect current phenomena.[10] Also, while it is usually impossible to attribute a celebrity endorsement to the growth or total revenue of the sponsoring firm, the single endorsement strategy of Nike allows us to causally attribute the rise of the golf brand on the basis of a single endorser Tiger Woods.[11] The identification of the endorsement effect comes from the detailed data that captures the sales of all major golf brands in the period when the golfer first endorsed the Titleist brand (1997-2000) and switched to the Nike brand (2000-2010).

We posit that endorsements play a direct role in a consumer's utility function when consuming the endorsed brand. We take the complementary view of celebrity endorsement where the

[5] In "The Fortunate 50", a list of 50 top earning American athletes in salary, endorsement and appearance fees compiled by the *Sports Illustrated*, in 2008 and 2009, Tiger Woods and Phil Mickelson came 1st and 2nd respectively. http://sportsillustrated.cnn.com/more/specials/fortunate50/2009/index.html
http://sportsillustrated.cnn.com/more/specials/fortunate50/2008/index.html

[6] It is documented that Tiger Woods has consistently earned significantly more off the course than on the course by a variety of endorsers. In fact, it was believed in 2008 that Tiger Woods was on his way to become the first $1 billion athlete. In 2007, his earning from on course was $23 million while endorsement deals totaled $100 million. http://www.golfdigest.com/magazine/2008-02/gd50

[7] Those who play 25 or more rounds of golf per year.

[8] $4.7 billion dollars were spent on equipment (clubs, balls, bags, gloves, shoes) in 2002.

[9] Tiger Woods' career began with an endorsement from the Nike Golf brand in 1996. In the beginning, Nike golf only endorsed Tiger Woods with apparel and shoes. Nike golf was a new player in the golf industry where they would eventually end up producing golf equipments (ball and golf clubs). Tiger Woods was the one of the first players to switch from the Titleist golf ball to the Nike Golf ball in 2000 with the 100 million dollar 5 year contract. (Nike golf ball was introduced in 1999)

[10] For example, firms with long history may have loyal customers that lead to persistent purchase.

[11] Towards the latter half of the decade under Tiger Woods' endorsement, it is not entirely true that Tiger Woods was the only endorser of Nike Golf products. However, it is a general consensus that Nike golf built its brand around Tiger Woods. Not only was Tiger Woods the most widely recognized golfer that endorsed Nike products from the very beginning of his career, but he was one of the first golfer to switch to the Nike golf equipments when it was made available in 2000.

consumption process can either be enhanced or worsened through additional or negative utility attached on the endorsed product. With this view, all else equal, we predict that endorsement in and of itself can alter demand and increase or decrease[12] a firm's market share.

By developing and estimating the consumer demand model for the golf ball market, we find that the celebrity endorsement effect on consumers can create product differentiation and generate shift in market share. After implementing several counterfactual scenarios we find, from 2000-2010, the Nike golf ball division reaped an additional profit of $60 million through an acquisition of 4.5 million customers from Tiger Woods' endorsement effect. As a result, approximately 33% of Nike's investment on the golfer's endorsement was recovered just in US golf ball sales alone. We also find that the recent scandal had a negative effect which resulted in a loss of approximately $1.2 million in profit with 94,000 customers switching away from Nike. However, we conclude that Nike's decision to stand by the golfer was the right decision because even in the midst of the scandal, the endorsement effect was strong enough that had Nike terminated its relationship with Tiger Woods, the overall profit would have been less by an additional $1.6 million. We also find that endorsed products have a primary demand effect. We empirically find that not only does celebrity endorsement take customers away from its competitors, but also attracts customers from the outside who would have otherwise not purchased the product in the absence of celebrity endorsements.

The paper is organized as follows: First, to motivate our empirical study, we provide a brief background on the celebrity endorsement and golf industry with a focus on the golf ball market

[12]The negative effect of celebrity endorsement is especially relevant today as firms have not been successful in staying away from celebrities who bring "negative" publicity. Recently it has been documented that Brett Favre has behaved inappropriately towards a reporter during his career with the New York Jets and Wrangler jeans company has yet to make a decision on keeping its ties with the athlete. (http://www.cnbc.com/id/39616665/) Other than Brett Favre, there are many more athletes throughout history who have not behaved as the firms would have liked. To name a few, Nike: Kobe Bryant when charged with rape, Pepsi: Mike Tyson when charged with beating his wife, Hertz: OJ Simpson and his first degree murder charge. Prince tennis racket: Jennifer Capriati when charged with marijuana possession.

In our case, November 2009 was the beginning of a tumultuous and embarrassing year for Tiger Woods, in which his infidelity was revealed to the public. Since then, endorsers, one by one, began to cut ties with Tiger Woods. The earnings he made off the course - an estimated $100 million a year - dwindled as a result of endorsers like Accenture, AT&T and Gatorade terminating its contracts. In the midst of all this, Nike announced that it would stand by Tiger Woods. We investigate whether his scandal has had any negative impact on Nike's sales.

in section 2 before providing the literature review in section 3. In section 4, we provide the data used for empirical estimation before proposing the model that captures the endorsement effect in section 5. In section 6, empirical results are provided followed by the counterfactual in section 7. We conclude in section 8 with discussions and limitations with directions for future research.

2 Background Information

2.1 Celebrity Endorsements

According to Frank Presbrey's 1929 book *History and Development of Advertising*, one of the earliest testimonials in advertising appeared in an advertisement for teething preparation in 1711.[15] In 1770, the London Chronicle newspaper published an advertisement containing the endorsement of Mary Graham, testifying the healing power of Dr. Rysseeg's Balsamic Tincture.[11] While the strategy of endorsement traces back hundreds of years to the 18th century, the wake of World War I was the beginning of modern endorsements. In the 1920s, so popular was the practice of endorsement that Famous Names Inc. was founded that linked celebrities to national manufacturers. In the late 1950s and onward, athletes became more important as endorsers than the non athletes, and the fees paid to them rose significantly. Frank Scott, an athlete agent is credited for blossoming of athlete endorsements. Through him, manufacturers from cigarettes to cement products scrambled to sign endorsement deals with athletes. Mickey Mantle, who led both baseball leagues in amount of money earned through endorsement, is said to have endorsed both Camel cigarettes and Bantron, an anti-smoking pill. In 1956, Mantles salaries was $30,000 while his endorsement earning was $70,000.[13] In 1969, Forbes reported that endorsement was the single most important source of outside income for many celebrities, while Sports Illustrated reported that athletes had risen to the top position as endorsers.[14][18, 12] In fact, the use of athletes had increased so much that the 70s became to be

[13] `http://www.nytimes.com/1998/06/30/sports/frank-scott-80-baseball-s-first-player-agent.html`

[14] This is attributed to the growth in endorsement industry in general and the growth of sport agents like Frank Scott.

known in the marketing world as the "Decade of the Athlete".[29]

While the 60s and the 70s saw significant increases in the contribution of sports athletes in a variety of product endorsements, it was not until the 1980s when Nike changed the landscape of sports endorsement. It is reported that Nike shoes were endorsed by 135 of 273 players in the NBA in 1983. This dominance was said to have resulted from Nike's promotional strategy of paying the athletes handsomely.[15] In this era of endorsements, it is reported that most top stars derive most of their income not through their winning but through endorsement deals. Today, endorsements are a multimillion dollar business.

2.2 The Golf Industry

The golf industry in the United States generated direct revenues of $76 billion in 2005 up from $62 billion in 2000. At $76 billion, the golf industry is larger than the motion picture and the video industries. With the industry consisting of 7 main parts ranging from facility operations to real estate, golfer equipment/supplies and golf endorsements combined made up to be a $ 7.8 billion industry in 2005. We present a general overview of the golf equipment used in the sport of golf. There are 3 main categories in golf equipment; bags, clubs and balls. Given that our paper assesses the impact of endorsement on sales of golf ball equipment, we include the overview of the other two categories in the appendix.

[15]The budget for this promotional strategy was around 10 times the amount spent on promotion by the next top ten sneaker makers combined.[6] Nike was also active in endorsing players who were yet to prove themselves at the professional level. For example, Michael Jordan had a five year $2.5 million contract with Nike in his first year as a Chicago Bulls player which rose to $18 million dollar by 1993. Similarly, in 1996, a Nike commercial starring Tiger Woods was broadcast less than 12 hours after the 20 year old golf sensation announced that he would turn professional. Nike signed an endorsement deal with Tiger Woods for 5 years for an estimated $40 million. Nike Golf division in 1996 which consisted of apparel and footwear had a total sales of approximately $120 million. In year 2000, Tiger signed a new deal worth $100 million over five years which was then said to be the largest ever offered to an active athlete. [20, 29] Lastly, even before he became the number 1 overall pick, Nike signed Lebron James at an estimated $90 million which was believed to be the largest initial shoe contract ever offered to an athlete.[10]

Golf Balls

Golf balls are estimated to generate $500 million dollars in annual sales with production of over 850 million golf balls per year.[4, 17] There are 1,051 models of golf balls that are listed on the United States Golf Association's list of conforming golf balls. It is believed by many experts in golf that the golf ball has more engineering per cubic centimeter than in any recreational product in the market.[32] Golf balls are usually white, weighing no more than 1.62 ounces with a diameter of no less than 1.68 inches.[33] In today's golf ball, there are 3 main components; the number of layers, the type of outer cover and the number of dimples.

Golf balls can have layers that ranges anywhere from 2 to 5. Most golf balls for amateurs (least expensive) are 2 layered golf balls consisting only the outer cover material and a core.[16] Depending on the number of layers, 2 layered golf balls are often called the "two piece" ball, 3 layered a "three piece" and so on. The more layers a golf ball the higher cost of production and thus a higher retail price.[17]

The type of outer cover on a golf ball determines how the golf ball "feels" under impact from the golf club. There are two main type of covers that are most widely used in the golf ball industry. The most popular is the ionomer/surlyn cover which is durable and resilient material made up of a blend of plastic resin. On the other hand, the urethane is a softer and a more elastic material that is more expensive to manufacture.[18] Most non premium golf balls are made of ionomer material while most premium golf balls that professional golfer use are made up of urethane cover.

Lastly, today's golf balls are characterized by the dimples on the surface. These are small

[16]The core of a ball is the resilient rubber compound located in the center of a ball that provides the transfer of energy from the golf club to the ball at impact.

[17]In three piece golf balls, there is an extra layer of material between the core and the cover. This is usually a "mantle", which is a layer of polymer that are used both to control spin off of high speed impact and provide "feel". Four piece balls either have 2 mantles or 2 cores. There is only one 5 piece golf ball in the market today. The TaylorMade Penta is priced at $45.99 in golf retail stores. For more information on the ball, http://www.taylormadegolf.com/mainlevel/golfshop/balls/Penta-TP.html#30

[18]Urethane is about twice as thin as the surlyn cover and during the casting process it is known that urethane goes from a liquid to a solid in 30 seconds, leaving no room of error for the manufacturer. On the other hand, producing surlyn balls are known to be straightforward. It is said that in the time that 160 surlyn balls are produced, only 1 multilayer urethane cover ball can be produced.

identically shaped indents that are usually circular. The main purpose of a dimple is that it creates the necessary aerodynamic forces for the ball to fly further and longer. Depending on the depth of the dimples, the trajectory of the flight differs, with shallow dimples creating higher flights while deeper dimples creating lower flights. Most golf balls today have 250-450 dimples. There have been differently shaped dimples to increase the number of coverage of the ball's surface. It is understood that covering the golf ball with more dimples is generally more difficult to manufacture and are reflected in the retail price.

The characteristics of the golf ball is important in this paper as they are the inherent part of the product characteristics that differentiate the products. In estimation, these characteristics become valuable instruments for the endogenous price variable.

3 Literature Review

Few have attempted to quantify the economic worth of celebrity endorsers. To best of our knowledge, there is no literature that directly assesses the impact of celebrity endorsements on sales and market share. Rather, those that have studied this domain have done so in an indirect manner- by using the event study methodology and looking into the fluctuation of stock prices during the time of the announcement of celebrity endorsement. Specifically, Agrawal and Kamakura (1995) study 110 celebrity endorsement contracts and find that, on average, the market reacts positively on the announcement of celebrity endorsement contracts. Based on this result, they conclude that celebrity endorsements are viewed as a profitable advertising strategy. More recently, Knittel and Stango (2009) study the negative impact of Tiger Woods' scandal. By looking at the stock prices of the firms that Tiger Woods endorses, they estimate that, after the event in November 2009, shareholders of Tiger Woods' sponsors lost $5-12 billion relative to those firms that Woods did not endorse. Furthermore, they find that sports related sponsors suffered more than his other sponsors. To the best of our knowledge, these two papers are the closest in terms of what we are trying to study in our paper. Even so, event study

analysis does not capture the true effects of celebrity endorsement. Our main concern with this methodology is that the study is an "event" study that takes a single event of an endorsement announcement and assesses the economic value. Also, event study analysis takes the behavior of the investors and their reaction to the endorsement announcement to assess the economic worth. This can be potentially misleading and problematic since we would like to directly study the consumers' behavior, not investors' behavior, and their change in preferences in products due to the endorsement. For example, when Tiger Woods initially signed a multimillion dollar deal in 1996 with Nike before turning professional, it is documented that stock price for Nike declined 5%. Despite this negative market valuation, looking back, it is difficult to argue against the fact that Tiger has been one of the biggest reasons why Nike has rose to such heights in the golf business (an industry in which they were not very well known for at the time). Nike rose to become a formidable golf company from producing not only apparel and shoes but also golf equipment, transforming a $120 million business to a $500 million business (sales) from 1996 to 2006.[7] Since celebrity endorsements occur over time, in order to assess the economic value of a celebrity, one must look at the time period in which the celebrity was under contract. We do this in our paper by explicitly tracking the sales of golf balls with celebrity endorsements.

