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ABSTRACT

Much attention has been devoted to studying models of tournaments or situations in which an individual's payment depends only on his output or rank, relative to other competitors. Such models are of more than academic interest as they may well describe the compensation structures applicable to many corporate executives and professors, to sales people whose bonuses depend on their relative outputs, and to the more obvious example of professional sports tournaments. Academic interest derives from the fact that under certain sets of assumptions tournaments have desirable normative properties because of the incentive structures they provide.

Our paper uses nonexperimental data to test if tournaments actually elicit desired effort responses. We focus on golf tournaments because information on the incentive structure (prize distribution) and measures of individual output (players' scores) are both available. Under suitable assumptions, players' scores can be related to players' effort and implications for both players' overall tournament scores and their scores on the last round of a tournament drawn. In addition, data are available to control for factors other than the incentive structure that should affect output; these factors include player quality, quality of the rest of the field, difficulty of the course, and weather conditions.

The data used in our analyses come from the <u>1985 Golf Digest Almanac</u>, the <u>Official 1985 PGA Tour Media Guide</u>, and the <u>1984 PGA Tour Player Record</u>. We find strong support for the proposition that the level and structure of prizes in PGA tournaments influence players' performance.

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I. Introduction

In recent years economists have devoted considerable attention to the normative properties of alternative compensation arrangements. Among the arrangements discussed have been deferred payment schemes, the payment of efficiency wages, piece-rates and the use of tournaments or payment by relative output.[1] The optimality properties of the various arrangements in certain states of the world (e.g., relating to monitoring costs, recruitment costs, turnover costs, asymmetric information, or random productivity shocks) derives from the postulated incentive effects that each arrangement is thought to have. Yet surprisingly there has been very little effort made to test whether these incentive effects actually exist <u>and</u> lead to improved individual or firm performance.[2]

Our work addresses models of tournaments, or situations in which an individual's payment depends only on his output or rank relative to other competitors. Such models are of more than academic interest as they may well describe the compensation structures applicable to many corporate executives, to professors (who can been thought of as being involved in promotion tournaments), to sales people (whose bonuses often depend on their relative outputs), and to the more obvious example of professional sports tournaments. Academic interest derives from the fact that, under certain sets of assumptions, tournaments have desirable normative properties because of the incentive structures they provide.

Very few attempts have been made to test if tournaments actually elicit desired effort responses. One experimental study of rank-order tournaments that used 225 paid undergraduate student volunteers as subjects did find mixed support for the theory, although disadvantaged (high cost of effort) subjects provided more effort than the theory predicted.[3] The lack of nonexperimental studies of tournaments is probably due to the difficulty of measuring both individuals' effort levels and the incentive structures competitors face in many circumstances.

To test in a nonexperimental setting whether tournaments do have incentive effects, we focus on golf tournaments because information on the incentive structure (prize distribution) and measures of individual output (players' scores) are both available. Under suitable assumptions, players' scores can be related to players' effort and implications for scores drawn. In addition, data are available to control for factors other than the incentive structure that should affect output; these factors include player quality, quality of the rest of the field, difficulty of the course, and weather conditions. Implications can be drawn both for how well a player will perform during an entire tournament and how well he will perform on the last (fourth) round contingent, ceteris paribus, on his rank in the tournament after the third round.

The next section sketches some simple two-person tournament models that provide the basis for our econometric work. Our empirical analyses make use of data from the 1984 Men's Professional Golf Association (PGA) Tour and section III discusses key institutional characteristics of the PGA Tour and specific hypotheses to be tested. Section IV describes the sources of the data used in our analyses and our econometric findings. Finally, section V presents some concluding remarks and discusses the implications of our findings for future research.

II. Some Models of Tournaments and Their Implications

The simple two-contestant tournament models that follow are extensions of those found in Lazear and Rosen (1981). While others, for example Green and Stokey (1983), have studied n person tournaments and derived normative implications about them, the simpler two-person tournament captures the essence of the incentive problem. If one wishes, one can interpret the two-person tournament as a competitor competing against a representative of "the rest of the field".