The underlying theory behind our model construct originate from Stigler and Becker (1977) and Becker and Murphy (1993) in which they analyze models that incorporate a brand's advertising level into a consumer's utility function. When such an interaction is positive they find that the likelihood of consumption increases. Moreover, *"advertising can in itself create prestige, differentiation, or association that may change the utility a consumer obtains from consuming a product"[1]*(Ackerberg 2001). This line of literature is closely related to our study in that one may think of the quality of a celebrity endorser as the analog to their advertising levels-a higher quality celebrity endorser increases the prestige associated with the endorsed product which thus leads to higher utility and sales. It must be noted however that we make a clear distinction between endorsement and advertisement. We define the endorsement effect as the overall effect the endorser has on the company during the time period in which he is under contract. For an ad-

vertisement effect, we define it as the overall brand exposure effect in the media at a given time. To distinguish the two effects, we explicitly take into account both the celebrity endorsement effect and the endorsing brand's advertising level in our consumer utility function.

4 Data

The data used in this study is aggregated monthly golf ball sales in the United States from February 1997 to April 2010. This data represents the total sales for the US for on course (green grass) and off course golf specialty stores.[19] There are a total of 669 unique products represented by a total of 26 different brands. Below are the summary statistics and plot of sales over time.[20]

	On Course	Off Course	Overall
Average Price	**$23.09** [$18.21,$26.37]	**$18.50** [$14.97,$22.33]	**$20.81** [$14.97,$26.37]
Units Sold	**12,582** [4,415,25,441]	**12,573** [5,681,29,461]	**12,577** [4,415,29,461]
No. of Products Available	**61** [35,90]	**71** [41,102]	**66** [35,102]
No. of Brands Available	**13** [9,17]	**14** [10,17]	**14** [9,17]

Table 1: Summary Statistics for each market (Feb 1997 - April 2010)

Looking at the total sales of golf balls over time, it is apparent that the golf ball market exhibit seasonality and time trend. Seasonality is expected as golf is a seasonal sport that takes place in warm climates. To take this into account, we include the month of year indicator variables in our estimation. Also to account for the general sales trend from 1997 to 2010, we include up to a cubic time trend to account for what is observed.

[19] For on course shops, the sales represent a mix of public and private course golf shops. For off course, a mix of single owner and chains stores are represented. The figures are made up of over 550 on course shops and over 250 off course shops.

[20] The average price (1997 dollars) of on course shops are higher in comparison to the golf balls available in off course golf shops. (identical products are on average more expensive on on course shops for each month) In the modeling procedure, we explicitly take this into account by using it as an instrument for prices, which is endogenous. Interestingly, while the number of products available in off course shops are on average 10 more than the on course golf shops with an average price that is lower by $4.59, the number of golf balls sold in both markets are strikingly similar. We come back to this later when we discuss the elasticities in on and off course shops.

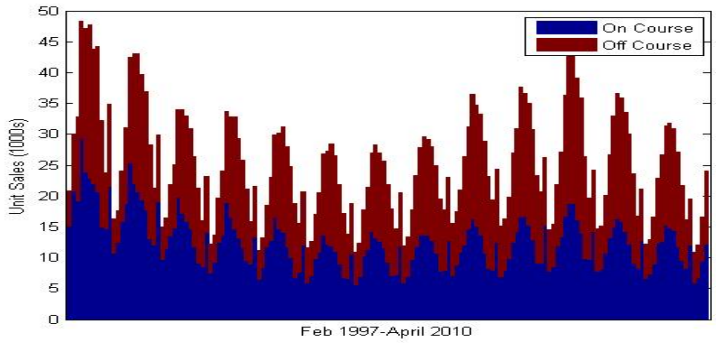

Figure 1: Total Golf Ball Sales (Dozens) for on and off course shops

4.1 Nike Golf Ball Sales

In this section, we explore the data further by looking at the sales of Tiger Woods' endorsed brand Nike. By doing so, we believe that the readers will be able to see the motivation of the questions we pose and the approach we take in answering them.

Below is the sales of Nike golf balls from its introduction in February 1999 until the end of our data period April 2010. The red vertical line represents June of 2000 when Tiger Woods made an official switch to the Nike golf ball.[21] It is not difficult to see that even after taking into account the seasonality on sales over months, there appears to be a "jump" in sales for Nike Golf ball "post" Tiger Woods' switch. While we are not able to make any causality arguement yet, this observation has left us wondering 1) Is there an endorsement effect on endorsed product? Mainly, does endorsement strategy actually increase sales and profit? 2) If so, how profitable are they?

[21] Tiger Woods signed a clothing and shoe contract from 1996 to 2000, and it was not until 2000 that he started his endorsement of Nike golf equipments. It is documented that Nike signed the golfer a 5 year $100 million dollar contract to endorse its then nascent golf equipments in 2000. He would extend the contract by signing what was reported as a 5 year $100 million dollar contract in 2005 that would extend to 2010.

Figure 2: Total Sales of Nike Golf Balls (Dozens) Pre & Post Tiger Woods' Endorsement

Our motivation to answer these questions led us to take a structural econometric approach that relies on economic/marketing theories in modeling the consumer behavior. By doing so, not only are we able to statistically assess the "existence" of endorsement effect, but also by recovering the primitives, we obtain predictions of the effect of strategy changes, enabling us to address our second question of quantifying the profitability of the endorsement strategy.

5 The Model

Given the nature of the data structure, our approach is to jointly estimate the demand and supply equations by following the methodology of Berry, Levinsohn and Pakes (1995).

5.1 The Demand Side

We define a market as the national golf market for each month from February 1997 to April 2010 for both on and off course golf shops. The indirect utility of consumer i from consuming golf ball j in market t is characterized by golf ball price p_{jt}, endorsement vector En_{jt} and product advertisement vector AD_t. We include a set of indicator variables including Tiger Woods' scan-

dal Sc_t, product specific fixed effects PD and the month of year indicator variables MD. We also include the time trend vector **Tr** where we include up to the cubic power as we have observed in the data section. We interact Sc_t with the time trend variable as we like to observe the persistence of the scandal effect on utility. Lastly, the utility is characterized by the unobservable (to the econometrician) product characteristics $\Delta\xi_{jt}$ and individual taste parameter ε_{ijt}, distributed i.i.d. type 1 extreme value across i, j and t.

A consumer i's indirect utility for golf ball j in market t is,

$$u_{ijt} = \alpha_i p_{jt} + \text{En}_{jt}\Gamma + \text{AD}_{t-1}\lambda + (\text{Tr x Sc}_t)\Upsilon + \phi PD + \kappa MD + \text{Tr}\Xi + \Delta\xi_{jt} + \varepsilon_{ijt} \tag{1}$$

$$\alpha_i = \overline{\alpha} + v_i\Sigma \qquad v_i \sim N(0,I) \tag{2}$$

For golf ball price p_{jt}, we adjust the price to 1997 dollars. Here α_i is unidimensional distribution and Σ is the estimate of the standard deviation of our random coefficient. The model parameters of interest consists of both linear and nonlinear parameters. The model parameters are $\theta = (\theta_1, \theta_2)$ where the vector $\theta_1 = (\overline{\alpha}, \Gamma, \lambda, \tau, \phi, \kappa, \Xi)$ contains the linear parameters while $\theta_2 = \Sigma$ is the nonlinear parameter. Consumers are assumed to purchase one unit of goods in each period that gives the highest utility, including the outside option which is normalized to zero.

5.1.1 Celebrity Endorsement Variable

For the direct effect of celebrity endorsements on the sale of the endorsed product, we define the (row) vector $\text{En}_{jt} = [E_{1jt}, E_{2jt}, E_{3jt}, ..., E_{Gjt}]$ for golfer g, product j in market t where

$$E_{gjt} = \begin{cases} \frac{1}{rank_{gt}} & \text{if} \quad D_{gjt} = 1 \\ 0 & \text{if} \quad D_{gjt} = 0 \end{cases} \tag{3}$$

Mainly, for each golfer g, given that the golfer endorses product j, we define E_{gjt} as a function of the skill level at time t . Here, the skill level of player g is assumed to be exogenous

in each period. To take the skill level into account, we use the inverse of the world ranking of the player g at time t as a proxy.[22] D_{gjt} is the indicator variable where it equals 1 if player g endorses product j at time t. By taking into account the variability of skill level over time, we maintain that if there exist an endorsement effect, the effect will be larger when the player is of higher quality.

We include five golfers in our model; Tiger Woods, Phil Mickelson, Ernie Els, Vijay Singh and David Duval. We chose these five players because of the following reasons. First, in the time period between 1997 and 2010, all five players switched their endorsed product at least once. Because of their switching behavior at time t, we are able to identify their endorsement effect on product j. Second, all five players were ranked high in the world ranking for the majority of the time period between 1997 and 2010[23] with a clear record of these five players being under the endorsement contract with the respective company of the golf ball that they used. Since our purpose is to study the impact of "celebrity endorsement", we are interested in the players who were the top players in the PGA tour.[24] Lastly, and perhaps most importantly, by simply including one celebrity, we suffer from omitted variable problem. For example, if we include just Tiger Woods as the En_{jt} variable, our estimate of Tiger Woods' endorsement effect for product j may be biased. If there are other "celebrity" endorsers that endorses the same product j, the estimate of endorsement effect could be biased upward. In our case, it is imperative to include other top golfers that endorsed the Titleist product since Tiger Woods was not the only top golfer in time t that endorsed Titleist.[25]

[22] The Official World Golf Ranking is published every week, but given that we define our time in months, we use the end of the month's world ranking. http://www.officialworldgolfranking.com/home/default.sps

[23] An exception from these 5 players is David Duval, who ranked high from 1997 to 2003 before falling outside of the top 200 in rank. (He would come back in 2009 by being ranked in the top 200) We decided to include Duval in our estimation because not only do we know the date in which he switched from the Titleist product to the Nike product but during the time he was ranked high, he was considered as one of the the best golfer of all time.

[24] In fact, for players who were not consistently ranked high in their career, it was difficult to find out whether they had a formal endorsement contract with the golf ball that they used.

[25] In fact, all five players that we include in our estimation were endorsed by Titleist when Tiger Woods first turns professional. Even though Tiger Woods signed an agreement with Titleist, there were other prominent players who we believe could have had an endorsement effect on the consumers.

5.1.2 Advertisement Level Variable

It is important to discuss why the advertisement level variable is essential in our estimation. If the advertisement level of brands that the celebrity endorse affect the indirect utility of consumers, but is not accounted for, then the endorsement variable can be biased as the estimate captures the combination of both the endorsement effect and the level of exposure of product j . To isolate the endorsement effect, we include the vector $\text{AD}_t = [A_{1t}, A_{2t}, ..., A_{Nt}]$ where $A_{jt} = \sum_{g=1}^{P} Ad_{gjt}$,

$$Ad_{gjt} = \begin{cases} MWIN_{gt} + win_{gt} & \text{if} \quad D_{gjt} = 1 \\ 0 & \text{if} \quad D_{gjt} = 0 \end{cases} \tag{4}$$

By taking into account the advertisement level, we are able to test not only the endorsement effect but also whether the advertisement level has any effect on consumer utility. The Ad_{gjt} variable is the exposure of product j at time t by player g. We use the winning of the PGA Tour tournaments by the player as the advertisement variable. We use the winning variable as oppose to the advertisement spending by each endorsement companies because we were not able to obtain a full set of advertisement spending that span the date range in our dataset. The variability of the winning by each player across time allows us to identify the parameters of AD_t. Here, the win_{gt} is the indicator variable that is 1 if the player g at time t wins the tournament. In the PGA Tour, there are 4 tournaments that are considered the "Major". These include the Masters, US OPEN, British Open(The Open Championship) and the PGA Championship. These tournaments are usually widely publicized with typically larger audience and longer TV coverage than the regular tour tournaments.[26] To take account for this extra exposure, we include the indicator variable $MWIN_{gt}$ where it equals 1 if the player who wins at t won one of the major tournaments. Therefore, we assign the major tournament to 2 while regular tournament as 1. We include 3 major golf ball manufacturers, Nike, Callaway and Titleist since at one point in their career, the top 5 players were endorsed by at least one of the three brands. For each firm, we match the

[26]Majority of the PGA tour tournaments are televised. The tournament starts on Thursday of a given week with 1 round (18 holes) played in each day for 4 days. Usually, the first two rounds are televised in cable channel while the last 2 rounds are televised in regular channel. In the last 2 rounds, the players that get most coverage are those that are high up in the leader board.

historic PGA tour winner to the golf ball used from 1997 to 2010.[27] For each advertisement variables, following players were included[28],

Nike	Titleist	Callaway
Tiger Woods	Tiger Woods	Phil Mickelson
David Duval	Phil Mickelson	Ernie Els
Stewart Cink	David Duval	
KJ Choi	Vijay Singh	
Trevor Immelman	Ernie Els	
Anthony Kim	Davis Love III	
Paul Casey	David Toms	
	Steve Stricker	
	Padraig Harington	
	.	
	.	
	.	

Table 2: PGA winning as a proxy for advertisement variable

To justify our use of the winning data as a measure advertisement level of product j, we first describe how golf tournaments are covered in television. In all cases, as long as the player is in the top 5 in the leaderboard in the final round, they will receive the most broadcast coverage, regardless of the world ranking of the player.[29] For viewers, it is not difficult to identify the product that the golfer use as the camera angle allows the explicit view of the brand.[30] [31]

[27] While we made ever effort to match the winners, in rare occasions we were not able to ascertain which ball the golfer would have used to win the tournament. This was especially the case for Titleist brand. In cases like this we left it as 0.

[28] Some players show up in multiple brands given that they switched their endorsed brand between 1997-2010. Also, we name only the top players for the Titleist brand given that there were significantly more players who won under Titleist brand than other brands on the PGA tour. This is expected since Titleist brand is the most widely used golf ball on the PGA tour. To name a few players we have included are winners like Ian Poulter, Hunter Mahan, Jason Bohn. For recent winners like these we used the PGA tour website with player profile that identifies whether Titleist golf ball was used. (http://www.pgatour.com/players/02/45/07/). For winners that trace back further, we made every effort to ascertain whether Titleist ball was used. For example, player like Brad Faxon, we were certain that he used Titleist golf ball to win tournaments.

[29] When Tiger Woods won the Masters tournament in April 2000, it was measured that he was on-screen for 32% of the broadcast time while the rest of the field was on for 36% of the time.[22]

[30] For example, when a player is on the putting green, the camera would zoom into the golf ball capturing the roll of the ball to the hole from the view of the ground level.

[31] It is documented that during the 2005 Masters tournament, when Tiger Woods chipped in his shot from the par 3 16th hole, the ball that Tiger Woods endorsed was made visible in close-up. Many believe that this specific coverage helped boost Nike's exposure to then relatively nascent Nike golf ball division.[24] http://www.youtube.com/watch?v=ZLKXvGE6kN8

Given the nature of how golf tournaments are covered on television, we have to assess whether these winning variables can be used as a proxy for advertisement level for each firm. We empirically verified the high correlation between the winning brand in the PGA tour and the advertisement spending level. To do so, we were able to obtain a sample of brand level advertisement spending on golf ball alone from June 2008 to December 2009 for all three manufacturers.

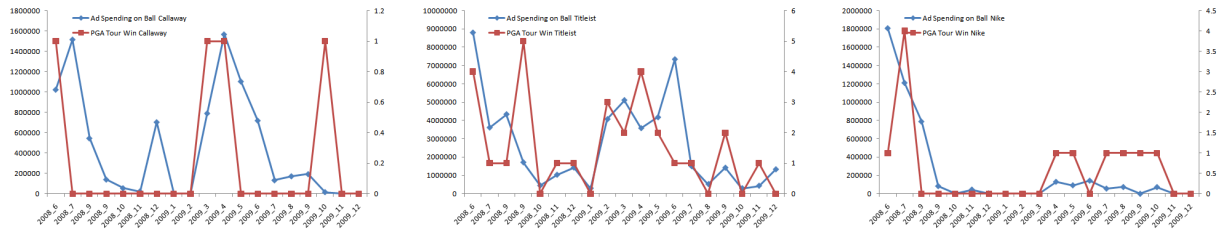

Figure 3: Correlation between the PGA tour winning brand and the advertisement level

As shown graphically, our use of the winning variable as a proxy for manufacturer's advertisement level is justified. This correlation is 0.5904.

In our specification, we take the lag operator L where $\mathrm{L}(\mathrm{AD}_t) = \mathrm{AD}_{t-1}$ for the advertisement variable to account for the fact sales data was collected at the end of the month.

5.1.3 Scandal Variable

We study the effect of Tiger Woods' scandal by including the vector $\mathrm{Sc}_t = [S_N, S_{NN}]$. Similar to the exposure variable, we look at both the effect of the scandal on Nike products as well as non Nike products. We define SC_t as an indicator variable where it equals 1 for months after October 2009. Defining $D_{Nike} = 1$ for Nike products, $S_N = \mathrm{SC}_t \times D_{Nike}$ and $S_{NN} = \mathrm{SC}_t \times (1 - D_{Nike})$ captures all the Nike products and the remaining products during Tiger Woods' scandal, respectively.

5.1.4 Instrumental Variables for Price Endogeneity

We assume that the explanatory variables less the price variable p are uncorrelated with the error term $\Delta\xi$. Therefore, we allow these variables to instrument for themselves. For p however, we look for variables that shift cost or margins that are not correlated with the demand shock $\Delta\xi_{jt}$. We have 20 instruments; Type of Outer Materials $\times$Number of Products, Layer Competition, Multiproduct Externality and Off Course Shop indicator. First, vectors of 17 different type of materia1 covers are interacted with the total number of products offered in each market. As mentioned in section 2, the production cost is affected by different material covers. We capture the competition present in each market for each material by interacting with the number of products. We expect that price is inversely correlated with this set of instruments. Another characteristics of a golf ball is the number of layers. To account for this, we include Layer Competition which we define as the total number of products in market t that has the same number of layers for a given product j. We also take into account the number of products each brand represents in each market with Multiproduct Externality variable.[32] This captures the relative diversification of the product line in each market for a given brand which impacts the price setting decisions. If more products are offered we conjecture that the price will be lower. Lastly, given that we have 2 separate markets with observed price premium on on course shops, we include the Off Course Shop indicator variable as an instrument for price.

To satisfy the exclusion restriction, these variables must first not enter the demand equation and second be uncorrelated with the unobservable product characteristics $\Delta\xi_{jt}$. We argue that these variables do not belong in the demand equation because consumer i's utility is not dictated by the state of "competition" for product j's characteristics space in market t. In fact, while our institutional knowledge tells us that consumer $i's$ utility from product j is a function of the type of material, layers, and even brand loyalty on product j, which we capture through product specific fixed effect variable PD, the relative competition of a particular products' material, layer as

[32]For example, if Titleist offers a total of 7 products in market t then all the Titleist product in that market will be assigned 7.

well as the level of product diversification of a particular manufacturer is not part of their decision process. Second, the proposed instruments are uncorrelated with the unobservable product characteristics $\Delta\xi_{jt}$ as these variables are market specific conditions not product j specific. For Off course variable, as mentioned in the data section, it is clear that there are mark-ups on golf balls sold in on-course pro shops. In fact, the same product offered in off course shops command price premium in on course shops. For this reason, the Off Course Shop variable is a good instrument since it is correlated with price yet not with the demand shock.

With these exclusion restrictions, we estimate the Two-stage least square (2SLS) using the 20 instruments and show that in the first stage, we reject the null hypothesis of the instruments being jointly zero with F-Statistics of 1.3270e+003 in an $F_{20,20250}$ distribution.[33]

5.1.5 Identification

We now discuss identification of the linear parameter θ_1. For the linear parameter $\overline{\alpha}$ the identifying power comes from the variation in the observed prices. For the Γ parameter, which is the endorsement variable that takes into account the inherent ability of a golfer, we are able to identify the parameter due to players switching endorsed products at least once during the time period between 1997 and 2010. Similarly, for λ which is the advertisement variable for a given product, the identifying power comes from the variation in the exposure of brands during PGA Tour tournaments. Lastly, τ which is a vector of parameters for the scandal effect on Nike products and non Nike products, we are able to identify both the parameters since we interact the time in which Tiger Woods' scandal was revealed with the product indicator variables.

For the non linear parameter $\theta_2 = \Sigma$, given that our model only takes price variable as random coefficient, the variation in the observed prices for a given product j across markets along with the entrance of new products over time provide the identifying power that govern the distribution

[33] Given the large dimension of instruments, to overcome the overidentification concerns that uses the same variations repeatedly to get significance, we also estimate the 2SLS and the proposed random coefficient model using only the last 3 instruments, LayCompete, Multiproduct externality and OffDummy. We compare our estimates and find similar results for these two sets of instruments, which we include in the appendix.

of the random coefficient.[27]

5.2 The Supply Side

The market we study is an oligopoly with multiproduct firms. Assuming that the observed prices are the result of an interior, pure strategy Nash-Bertrand equilibrium, we can make use of the information from the first order condition of profit maximization. Mainly, given the profit function for firm f,

$$\pi_f(\mathbf{p},\mathbf{z},\xi,\omega_f,\theta) = p_f M \cdot s_f(\mathbf{x},\xi,\mathbf{p},\theta_d) - C_f(M \cdot s_f(\mathbf{x},\xi,\mathbf{p},\theta_d), w_f, \omega_f, \gamma) \tag{5}$$

where $\theta = (\theta_d, \gamma)$, $\mathbf{z} = (\mathbf{x}, \mathbf{w})$, M is the market size, s_f is a vector of shares, C_j is the total costs for firm f, w_f is the characteristics that affects marginal costs while ω_f is the unobserved cost variable. Bolded variables $\mathbf{x}, \xi, \mathbf{p}, \mathbf{z}$ are vector of variables for all firms. The price vector that satisfies the first order condition is,

$$M\{[p_f - mc_f(q_f, w_f, \omega_f, \gamma)][\frac{\partial s_f(\mathbf{x},\xi,\mathbf{p},\theta_d)}{\partial p_f}] + s_f(\mathbf{x},\xi,\mathbf{p},\theta_d)\} = 0 \tag{6}$$

$$mc_f(q_f, w_f, \omega_f, \gamma) = p_f + \frac{s_f(\mathbf{x},\xi,\mathbf{p},\theta_d)}{\frac{\partial s_f(\mathbf{x},\xi,\mathbf{p},\theta_d)}{\partial p_f}} \tag{7}$$

where $-\frac{s_f(\mathbf{x},\xi,\mathbf{p},\theta_d)}{\frac{\partial s_f(\mathbf{x},\xi,\mathbf{p},\theta_d)}{\partial p_f}}$ is the vector of markups for firm f. We observe p_f and θ_d is the parameters from the demand side which we can estimate, thus allowing us to compute the marginal cost mc_f. We assume that the marginal cost decomposes into an observable w_f and unobservable component ω_f (to the econometrician),

$$mc_f = w_f \gamma + \omega_f \tag{8}$$

with γ being the vector of parameters to be estimated. In our case, we define w_f as a matrix consisting of vectors of golf ball characteristics (material cover, layers, dimples), firm indicator and a time trend.

We assume that the observed component w_f is uncorrelated with ω_f. However, for the markup which is a function of market share, we use the predicted markup and the predicted market share from the demand side as instruments. As the predicted markup from the demand side is a function of exogenous variable and the instruments for price variable, we are effectively instrumenting for the mark up with demand shifters. (Berry, Levinsohn and Pakes (2004))

The vector of parameters γ are identified with the same reasoning that we have provided for the demand side linear parameters θ_1. With the data structure that consist of different number of firms with different number of products in each market and the variation in the type of golf balls available, we are able to identify the parameters of both the ball characteristics as well as the firm parameter.

5.3 The Moment Conditions

We have two sets of moment condition coming from the demand and the supply side equation. The demand side moments are,

$$E[\Delta\xi' Z^d] = 0 \tag{9}$$

where $\Delta\xi = [\Delta\xi_1, ...\Delta\xi_T]'$ where $\Delta\xi_t$ is a J dimensional vector of $\Delta\xi_{jt}$ where j is the product (j=1..J) in market t (t=1,..T), $\Delta\xi_{jt} = \delta_{jt} - (\alpha_i p_{jt} + \text{En}_{jt}\Gamma + \text{AD}_{jt}\lambda + \text{Sc}_t\tau + \phi PD + \kappa MD + \text{Tr}\Xi)$. δ_{jt} is recovered by equating the predicted and the observed market shares for product j in market t through the contraction mapping. $Z^d = [z_p^d, Rd]'$ where $Rd = [\text{En}, \text{AD}, \text{Sc}, PD, MD, \text{Tr}]$ and z_p^d is the demand side instrument p where $p = 1, ..., 20$.