Consider first the case of homogeneous competitors. Individual j's output in tournament i, q_{ji}, is given by

$$(1) \qquad q_{ji} = u_{ji} + \epsilon_{ji} + \delta_i \qquad j = a,b \qquad i = 1,2\ldots n.$$

There are two individuals (a and b) and n tournaments. Here u_{ji} is individual j's level of effort/concentration in tournament i, ϵ_{ji} is a pure random or luck component which is drawn from a known symmetric distribution that is further assumed to be normal with mean zero and variance σ^2, and δ_i is a tournament specific effect on output. The latter is due to factors like the difficulty of the course and the adversity of weather conditions and, for simplicity, is assumed to affect all players in tournament equally. Increases in effort are translated into higher outputs which, in the context of a golf tournament, means lower scores.

Of course, one may argue that our empirical focus is on professional golfers and that professionals <u>always</u> play as hard as they can.[4] What this criticism ignores, however, is how difficult it is even for professionals to maintain their concentration levels over tournaments that typically last four days per week and that involve two to three hours of physical effort per day. Furthermore, playing on the tour involves weekly travel and a "hotel lifestyle". At the very least, one might expect fatigue to set in on the latter days of a tournament and players' ability to maintain their concentration to diminish at these times. To capture this, we assume that each individual faces a "cost of effort/ concentration" function ($c(u)$), with the marginal cost of effort being positive and increasing ($c'(u) > 0$, $c''(u) > 0$).

Suppose that the prize for winning tournament i is w_{1i}, while the prize for the loser is w_{2i}. Given these assumptions, an individual's expected utility is given by,

$$(2) \qquad p[w_1 - c(u)] + (1-p)[w_2 - c(u)] = pw_1 + (1-p)w_2 - c(u)$$

where p is an individual's probability of winning.

Now individual a's probability of winning tournament i is given by

$$(3) \qquad p_a = \text{prob}(q_{ai} > q_{bi}) = \text{prob}\ (u_{ai} - u_{bi} > \epsilon_{bi} - \epsilon_{ai} + \delta_i - \delta_i)$$
$$= \text{prob}(u_a - u_b > \theta) = G(u_a - u_b).$$

Here $\theta = \epsilon_b - \epsilon_a$, θ is distributed as $g(\theta)$, $G(\theta)$ is the cumulative distribution function of θ and -- if we assume ϵ_{ai} and ϵ_{bi} are independent and identically distributed -- $E(\theta) = 0$ and $E(\theta)^2 = 2\sigma^2$. Under these assumptions, θ is also normally distributed and hence $g(\theta) = g(-\theta)$ and $g'(\theta) = -g'(-\theta)$ for all $\theta \neq 0$.

Each player chooses his effort level to maximize expected utility, which leads (assuming interior solutions) to first and second order conditions respectively of the form

$$(4)\qquad (w_1-w_2)(\partial p/\partial u_j) - c'(u_j) = 0 \qquad j = a,b$$

$$(w_1-w_2)(\partial^2 p/\partial u_j^2) - c''(u_j) < 0$$

If one assumes a Nash-Cournot equilibrium, that is that each player optimizes against his opponent assuming that the opponent has chosen his optimal strategy, one obtains

$$(5)\qquad \partial p_a/\partial u_a = \partial G(u_a-u_b)/\partial u_a = g(u_a-u_b)$$

$$\partial p_b/\partial u_b = \partial G(u_b-u_a)/\partial u_b = g(u_b-u_a).$$

Substituting (5) into the first-order conditions in (4) yields reaction functions for the two players.

$$(6)\qquad (w_1-w_2)g(u_a-u_b) = c'(u_a)$$

$$(w_1-w_2)g(u_b-u_a) = c'(u_b).$$

Since $g(\theta) = g(-\theta)$, $c'(u_a)$ must equal $c'(u_b)$, which in turn implies $u_a = u_b$. Both players exert the same effort level and have an ex ante probability of winning of one-half. Moreover, (6) reduces to

$$(7)\qquad (w_1-w_2)g(0) = c'(u)$$

and it is straightforward to show that

$$(8)\qquad \partial u/\partial(w_1-w_2) = (g(0)/c''(u)) > 0$$

That is, increasing the prize differential for winning should lead to increased player effort and thus, ceteris paribus, to lower scores. Indeed, returning to (1), we can rewrite it as

$$(9) \qquad q_{ji} = u_{ji}(w_{1i} - w_{2i}) + \epsilon_{ji} + \delta_i .$$

In the homogeneous contestant model scores should depend only on the prize differential for winning and on tournament specific factors (the weather and course difficulty).