The supply side moment is,

$$E[\omega' Z^s] = 0 \tag{10}$$

where $\omega = [\omega_1, ..., \omega_T]'$ where ω_t is a F dimensional vector of ω_{ft} where f is the firm (f=1,..,F) in market t (t=1,..,T), $\omega_{ft} = p_{ft} + \frac{s_{ft}(\mathbf{x},\xi,\mathbf{p},\theta_d)}{\frac{\partial s_{ft}(\mathbf{x},\xi,\mathbf{p},\theta_d)}{\partial p_{ft}}} - w_{ft}\gamma$. $Z^s = [\hat{\text{markup}}^d, w]'$ where $\hat{\text{markup}}^d$ is the markup estimated with the exogenous variables and instruments from the demand side

while w is the regressor for the supply equation; Firm indicator variable, material cover indicator variable, number of layers, number of dimples, and time trend. With the addition of the supply side, we form additional moment conditions and jointly estimate the parameters of the demand and the supply side equation. Because the marginal cost is a function of markup which in turn is a function of the price sensitivity parameter α, by forming the supply side moment condition and estimating the parameters jointly, it allows the estimation to take into account the cross-equation restrictions on the parameter of interest.

6 Estimation Results

We estimate the model using generalized method of moments (GMM) as part of a nested fixed-point algorithm matching the simulated market share to the observed market share and forming moment conditions. As a benchmark, we first estimate the logit model with and without the instrumental variables. The estimation procedure and result are in the appendix. For the proposed random coefficient model, to save space, we do not report the estimated values of seasonality variables MD and the product indicator variables PD. However, both vectors were statistically significant.

As shown in table 3, Tiger Woods' endorsement effect on both Nike and Titleist products are statistically significant with the estimated coefficients of 0.142 and 0.143 respectively. This suggests that Tiger Woods had the endorsement effect on all Titleist products between 1997 to 2000 and all Nike products during the endorsement period 2000-2010 by contributing to additional utility attached to the respective brand products. We also find the advertisement by Nike had a statistically significant effect on its product with the marginal utility of 0.066 attached to the products during which Nike products were advertised.

Random Coefficient Model		
Linear Parameters	**Estimate**	**SE**
Woods Scandal x Non Nike Products x *time*	5.005 ***	1.611
Woods Scandal x Non Nike Products x $time^2$	-0.064 ***	0.021
Woods Scandal x Non Nike Products x $time^3$	0.00020 ***	0.00007
Woods Scandal x Nike Products x *time*	5.700 ***	2.781
Woods Scandal x Nike Products x time^2	-0.073 ***	0.036
Woods Scandal x Nike Products x $time^3$	0.0002 ***	0.0001
Woods Nike Endorsement	0.142 ***	0.072
Duval Nike Endorsement	-0.108	0.218
Mickelson Callaway Endorsement	0.020	0.164
Els Callaway Endorsement	-0.274	0.233
Woods Titleist Endorsement	0.143 ***	0.061
Mickelson Titleist Endorsement	-0.637 ***	0.165
Duval Titleist Endorsement	0.446 ***	0.096
Singh Titleist Endorsement	-0.134	0.085
Els Titleist Endorse	0.275 ***	0.118
Nike Advertisement	0.066 ***	0.017
Callaway Advertisement	-0.008	0.037
Titleist Advertisement	0.004	0.010
time	-0.02013 ***	0.00264
$time^2$	0.00015 ***	0.00004
$time^3$	-0.0000004 ***	0.0000002
Non Linear Parameters	**Estimate**	**SD**
Price	-0.087 ***	0.019 ***
	(0.003)	(0.005)
GMM objective	196.105	

*** Significant at 0.05 ** Significant at 0.10

Table 3: Estimate of the Random Coefficient Model

As for the scandal, we find that Tiger Woods had a negative impact on both Nike and Non Nike products. Since the scandal variables were interacted with the time trend variable, the impacts are not readily seen by simply observing the estimates. Below are the attached utilities for all products during the scandal period.

Month (2009-2010)	November	December	January	February	March	April
Time represented in data	154	155	156	157	158	159
Nike Products	0.052	-0.105	-0.192	-0.207	-0.149	-0.016
Non Nike Products	0.034	-0.090	-0.152	-0.150	-0.083	0.049

Table 4: Scandal with Time Trend

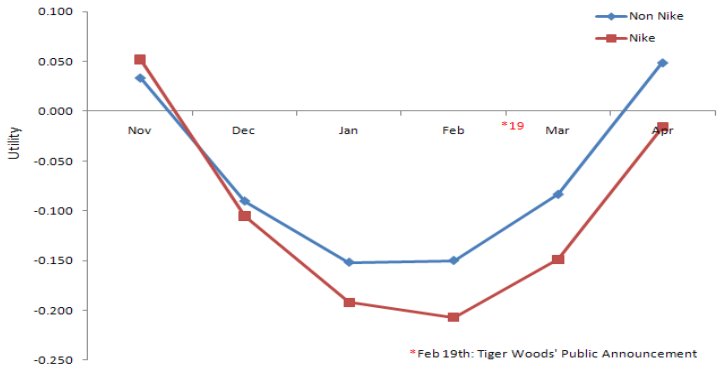

Figure 4: Effect of Scandal over time

As expected, Nike products are affected more than non Nike products. In fact, even after separately controlling for seasonality (*MD*) and time trend (**Tr**) in the utility function, we find that the scandal had a progressively stronger negative effect over time for Nike until February 2010. The turning point in the utility coincide with the announcement by Tiger Woods regarding his infidelity and his apologies to his fans.[34] While the additional utility associated with both Nike and Non Nike products due to scandal were still negative up to March, our result indicate that the negative impact was alleviated by March before becoming positive in April 2010 for non Nike products.

Amongst other golfers, it is interesting to note that David Duval has had the largest impact for Titleist brand in terms of the endorsement variable at 0.446. This is larger than Tiger Woods' 0.143. This effect however disappears when David Duval switches the endorsed brand to Nike. While this may be surprising, when one understands the context of David Duval as a player it is not difficult to understand this phenomenon. David Duval's dramatic decline in performance

[34]Full transcript can be read at http://articles.cnn.com/2010-02-19/us/tiger.woods.transcript_1_elin-behavior-core-values?_s=PM:US

as a golfer is a well known story in the golf community. In fact, it was around the time when David Duval switched to Nike did his skill level drop significantly.[35] Since we explicitly take into account the variability of skill level for each players through the world ranking, which we assume to be exogenous, this result confirms our belief that David Duval's fall as a top athlete should have caused the drastic change in the impact on his new endorsed product Nike. We also find statistically significant results for other golfers, Phil Mickelson and Ernie Els. For Mickelson, we find that he had a negative endorsement effect on Titleist products.[36] For Ernie Els, he was an effective endorser under Titleist at 0.275, although this effect disappears when he switches to Callaway.[37]

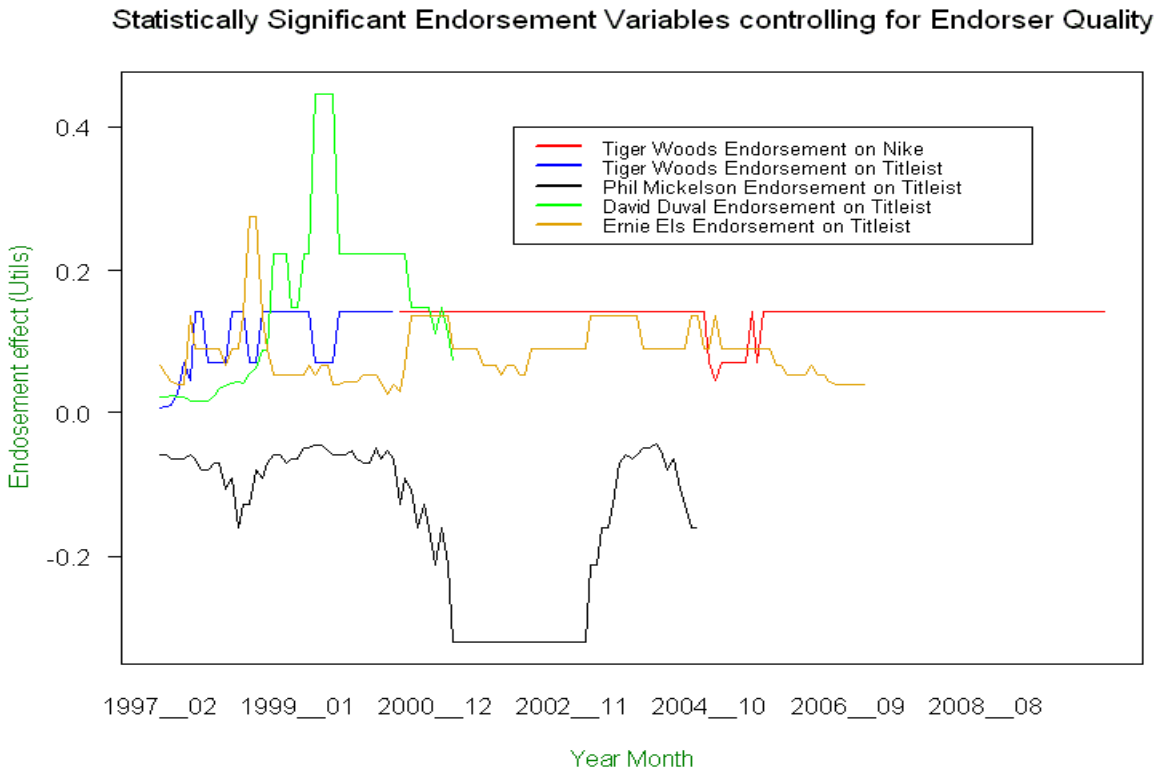

Figure 5: Effect of Endorsement over time

A random coefficient was set on price. As expected, we find customer heterogeneity in

[35] David Duval switched to the Nike product in 2001-2002 season.
[36] While we find this odd, the estimated coefficient has been robust for many different specifications.
[37] Els is documented to have switched to Callaway in 2007.

price sensitivity. With the average price sensitivity of -0.087 per dollar, 95% of the consumers are estimated to have price sensitivities between -0.125 and -0.050. The mean of the price coefficient is close to twice the estimate of the benchmark model that does not take into account the endogeniety of prices.

Lastly, for the supply side we estimate the parameters of marginal cost. We find that our regressors are all significant with sign and magnitude that correspond with our prior knowledge of the production process being affected by firm and ball characteristics. In fact, while our institutional knowledge estimated the marginal cost for a dozen of golf ball being $4-$8, our estimate show that the average marginal cost for a dozen of golf ball is $7.02. We use the estimated marginal cost. We include the estimate in the appendix since they provide little pertinent information outside aggregate marginal cost which we use for profit calculation in the counterfactual.

6.1 Price Elasticities

One of the main advantages of estimating the random coefficient model in the context of differentiated products is its ability to take into account the similarity between products. In contrast to the logit model, in which substitution is driven only by similar market shares in each market, the random coefficient model produces more realistic own and cross elasticities. In this section, we address the strikingly similar nature of sales across two channels in rather disparate environment (choice sets and price) by studying the elasticities of on and off retail channels.

We report one set of elasticities for on and off course shops out of 318 markets. In June 2007, 68 and 55 products were present in the off course and the on course shops respectively. Given the large dimension, we report a subset of these elasticities by categorizing the products into the premium and the non premium brands. Table 5 and 6 shows the premium brand for off and on course shops respectively. For both channels, the own price elasticity is elastic with the magnitude ranging from -1.571 to -2.989. Comparing products across two channels, we observe

that for a given product j, the on course shop has higher elasticity. For example, Titleist Pro V1 has an off and on course shop own price elasticity of -2.572 and -2.699 respectively. Looking at the off diagonal values for cross price elasticities, we observe that the on course shop have on average higher values for each product j. For example, looking at column 2 for both off and on course, for product Titleist Pro V1x, when Pro V1x's price is increased by one percent, the percent change in share for Pro V1 is 0.381 for on course whereas it is only 0.235 in off course. This informs us that in on course shops, consumers are more price sensitive but are willing to substitute away from the product more readily than in the off course shops. This makes intuitive sense as we know that there are higher markups in on course shops yet circumstantially golfers may need to purchase some golf ball given that they are pressed with time before playing a round of golf.[38] Looking at the non premium products, in table 7 and 8, in contrast to the premium products, the own price elasticity is smaller in magnitude. The own price elasticity ranges from -0.554 to -1.590 across two channels suggesting the existence of inelastic demand in some products. This suggests that for those products that have elasticity larger than -1.000 ($-1 < \eta_{jjt} < 0$), the brand can potentially earn larger profit by increasing the price. In our market, these corresponds to two Pinnacle products, Nike Mojo, Maxfli Distance, and Top Flite products in the off course shop and Pinnacle Gold Distance, Precept Lady SIII, and Top Flite XL Distance in the on course shop. Similar to what was observed in premium products, we find that the own price elasticity is greater in magnitude in the on course shops than the off course shops. In fact, a few products have an inelastic demand in off course while elastic demand in on course. For example, both Pinnacle Gold Lady and Nike Mojo have own price elasticities of -0.807 and -0.869 in the off course shop and -1.177 and -1.590 in the on course shop respectively.

Comparing cross price elasticities, we observe realistic substitution patterns across products. For example, cross price elasticity for Pro V1 is greatest for the most similar product Pro V1x.

[38] Recall that we have the outside option of not purchasing so it does not necessarily mean that when own price elasticity is high then the cross price elasticity is also higher. What we find here is that even though consumers have an option to not buy golf balls in on course given their price sensitivity, they do substitute more to similar products than we observe in off course shops. This makes sense once we take into account the circumstances that these consumers may be faced in the on course golf shops.

Price Elasticity Off Course Shop 2007.06												
TITLEIST PRO V1	-2.572	0.235	0.227	0.232	0.232	0.233	0.233	0.232	0.232	0.232	0.234	0.234
TITLEIST PRO V1x	0.164	-2.633	0.159	0.162	0.162	0.162	0.162	0.162	0.161	0.162	0.163	0.163
TITLEIST NXT TOUR	0.058	0.058	-1.571	0.059	0.059	0.058	0.058	0.059	0.059	0.059	0.058	0.058
BRIDGESTONE TOUR B330	0.019	0.019	0.019	-2.382	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
BRIDGESTONE TOUR B330-S	0.019	0.019	0.019	0.019	-2.352	0.019	0.019	0.019	0.019	0.019	0.019	0.019
CALLAWAY HX TOUR	0.038	0.038	0.038	0.038	0.038	-2.456	0.038	0.038	0.038	0.038	0.038	0.038
CALLAWAY HX TOUR 56	0.028	0.028	0.028	0.028	0.028	0.028	-2.488	0.028	0.028	0.028	0.028	0.028
NIKE ONE PLATINUM	0.037	0.037	0.037	0.037	0.037	0.037	0.037	-2.275	0.037	0.037	0.037	0.037
NIKE ONE BLACK	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	-2.276	0.021	0.021	0.021
SRIXON Z-UR	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	-2.393	0.002	0.002
TAYLORMADE TOUR PREFERRED BLACK	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	-2.626	0.011
TAYLORMADE TOUR PREFERRED RED	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	-2.595

Table 5: Price Elasticities of Premium Golf balls in Off Course golf Shop June 2007

Price Elasticity On Course Shop 2007.06												
TITLEIST PRO V1	-2.699	0.381	0.368	0.378	0.378	0.380	0.367	0.379	0.365	0.374	0.376	0.375
TITLEIST PRO V1x	0.246	-2.850	0.237	0.244	0.244	0.245	0.237	0.245	0.236	0.241	0.243	0.242
TITLEIST NXT TOUR	0.129	0.129	-1.916	0.131	0.131	0.130	0.134	0.130	0.135	0.132	0.131	0.132
BRIDGESTONE TOUR B330	0.012	0.012	0.012	-2.839	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
BRIDGESTONE TOUR B330-S	0.003	0.003	0.003	0.003	-2.825	0.003	0.003	0.003	0.003	0.003	0.003	0.003
CALLAWAY HX TOUR	0.016	0.016	0.015	0.016	0.016	-2.989	0.015	0.016	0.015	0.016	0.016	0.016
CALLAWAY HX TOUR 56	0.024	0.024	0.025	0.025	0.025	0.024	-1.945	0.024	0.025	0.025	0.025	0.025
NIKE ONE PLATINUM	0.015	0.015	0.015	0.015	0.015	0.015	0.015	-2.918	0.015	0.015	0.015	0.015
NIKE ONE BLACK	0.003	0.003	0.004	0.004	0.004	0.003	0.004	0.003	-1.839	0.004	0.004	0.004
SRIXON Z-UR	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	-2.527	0.003	0.003
TAYLORMADE TOUR PREFERRED BLACK	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	-2.719	0.008
TAYLORMADE TOUR PREFERRED RED	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	-2.601

Table 6: Price Elasticities of Premium Golf balls in On Course golf Shop June 2007

Note: Change in Marketshare for product i with 1% change in price of product j where i=row, j=column.

Price Elasticity Off Course Shop 2007.06										
PINNACLE GOLD DISTANCE	-0.796	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019
PINNACLE GOLD LADY	0.004	-0.807	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
PRECEPT LADY SIII	0.024	0.024	-1.341	0.023	0.023	0.023	0.023	0.024	0.023	0.024
CALLAWAY HX BIG BERTHA	0.012	0.012	0.012	-1.336	0.012	0.012	0.012	0.012	0.012	0.012
NIKE MOJO	0.006	0.006	0.006	0.006	-0.869	0.006	0.006	0.006	0.006	0.006
NIKE JUICE 312	0.016	0.016	0.016	0.016	0.016	-1.330	0.016	0.016	0.016	0.017
MAXFLI NOODLE	0.020	0.020	0.019	0.019	0.020	0.019	-1.056	0.020	0.020	0.020
MAXFLI DISTANCE	0.003	0.003	0.003	0.003	0.003	0.003	0.003	-0.774	0.003	0.003
TOP FLITE D2 DISTANCE	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	-0.895	0.007
TOP FLITE XL DISTANCE	0.017	0.017	0.016	0.016	0.017	0.016	0.017	0.017	0.017	-0.554

Table 7: Price Elasticities of Non Premium Golf balls in Off Course golf Shop June 2007

Price Elasticity On Course Shop 2007.06										
PINNACLE GOLD DISTANCE	-0.966	0.091	0.093	0.090	0.089	0.089	0.090	0.092	0.091	0.093
PINNACLE GOLD LADY	0.006	-1.177	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
PRECEPT LADY SIII	0.006	0.006	-0.904	0.006	0.005	0.005	0.005	0.006	0.006	0.006
CALLAWAY HX BIG BERTHA	0.016	0.016	0.016	-1.426	0.016	0.016	0.016	0.016	0.016	0.016
NIKE MOJO	0.016	0.016	0.017	0.016	-1.590	0.016	0.016	0.016	0.016	0.017
NIKE JUICE 312	0.011	0.011	0.011	0.011	0.011	-1.501	0.011	0.011	0.011	0.011
MAXFLI NOODLE	0.018	0.018	0.018	0.018	0.017	0.017	-1.432	0.018	0.018	0.018
MAXFLI DISTANCE	0.003	0.003	0.003	0.003	0.003	0.003	0.003	-1.045	0.003	0.003
TOP FLITE D2 DISTANCE	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	-1.272	0.004
TOP FLITE XL DISTANCE	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	-0.867

Table 8: Price Elasticities of Non Premium Golf balls in On Course golf Shop June 2007

Note: Change in Marketshare for product i with 1% change in price of product j where i=row, j=column.

Interestingly, we find that substitution pattern for its counterparts are different in magnitude. For example, for the off course shop's premium product, the cross price elasticity of ProV1 to ProV1x is 0.164, while ProV1x to ProV1 is 0.235. This suggests that given a price change in one of the two products, consumers of Pro V1 products are "less" likely to substitute away to ProV1x than the consumers of ProV1x would to Pro V1. This confirms with our institutional knowledge of Pro V1 being the standard golf ball for low handicap players who are reluctant to switch to other balls.

Recall that we had made a puzzling observation of the total sales being strikingly similar across two channels. We conjectured that the price sensitivity for a given product j may be lower in on course shops which would explain the similar sales figures across the two channels in the midst of disparate prices. However, we find that the price elasticity is larger in higher priced market for a given product j. While the two observations do not support each other, what reconciles this is the relatively larger cross price elasticities in the on course shops. Interestingly, we find that in on course shops, consumers are more willing to switch to different products even though they have an option to not purchase any product. With this higher level of substitution, we are able to explain why we observe strikingly similar sales figure across two channels.

7 Counterfactuals

By incorporating the endorsement and advertising level into the consumers' utility function, we found that consumers attach additional utility to celebrity endorsed products. In this section we first look at the overall effect of celebrity endorsement in the golf industry. Mainly, we want to assess whether or not endorsement can also *"create prestige, differentiation, or association that may change the utility a consumer obtains from consuming a product."[1]*(Ackerberg 2001) Once we show that celebrity endorsement generates shift in market shares, we assess the economic value of celebrity endorsement by looking specifically at Tiger Woods.

7.1 Product Differentiation through Celebrity Endorsements

Our demand estimate suggests that there are statistically significant celebrity endorsement effects attached on endorsed products. Given this finding, we assess whether the extra utility attached to the endorsed products are large enough to generate shift in market shares. We first want to assess the overall endorsement effect in the golf market. To do so, we run the counterfactual by assuming that no celebrity endorsements exist in the golf industry and compare it with a regime where celebrity endorsements exist in the industry.

	Change in Share
Nike	0.008
Titleist	0.003
Callaway	-0.001
Others	-0.005
Outside Option	-0.005

Table 9: Change in Share with the presence of endorsement

As shown, we see that with the presence of endorsements in the industry, Nike and Titleist benefit. This is not surprising since we have shown in our demand estimation the positive and significant endorsement effects on these brands. On the other hand, we find that, both Callaway and the rest of the market suffer in market share due to endorsements. It is interesting to note that, the endorsement effect not only increases the share for the company with effective endorsers, but the presence of endorsements in the golf market increase the overall demand. Recall that the outside option in our model is "no purchase" and through our counterfactual we observe that the size of the outside option share decreases with the introduction of endorsements in the industry. This suggests that the endorsement effect is large enough such that those who would have otherwise not purchased a product does so when there are celebrity endorsements in the industry. This counterfactual not only makes clear that indeed endorsement effects are large enough to create product differentiation and shift market shares within the market but also is characterized as having a "primary demand" component where it attract customers who would have otherwise not purchased a product in the absence of celebrity endorsements.

7.2 Economic Value of Celebrity Endorsements

Having found that celebrity endorsements can change the utility a consumer obtains from consuming a product, we assess the economic value of celebrity endorsement by looking at Tiger Woods. Our demand estimates suggest that Tiger Woods had a significantly positive effect on Nike products during the endorsement period. Given this finding, we ask the following question: What would have been the share of Nike's products if Nike elected to forgo endorsing Tiger Woods for the past 10 years? In 2000, Tiger Woods reportedly signed a 5 year $100 million dollar renewal contract with Nike, agreeing to endorse both apparel and golf balls, a golf segment that Nike entered as recently as 1999. In 2005, he was reported to have signed a 5 year $100 million extension. We would like to assess whether Tiger Woods' endorsement translated into sales and whether such sizable contracts were profitable. Therefore, in this section, by focusing on the impact of Tiger Woods on the Nike ball brand we run the counterfactuals to measure the economic value of a celebrity endorsement.

To find the impact of Tiger Woods on Nike's sales, we calculate the new market share of Nike's product under the environment where consumers choose a product without the extra "utility" associated with Nike products. To do so, we make the assumption that Tiger Woods would have continued his endorsement with the Titleist golf ball if it was not for Nike's offer in 2000. Therefore, we run the counterfactual by "assuming" that the statistically significant values of the "Tiger effects" are absent in the consumer utility for Nike products while the extra utility that was shown to be statistically significant for Titleist between 1997 to 2000 be present for 2000-2010. By doing this, we study the consumers' choice of Nike and its impact on sales under the "Tiger-less" environment.