Most tournaments, of course, do not have homogeneous contestants and it is possible to introduce heterogeneity into the model in at least three ways. First, one can assume that the marginal return to effort is greater for one contestant; instead of (1) one would then have

$$(10) \qquad q_{ai} = u_{ai} + \epsilon_{ai} + \delta_i, \; q_{bi} = nu_{bi} + \epsilon_{bi} + \delta_i$$

where if n is greater than one, b is the better player. Second, one can assume that the players differ not in the return to effort but rather in their cost of effort function; in this case the cost of effort functions would become

$$(11) \qquad c_a(u) = c(u), \; c_b(u) = \gamma c(u) \qquad 0 < \gamma < 1$$

where, since γ is less than one, b can achieve any effort level at a lower cost than a and hence again b is a better player. Finally, one could assume that the marginal return to effort and marginal cost of effort functions were identical, but that one player had an absolute advantage over the other player. That is

$$(12) \qquad q_{ai} = u_{ai} + \epsilon_{ai} + \delta_i, \; q_{bi} = u_{bi} + \phi + \epsilon_{bi} + \delta_i .$$

If ϕ is greater than 0, b is the better player in the sense that, ceteris paribus, b will have greater output (a lower score) than a if both exert the same level of effort.

It is straightforward to substitute these alternative assumptions about heterogeneity into the model and to obtain comparative static results. For brevity, we omit the details here and simply summarize two key implications.[5] First, all three modifications still lead to the result that a greater prize differential for winning should lead to more effort and thus lower scores. Second, all three suggest that a player's effort, and hence output, will depend both on his own ability (A_{jo}) and the ability of his competitor (A_{jc}). Hence, the output of individual j in tournament i can be written as

$$(13)\ q_{ji} = u_{ji}((w_{1i}-w_{2i}),\ A_{jo}, A_{jc}) + \epsilon_{ji} + \delta_i .$$

That is, in the heterogeneous contestant model, a player's score should depend upon the prize differential for winning, measures of his and his opponent's ability, and tournament specific factors, such as the weather and course difficulty.

III. The 1984 Men's Professional Golf Tour: Institutional Characteristics and Hypotheses to be Tested

The typical golf tournament is a four round tournament. Half the field is "cut" at the end of the second round, two additional rounds are played, and then prizes awarded on the basis of the players' ranks after the final round. Of the 45 tournaments on the 1984 Men's Professional Golf Association Tour, 40 were of this type, and data from them are used in our analyses.

Across these tournaments the structure of prize money by rank was virtually identical, although the level of prize money varies across tournaments.[6] Figure 1 summarizes this structure. A key element of the prize structure is that the marginal return from improving one's performance by one rank (or by not seeing one's performance decline by one rank) was much higher for people who were close to the leaders after three rounds than it was for people who were far from the leaders. For example, the marginal prize received from finishing second instead of third was 4.0 percent of the total tournament prize money, while the marginal prize received from finishing twenty-second instead of twenty-third was 0.1 percent of the total tournament prize money.[7]

This structure of prizes, coupled with variations in the level of prizes across tournaments suggests two types of tests of the theories sketched in the preceding section. First, since the structure of prizes is constant across tournaments, the prize differential for "winning" depends only on the level of total prize money. Thus, one can focus on a tournament as a whole and ask, other things equal, if higher total prize money leads to lower scores. Second, one can focus only on the last round of a tournament and ask, other things equal, if a player's performance on the last round depends on the marginal return to effort he faces. The latter will depend in turn on the total prize money in the tournament, his rank after the third round, and how many players are tightly bunched around him after three rounds. Both types of analyses are reported in the next section.

Before turning to the empirical results, however, one institutional complication must be discussed. Not every pro golfer who wanted to enter any given PGA tournament in 1984 could. Rather, a system of exemptions and priorities existed. At the risk of simplifying a very complex system, the system worked as follows:[8]

(i) Any golfer who had won a major tournament since 1975 or any PGA Tour tournament in 1983 could enter any tournament he wanted in both 1984 and 1985.