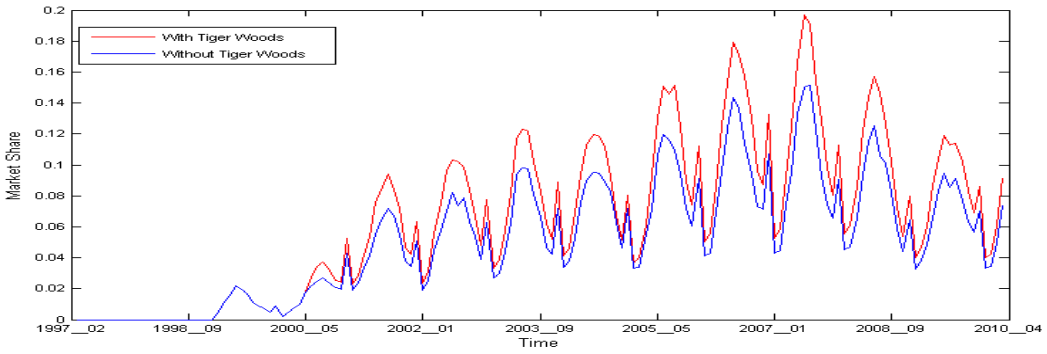

Figure 6: Share of the Nike Products for on & off course shops combined

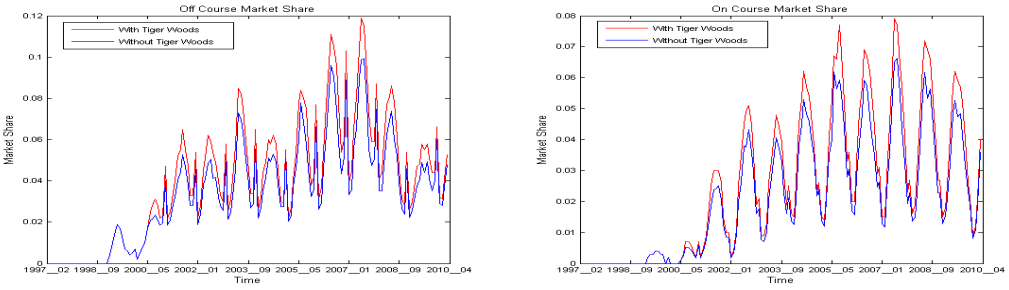

Figure 7: Share of the Nike Products for each retail channels (off, on)

Above are the aggregated market shares for Nike golf balls for all time periods for both on and off course combined/separated. We can readily see that the market share is larger during the time that Tiger Woods was under Nike sponsorship. What this suggests is that for some consumers, the endorsement effect is large enough that they switch their brand choice.

Having shown that there is a general increase in the market share for Nike products over the time when Tiger Woods was under Nike's endorsement, we like to calculate the economic impact for Nike in terms of additional revenue, profit and customer acquisition. Assuming a pure strategy Nash-Bertrand equilibrium, we allow the firms to adjust their price setting behavior according to the environment. For example, it is reasonable to think that Nike takes Tiger Woods' endorsement into account before setting prices. For Nike, with Tiger Woods, we would expect that they would command a price premium given the additional utility attached to their products. In fact, other firms will also take this information into account before setting prices.

For non Nike products, to compete against Nike, we expect lower prices. Specifically, in our scenario where we set Nike to be "Tiger-less", we expect Nike would set their prices lower than in the regime with Tiger. For Titleist, since we assume that Tiger would have stayed with the company if it wasn't for Nike's multi-million dollar contract, we expect the price for Titleist products to be higher. In sum, depending on the market environment, we allow for the price vector to adjust so that it satisfies the first order condition of the profit function for each firms.

	Tiger with Nike	Tiger with Titleist	Difference
Average Price of Titleist	\$27.86	\$28.09	\$0.23
Average Price of Nike	\$21.00	\$20.89	-\$0.11
Other	\$19.49	\$19.49	\$0.00

Table 10: Average Price Adjustments Before and After Policy

Empirically, we verify that in a "Tiger-less" environment for Nike, Nike adjust their price accordingly by cutting prices. For Titleist, we observe that their price is adjusted upward in an environment where they did not lose Tiger Woods to Nike. For other firms, we do not see any change in price. Solving for the profit maximizing prices for two regimes, and with the estimated marginal cost we calculate the revenue, profit and customer acquisitions for the Nike company.

	Off course	On course	Both Retail
Revenue Gain	\$49,230,872	\$42,458,123	\$91,688,995
Profit Gain	\$36,477,385	\$23,994,724	\$60,472,109
Customer Acquisition	2,706,311	1,822,618	4,528,929

Table 11: Economic Value of Tiger Woods (2000-2010)

We find that during the endorsement period, Nike earned approximately \$92 million in extra revenue from both on and off course combined.[39] Furthermore, we estimate that the total additional profit earned by Nike golf ball division was approximately \$60 million for the ten year endorsement period. More importantly, for the Nike golf division, we find that the company

[39]We assume that the market size for the golf ball market is 40 million per year. We make this assumption based both on the size of the population of golfers and the quantity of products sold in each market while maintaining a large enough market to allow for a non zero outside share.

acquired approximately 4.5 million additional customers during the endorsement period. We believe that, at least in the first half of the decade, this was pivotal for Nike as they were trying to launch their nascent golf division with the help of Tiger Woods as its primary endorser.[25] Through the endorsement of Tiger Woods, Nike was able to induce a significant portion of the population to switch their golf ball as a result of extra utility attached to the Nike golf balls.

Recall that Tiger Woods signed two 5 year $100 million contracts. Therefore, given that he was paid a total of $200 million ($181 million in 1997 price) for ten years, our estimates show that, just in golf ball sales in the United States alone, approximately 33% of its investment on endorsement was recovered by Nike. Given that the sport of golf is also widely popular outside the United States, we conjecture that Nike would have recovered the majority, if not all, of its endorsement investment through golf ball sales alone. Considering the sales in the apparel and other equipments that Tiger Woods also endorsed as part of the contract agreement, we believe that Tiger Woods could have commanded an even larger contract from Nike.

7.3 Negative Publicity

In November of 2009, starting with a small car accident, the revelation of Tiger Woods' infidelity marked the beginning of the golfer's scandal. Since then, fearing the negative impact, the endorsers began to cut ties with Tiger Woods. The earnings he made off the course- an estimated $100 million a year- dwindled as a result of endorsers like Accenture, AT&T and Gatorade terminating its contract. In the midst of all this however, Nike announced that it will stand by Tiger Woods.

Having shown that Tiger Woods' scandal has had a negative impact on the Nike products alone, we assess the economic consequence for Nike for having stood by Tiger Woods. We run the counterfactual with the "Scandal-less" environment and calculate the market share from November 2009 to the end of our observation point. By running this counterfactual, we are able to assess the relative loss in revenue, profit and the number of customers during the 6 months

scandal period. Additionally, to assess whether Nike's strategy to stand by Tiger Woods was the correct decision, in the next subsection, we run a second counterfactual which assume that scandal occurs but Nike leaves Tiger Woods where he is without an endorsed brand.

With firms adjusting to their environment and setting prices accordingly, we expect that Nike would take into account the negative impact that Tiger Woods had on Nike products. Empirically, in contrast to what was shown for the endorsement effect section, the price change is close to zero. While our conjecture of Nike products setting a relatively higher price in the "scandal less" environment is verified, the change is close to zero. For the non Nike products, it is zero.

	Tiger with Scandal	**Tiger without Scandal**	**Difference**
Average Price of Nike	\$18.21	\$18.22	\$0.01
Other	\$20.22	\$20.22	\$0.00

Table 12: Average Price Adjustments Before and After Policy

	Off course	**On course**	**Both Retail**
Revenue Gain	-\$897,961	-\$587,003	-\$1,484,964
Profit Gain	-\$820,538	-\$365,009	-\$1,185,547
Customer Acquisition	-64,737	-29,275	-94,012

Table 13: Economic Value of Scandal on Nike

Nonetheless, taking into account the price adjustments, we find that Nike lost approximately \$1.5 million in revenue which we estimate to be a profit loss of \$1.2 million. The number of customer lost due to the scandal is estimated at approximately 94,000. This suggests that without the negative publicity of Tiger Woods, Nike would have, ceteris paribus, earned \$1.2 million more in profit.

7.4 Nike's Decision

We now assess Nike's decision to stand by Tiger Woods. To study Nike's decision, we run the counterfactual where Nike elects to terminate its ties with Tiger Woods. This is different from our first counterfactual where we assumed that Tiger Woods would have stayed with Titleist if

it wasn't for Nike. In this counterfactual, we assume that Nike would have stayed with Tiger Woods until November 2010 and thereafter terminated its contract with Tiger where he would be without any endorsement. This is reasonable since we do not believe, post the scandal (November 2009 - April 2010) any company would have signed a contract with the golfer. While we have shown that the negative publicity of Tiger Woods generated relative loss in terms of revenue, profit and customer acquisition, our result indicate that Nike would have lost even more had they ended its relationship with the golfer.

	Off course	**On course**	**Both Retail**
Revenue Gain	$1,157,834	$806,681	$1,964,514
Profit Gain	$1,061,605	$512,913	$1,574,518
Customer Acquisition	82,068	40,403	122,471

Table 14: Economic Value of Tiger Woods during the Scandal Period (11.09~04.10)

We find that Nike still benefited from the relationship with Tiger Woods despite the negative impact the scandal had on the company. During the time period of November 2009 to April 2010, had they ended its relationship with the golfer, Nike would have lost an additional revenue of $2.0 million ($1.6 million in profit) totaling approximately $3.5 million in revenue and $2.8 million in profit. From this, we conclude Nike's decision not to join the likes of Accenture, AT&T and Gatorade was the correct decision. Furthermore, this finding corroborates with the industry report that documents that Tiger Woods' merchandise were not affected by the scandal. In fact, Golfsmith International Holding Inc, is said to have sold more Woods-brands hats, shirts and belts from October 2009 to March 2010 which resulted in a growth of 8% from the previous year.[16] This finding is interesting especially when the event study analysis by Knittel and Stango (2009) finds that sports related sponsors suffered more than the non sports related sponsors. Based on our finding, we find that even in the midst of the scandal Nike was actually better off with Tiger Woods than without.

8 Conclusion

Historically, celebrity endorsement has been an accepted strategy by many firm executives and has been around for centuries. Recently with the size of the endorsement reaching the heights of tens to hundreds of millions of dollar it left us wondering of the effectiveness of these endorsements. While it is terribly difficult to identify an endorser's effect on a firm's profit, with the unusually favorable circumstances, we believe we were able to do so in this paper. Although our study has been on the economic value of celebrity endorsements in the context of Tiger Woods and the golf ball market, the implication of the endorsement effect extends to many other industries. For example, the implication extends to the current situation that the Wrangler jeans company is faced with with Brett Favre. While our study has looked into an endorsed product that is physically used in the profession by the endorser, it would be interesting to see how the endorsement effect changes for products that is not explicitly used by the endorser in his/her profession. This would provide some insights of why firms like AT&T and Accenture ended its tie with the golfer.

In this paper, by taking a direct approach and studying the endorsement period in conjunction to the sales of the endorsed product we have shed some light on the economic value of celebrity endorsement. By studying the golf ball market in the framework of the random coefficient model of differentiated product (BLP), we found that after controlling for the brand level advertisement and the inherent quality of the endorser, there is a significant endorsement effect as a result of the extra utility attached to the endorsed product. We empirically showed that endorsements can have a strong effect on consumer utility such that there is a shift in market share in the industry. In fact, we observe that endorsement effect has a dual component where existing customers switch to the more effective endorsed brand while bringing in additional customers who would have otherwise not purchased the product if it wasn't for the endorsement effect. Perhaps, the tremendous growth in the size of endorsement contracts over the past few years is a testament of large profits earned through these two effects present in celebrity endorsement. However, managers must also be cognizant that, unlike the typical advertisement strategy, in

celebrity endorsement, there exist a negative component in which it can bring greater loss for the company. For Tiger Woods, we observed that while there was an overall positive endorsement effects, the negative publicity hurt the Nike company in profit and sales. What differentiates celebrity endorsement from other forms of promotion strategy is the natural evolution of the endorser over time which firms must take into account before making the decision to sign an extended contract with an endorser.

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Appendix

The Golf Equipments

Golf Bags

Golf bags are designed to transport the golf clubs which are used to play the sport of golf. There are two main type of bags, a stand bag and a cart bag. Stand bags are usually smaller and made with lighter material with retractable v-shaped tripod-like stand while cart bags are larger in size made with heavier material. Stand bags are primarily used for golfers who carry their own golf bags when playing the sport of golf. Cart bags are used either by professionals who have "caddies"[40] or by golfers who primarily use golf carts to play golf.

Golf Clubs

In a golf bag, there are typically 14 golf clubs[41]. Golf clubs are the equipment used in the sport of golf to hit golf balls. Each club is made up of a shaft and a clubhead. Within golf clubs, there are 3 main different types of clubs; Woods, irons and putters. Woods are traditionally the longest type of clubs with the longer shafts and larger clubhead, used mainly for long distance shots. Traditionally, there are 3 woods in a bag, a 1 wood (Driver), 3 wood (fairway wood), 5 wood (fairway wood), with 1 wood being the longest and the lowest lofted clubhead. It is called "Woods" because the club head was traditionally made of hardwood. Today, no longer are the woods made up of wood materials but rather metal materials like titanium and steel. 1 wood is called the "driver" because they are the largest and the longest club in a golf bag that are primarily used for the first tee shot in each golf holes. First shots are called the "tee shot" because players are allowed to use the wooden "tee" to elevate the golf ball from the ground before hitting the ball with the golf club. 3 woods and 5 woods are also called the "fairway woods" because they are designed for shots that are long in distance from the hole from the fairway. Irons are the most versatile clubs that consist of different length of shafts with different loft of clubhead face. In iron clubs, there are two types of clubhead face. The more traditional of the two are the "blades" or the "muscle back blades" which are typically recommended for lower handicap (better player) players. It is estimated that blade irons account for only about 2% of sales in the market (2006 GolfDigest). The more common type of irons are the "cavity back", the name referring to a "cavity" created from a small amount of metal in the back of the clubface removed. These clubs are more forgiving and are recommended for all type of golfers. The iron clubs are traditionally numbered from 3- 9 with 3 being the the longest with the smallest loft. The purpose of the lower numbered iron clubs are for shots that are longer in distance with a ball flight that will result in a low trajectory. On the other hand, higher numbered irons are shorter in length providing shorter distance with a higher launch angle resulting from a lofted clubface. Part of the iron sets that are not numbered are the wedges. Wedges are irons with even higher

[40] A caddie is a person who carries the golf bag for the player in a tournament. Other than carry the bag, good caddies usually provide advice on the course with strategies to which the player should play. Also, good caddies are known to give moral support for the player.

[41] United States Golf Association (USGA), the national governing body of golf for the US and Mexico states under section III rule 4-4 that the player must not start a round with more than 14 clubs. Fewer than 14 clubs are permitted.

loft than a 9 iron, used primarily to make short shots near the green surface.There are 4 types of wedges;Pitching wedge, Gap wedge, Sand Wedge and Lob Wedge. Pitching wedge is the least lofted wedge with the loft between 44 to 50 degrees. Gap wedges, generally has a loft between 46 to 54 degree, while Sand Wedge is between 54 to 58. Sand wedge, as the name implies is used for golfer to hit the ball out of the sand traps hazard that are typically located around the green surface. Lastly, the Lob Wedge range from 60 to 65 degrees which helps the golfer hit the ball high up in the air. The loft of the wedges are inversely related to the distance traveled. Once the golf ball lands on the green or the "putting" surface, which is the portion of the golf course that consists of the shortest and closely cropped grass, players use the putter to roll the golf ball into the cup. Putters are the type of clubs that are most varied in design, both in length and shape. A typical golfer would carry 3 woods, iron set (7 clubs), 2-3 wedges, and a putter.

Titleist Golf Ball Sales Before/After Tiger Woods' Switch

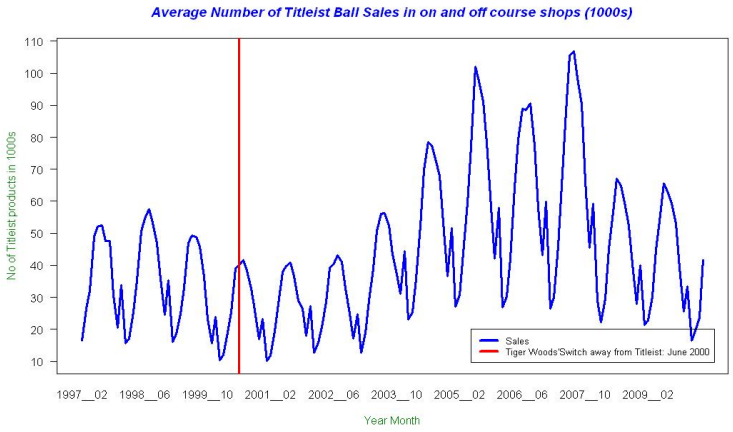

Figure 8: Total Sales of Titleist Golf Balls (Dozens) Pre & Post Tiger Woods' Endorsement Termination

In contrast to the Nike golf ball sales, although there seem to be some decline in sales immediately after (first 3 years after June 2000) Tiger Woods' switch away from Titleist, it is difficult to observe a drastic change in sales in the two endorsement periods. Interestingly, the sales increase dramatically after 2003, which may explain that Titleist, having lost Tiger Woods as an endorser (assuming that there is a significant endorsement effect, which we show in this paper) has found another dimension in their promotional strategy to increaes profit. This is an avenue for our future research.

Estimation Procedure

There are two main parts in the estimation procedure. (1) Recover δ_{jt} from share inversion by numerically evaluating the predicted share and matching against the observed share. (2) Estimate θ by minimizing the GMM objective function formed by the moment conditions from both the demand and the supply side. For step 1, BLP proposes a contraction mapping algorithm. Furthermore, both Berry (1994) and BLP suggest "nesting" this inversion step (1) directly into the parameter search step (2) of the GMM objective function. Because of this "nesting" structure, this approach is also referred to as the "Nested Fixed Point" or the NFP approach. The procedure for estimation is as follows,

1. Make draws from $v_i \sim N(0, I)$
2. For a given initial guess θ_2 and δ, compute the market share implied by $s_{jt}(\cdot;\theta_2) = \int_{A_{jt}} dP^*_\varepsilon(\varepsilon) dP^*_v(v)$.
3. For a given θ_2 value, compute the δ value by solving the contraction mapping that equates the market shares to the observed shares; $\delta^{h+1}_{\cdot t} = \delta^h_{\cdot t} + ln(S_{\cdot t}) - ln(s_{\cdot t})$ for t=1,...,T , h=0,...,H
4. Given the vector δ from step 3, compute the error term ξ, interact with the instrument Z^d. Similarly, compute ω and interact with the supply instrument Z^s. Form the GMM objective function with the two sets of moment conditions.
5. Search for the value of θ that minimizes the objective function computed in step 4.

The tolerance level for both inner and outer loop, we set NFP algorithm to be $\varepsilon_{in} = 10^{-12}$ and $\varepsilon_{out} = 10^{-6}$.

Estimation Results

OLS:

OLS			
Linear Parameters	**Estimate**	**SE**	**Estimate/SE**
Price	-0.043	0.002	-27.892
Woods Scandal x Non Nike Products x *time*	4.938	1.767	2.795
Woods Scandal x Non Nike Products x $time^2$	-0.063	0.023	-2.798
Woods Scandal x Non Nike Products x $time^3$	0.00020	0.00007	2.802
Woods Scandal x Nike Products x *time*	5.649	4.028	1.403
Woods Scandal x Nike Products x $time^2$	-0.072	0.051	-1.402
Woods Scandal x Nike Products x $time^3$	0.0002	0.0002	1.402
Woods Nike Endorsement	0.205	0.078	2.640
Duval Nike Endorsement	-0.122	0.218	-0.561
Mickelson Callaway Endorsement	-0.010	0.163	-0.060
Els Callaway Endorsement	-0.337	0.262	-1.287
Woods Titleist Endorsement	0.164	0.062	2.656
Mickelson Titleist Endorsement	-0.429	0.137	-3.132
Duval Titleist Endorsement	0.419	0.097	4.330
Singh Titleist Endorsement	-0.051	0.091	-0.564
Els Titleist Endorse	0.333	0.104	3.205
Nike Advertisement	0.060	0.018	3.303
Callaway Advertisement	-0.015	0.043	-0.336
Titleist Advertisement	0.007	0.010	0.656
time	-0.021	0.002	-10.565
$time^2$	0.0002	0.000030	7.509
$time^3$	-0.000001	0.000000	-6.119

Table 15: Estimate of the Logit Model-OLS (Benchmark)

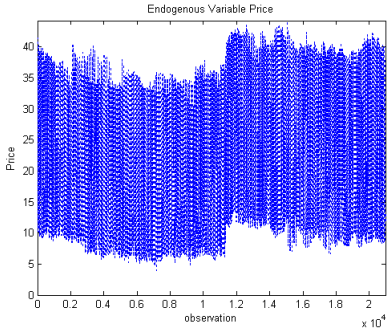

Figure 9: Plot of Endogenous Variable Price

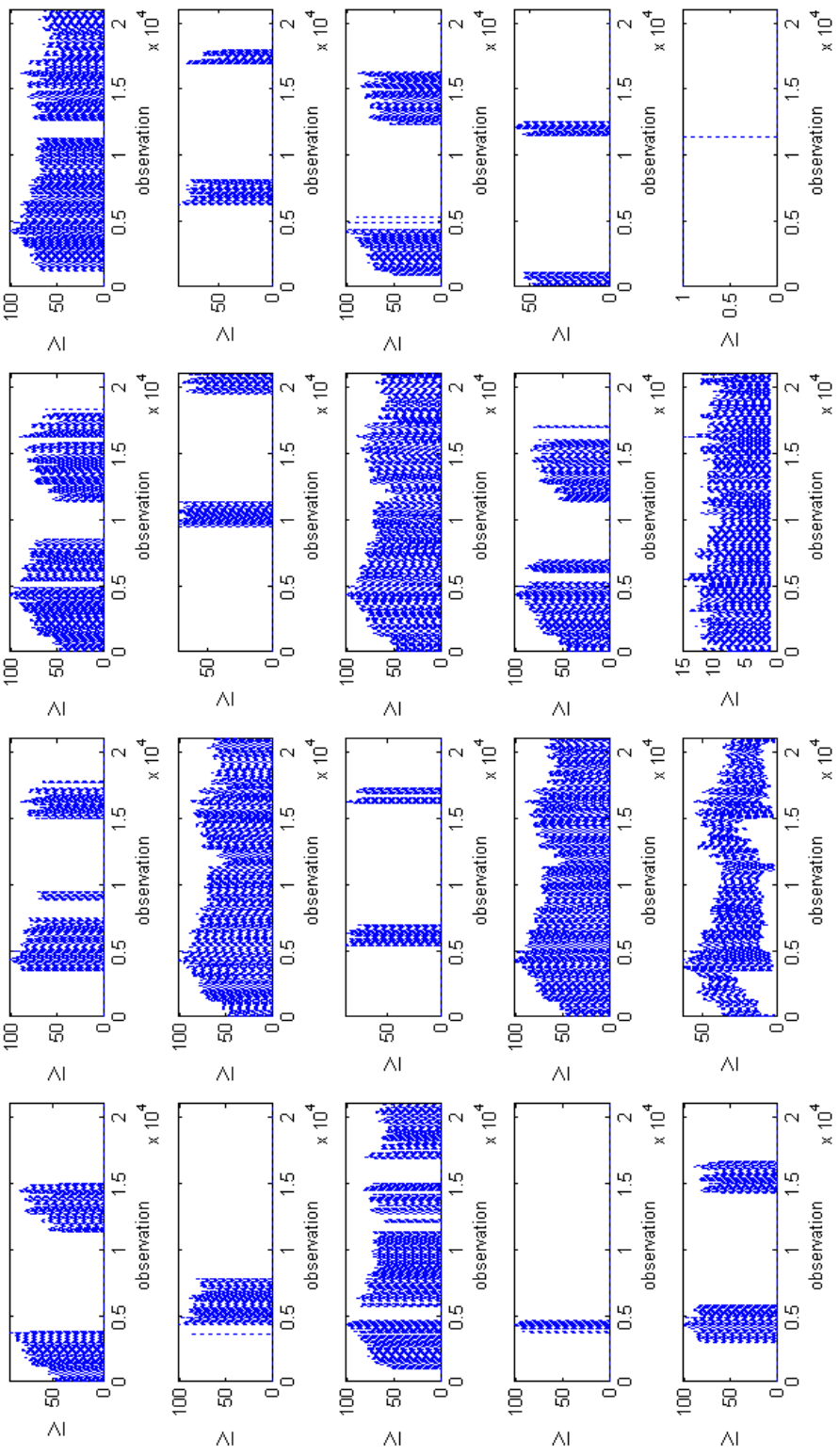

Figure 10: Plot of IVs for Price Variable

1st stage of 2SLS (Price~ IV+X)			
	Estimate	**SE**	**Estimate/SE**
Material x Num prod 1	0.110	0.015	7.579
Material x Num prod 2	0.021	0.011	1.945
Material x Num prod 3	0.014	0.011	1.237
Material x Num prod 4	-0.009	0.009	-1.046
Material x Num prod 5	-0.031	0.041	-0.754
Material x Num prod 6	0.017	0.005	3.676
Material x Num prod 7	0.096	0.033	2.877
Material x Num prod 8	0.167	0.024	6.818
Material x Num prod 9	0.053	0.013	4.149
Material x Num prod 10	-0.110	0.059	-1.874
Material x Num prod 11	0.035	0.004	8.099
Material x Num prod 12	-0.001	0.016	-0.035
Material x Num prod 13	-0.095	0.112	-0.849
Material x Num prod 14	-0.001	0.004	-0.334
Material x Num prod 15	-0.064	0.011	-5.984
Material x Num prod 16	0.059	0.060	0.977
Material x Num prod 17	-0.070	0.019	-3.761
LayCompete	-0.041	0.006	-6.769
MultiProdExternality	-0.277	0.012	-23.956
OffDummy	-4.407	0.038	-115.187

Table 16: Estimate of the first stage of 2SLS

2SLS			
Linear Parameters	**Estimate**	**SE**	**Estimate/SE**
Price	-0.087	0.002	-42.097
Woods Scandal x Non Nike Products x *time*	4.996	1.609	3.105
Woods Scandal x Non Nike Products x $time^2$	-0.064	0.021	-3.105
Woods Scandal x Non Nike Products x $time^3$	0.00020	0.00007	3.103
Woods Scandal x Nike Products x *time*	5.596	2.755	2.031
Woods Scandal x Nike Products x $time^2$	-0.071	0.035	-2.028
Woods Scandal x Nike Products x $time^3$	0.0002	0.0001	2.024
Woods Nike Endorsement	0.136	0.072	1.888
Duval Nike Endorsement	-0.119	0.215	-0.552
Mickelson Callaway Endorsement	-0.013	0.164	-0.078
Els Callaway Endorsement	-0.283	0.232	-1.217
Woods Titleist Endorsement	0.157	0.059	2.656
Mickelson Titleist Endorsement	-0.663	0.164	-4.046
Duval Titleist Endorsement	0.439	0.094	4.658
Singh Titleist Endorsement	-0.144	0.084	-1.710
Els Titleist Endorse	0.272	0.116	2.344
Nike Advertisement	0.064	0.017	3.771
Callaway Advertisement	-0.006	0.037	-0.172
Titleist Advertisement	0.003	0.010	0.311
time	-0.020	0.003	-7.660
$time^2$	0.0002	0.000039	3.906
$time^3$	-0.0000004	0.0000002	-2.594

Table 17: Estimate of the Logit Model -2SLS (Benchmark) with 20 IVs

Estimating the Proposed model using subset of IVs:

1st stage of 2SLS (Price~ IV(3)+X)			
	Estimate	**SE**	**Estimate/SE**
LayCompete	-0.014	0.004	-3.554
MultiProdExternality	-0.273	0.011	-23.950
OffDummy	-4.350	0.034	-128.648

Table 18: Estimate of the first stage of 2SLS

2SLS (3IV)			
Linear Parameters	**Estimate**	**SE**	**Estimate/SE**
Price	-0.088	0.002	-41.608
Woods Scandal x Non Nike Products x *time*	4.997	1.610	3.104
Woods Scandal x Non Nike Products x $time^2$	-0.064	0.021	-3.103
Woods Scandal x Non Nike Products x $time^3$	0.00020	0.00007	3.102
Woods Scandal x Nike Products x *time*	5.595	2.753	2.033
Woods Scandal x Nike Products x $time^2$	-0.071	0.035	-2.029
Woods Scandal x Nike Products x $time^3$	0.0002	0.0001	2.025
Woods Nike Endorsement	0.135	0.072	1.887
Duval Nike Endorsement	-0.119	0.215	-0.552
Mickelson Callaway Endorsement	-0.013	0.164	-0.078
Els Callaway Endorsement	-0.281	0.233	-1.215
Woods Titleist Endorsement	0.157	0.059	2.651
Mickelson Titleist Endorsement	-0.668	0.164	-4.038
Duval Titleist Endorsement	0.440	0.095	4.647
Singh Titleist Endorsement	-0.146	0.084	-1.705
Els Titleist Endorse	0.270	0.116	2.338
Nike Advertisement	0.064	0.017	3.764
Callaway Advertisement	-0.006	0.037	-0.172
Titleist Advertisement	0.003	0.010	0.311
time	-0.020	0.003	-7.650
$time^2$	0.0001	0.000039	3.901
$time^3$	-0.0000004	0.0000002	-2.590

Table 19: Estimate of the Logit Model -2SLS (Benchmark) with 3 IVs

Random Coefficient Model (3IV)			
Linear Parameters	**Estimate**	**SE**	**Estimate/SE**
Woods Scandal x Non Nike Products x *time*	5.171	1.611	3.209
Woods Scandal x Non Nike Products x $time^2$	-0.066	0.021	-3.208
Woods Scandal x Non Nike Products x $time^3$	0.00021	0.00007	3.207
Woods Scandal x Nike Products x *time*	5.551	2.780	1.997
Woods Scandal x Nike Products x $time^2$	-0.071	0.036	-1.994
Woods Scandal x Nike Products x $time^3$	0.000	0.000	1.990
Woods Nike Endorsement	0.141	0.072	1.944
Duval Nike Endorsement	-0.108	0.218	-0.495
Mickelson Callaway Endorsement	0.021	0.164	0.128
Els Callaway Endorsement	-0.274	0.233	-1.174
Woods Titleist Endorsement	0.143	0.061	2.350
Mickelson Titleist Endorsement	-0.642	0.166	-3.875
Duval Titleist Endorsement	0.446	0.097	4.619
Singh Titleist Endorsement	-0.136	0.086	-1.594
Els Titleist Endorse	0.274	0.118	2.316
Nike Advertisement	0.066	0.017	3.875
Callaway Advertisement	-0.008	0.037	-0.212
Titleist Advertisement	0.004	0.010	0.401
time	-0.020	0.003	-7.593
$time^2$	0.00015	0.00004	3.964
$time^3$	-0.0000004	0.0000002	-2.683
Non Linear Parameters	**Estimate**	**SD**	
Price	-0.088	0.019	-33.266
	(0.003)	(0.010)	
GMM objective	62.849		

Table 20: Estimate of the Random Coefficient Model with 3 IVs

Supply Side Model			
	Estimate	**SE**	**Estimate/SE**
BALATA	16.790	0.726	23.119
BETA TITANIUM	12.325	0.727	16.947
ELASTOMER	19.077	0.772	24.719
FUSABLEND	18.750	0.737	25.434
HPF POLYMER	11.689	0.837	13.972
IONOMER	11.767	0.669	17.582
IOTHANE	10.428	0.745	14.003
PWR DYNARON	8.430	0.810	10.411
RABALON	10.786	0.688	15.685
SPINTHANE	13.384	0.891	15.017
SURLYN	9.746	0.679	14.354
TITANIUM	7.029	0.699	10.059
TRITHAN	7.497	0.819	9.150
URETHANE	18.728	0.691	27.094
Z BALATA	16.335	0.773	21.134
ZA BALATA	26.091	0.881	29.600
ZYNTHANE	21.938	0.924	23.754
ACUSHNET	-4.861	0.286	-16.996
BEN HOGAN	-17.573	1.462	-12.023
BRIDGESTONE	-0.586	0.284	-2.068
HPG	-5.026	0.451	-11.156
MAXFLI	-9.978	0.665	-15.015
SLAZENGER	2.808	0.388	7.245
SPALDING	-6.775	0.308	-21.997
WILSON	-5.647	0.312	-18.081
OTHER	-5.909	0.345	-17.151
DUNLOP/MAXFLI	-3.541	0.342	-10.339
HOGAN	-17.788	0.556	-31.973
SRIXON	0.922	0.309	2.985
NIKE	-1.756	0.288	-6.102
COBRA	3.757	0.702	5.353
TAYLORMADE	0.600	0.338	1.776
CALLAWAY	0.937	0.279	3.353
DUNLOP SLAZ	-1.956	0.416	-4.703
AFFINITY GO	-10.043	0.380	-26.455
DUNLOP SPOR	-9.799	0.458	-21.387
MAXFLI GOLF	-2.325	0.360	-6.464
TOP FLITE G	-6.558	0.293	-22.387
VOLVIK	3.836	0.358	10.715
FOCUS GOLF	-12.198	0.590	-20.664
layer	4.075	0.092	44.178
dimples	-0.015	0.001	-11.581
time	-0.077	0.001	-59.159

Table 21: Estimate of Marginal Cost of Golf balls

Price Elasticities

The price elasticities of the market share s_{jt}

$$\eta_{jkt} = \frac{\partial s_{jt} p_{kt}}{\partial p_{kt} s_{jt}} = \begin{cases} -\frac{p_{jt}}{s_{jt}} & \int \alpha_i s_{ijt}(1 - s_{ijt}) dP_v^*(v) \quad \text{if} \quad j = k, \\ \frac{p_{kt}}{s_{jt}} & \int \alpha_i s_{ijt} s_{ikt} dP_v^*(v) \qquad \text{otherwise} \end{cases} \tag{11}$$

where $s_{ijt} = \frac{\exp(\delta_{jt} + \mu_{ijt})}{1 + \sum_{k=1}^{K} \exp(\delta_{kt} + \mu_{ikt})}$, the probability of individual i purchasing product j at time t. Similar to our estimation procedure where there was no analytical solution to the integral, we estimate the elasticities by the smooth simulator.

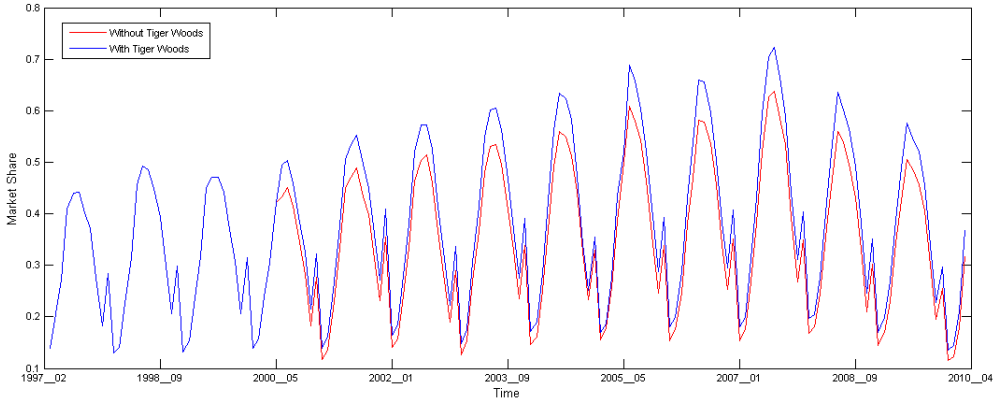

Figure 11: Share of the Titleist Products for on & off course shops combined

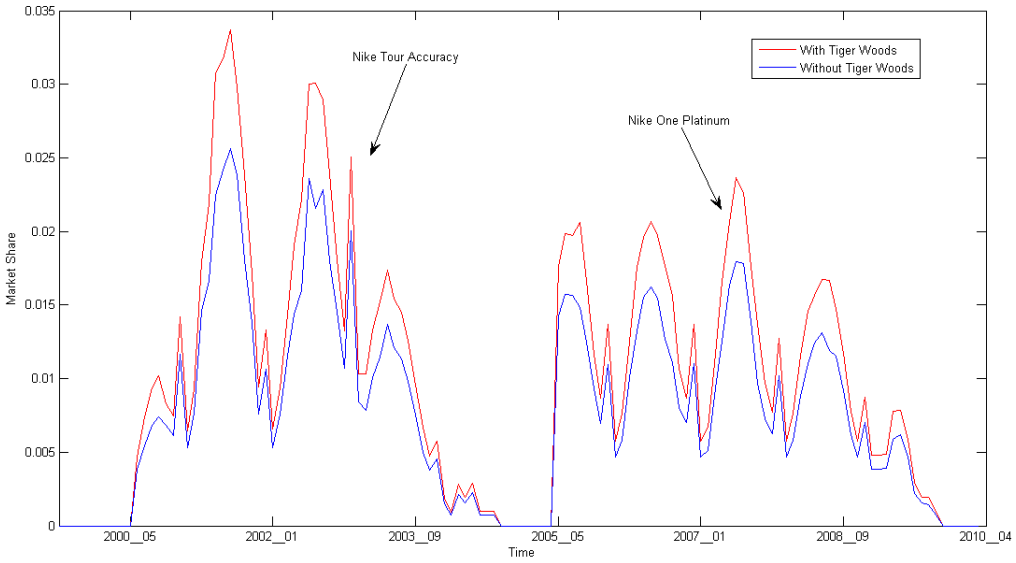

Figure 12: Tiger Woods' switch within Nike Brand

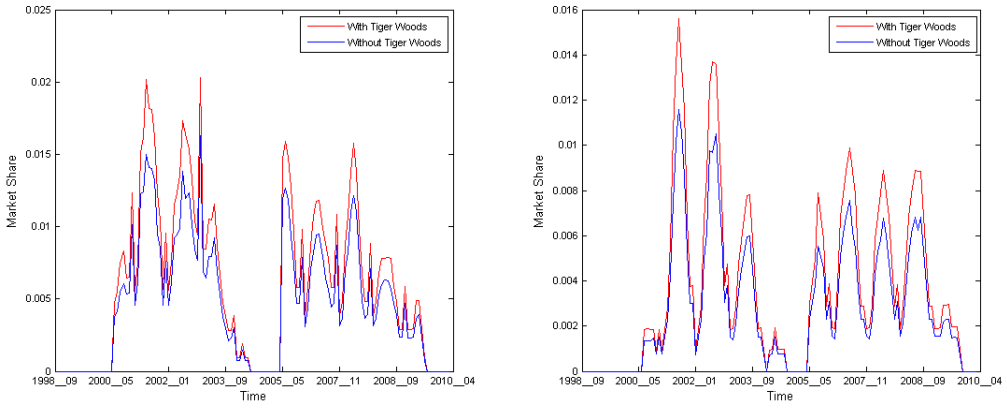

Figure 13: Tiger Woods' Nike ball switch and its share for off and on course golf shops