(ii) Any golfer who failed to qualify under (i) and had won a major tournament in 1975 or any PGA Tour tournament in 1982 could enter any tournament he wanted in 1984 but had no promise of entry for tournaments in 1985.

(iii) If all positions in a 1984 tournament were not filled by individuals from categories (i) and (ii), any golfer who finished among the top 125 money winners on the 1983 PGA Tour could enter the tournament.

(iv) Any remaining vacancies in a tournament were filled using other criteria (e.g., the sponsor got to choose a number of players, lower ranked players on the 1983 tour, leaders from the PGA Tour Qualifying Tournament).

As we shall show, this system of exemptions and priorities helps to explain which players entered which 1984 PGA Tour tournaments; this is important because analyses that use data on the scores of entrants to tournaments will be subject to potential selectivity biases. In addition, individuals in categories (ii), (iii), and (iv) had to be very concerned about their total tour earnings in 1984.[9] For unless they won a PGA Tour tournament during the year, they had to finish in the top 125 money winners during the year in order to be assured of virtual automatic entry if they desired to PGA Tour tournaments in 1985 (i.e., to be in category (iii) in 1985). In contrast, no matter what individuals in category (i) accomplished during the 1984 tour, they were assured the option of entry into any PGA Tour tournament that they wanted to enter in 1985.

Suppose that the latter group, who we refer to henceforth as the _exempt_ players, exhibited effort levels that were sensitive to the level and structure of prizes in a tournament. Because the former group, who we henceforth refer to as the _nonexempt_ players, had to worry about qualifying for the next year's tour, the level and structure of prize money in a tournament may not be an accurate indicator of their marginal financial return to effort. Rather, one would need to also know how an increase in effort for one of them increased both the probability that he would be classified as an exempt player in 1985 and his expected future earnings if he was so classified. As such, even if the exempt and nonexempt players' marginal responses to financial returns were equal, one might intuitively "expect" nonexempt players' effort levels, and hence scores, to be less sensitive to tournament specific prize variables. The appendix presents a simple omitted variables model that indicates the precise (and restrictive) conditions under which this expectation is theoretically correct and we test to see if responses differ between the two groups in the next section.[10]

IV. Empirical Analyses

Our empirical analyses proceeds in stages. First we estimate final score equations for players on the 1984 Men's PGA Tour. Next, we estimate score after the second round equations. Third, we estimate final round score equations. Finally, we present some estimates for older men who played on the 1984 PGA Men's Senior Tour.

A) Final Score Equations

Data are available in the 1985 Golf Digest Almanac (1984) and the Official 1985 PGA Tour Media Guide (1985) for each 1984 Men's PGA Tournament on the score by round, final rank, and prize money won for all players who entered and made the cut in each tournament.[11] Data on each player's scoring average on all rounds during the year, a measure of his "ability", are available only for the top 160 money winners during the year; consequently the analyses reported below are restricted to these individuals.[12] Equations were estimated (pooling the data across individuals and tournaments) of the form

$$(14) \qquad s_{ji} = a_0 + a_i TPRIZE_i + a_2 x_i + a_3 y_j + a_4 z_i + v_{ij}$$

Here s_{ji} is the final score of individual j in tournament i, TPRIZE is the total prize money awarded in the tournament, x_i is a vector of variables to control for the difficulty of the tournament course and weather conditions, y_j is a vector of proxies for player j's ability, z_i is a vector of variables to control for the quality of other players in the field and v_{ij} is a random error term. If the theory of tournaments is correct, higher prizes should lead to lower scores, hence estimates of a_1 should be negative.

The controls for other tournament specific factors are PAR, the par for the tournament course; DIST, the total course yardage; RATING, the PGA's evaluation of the playing difficulty of the course as it was set up for the tournament (expressed in strokes); and WAVE, the average of three raters' perceptions of the number of days during the tournament that the weather significantly influenced player performance. Player ability is proxied by SCOREAVE, his scoring average on all rounds played during the 1984 tour; and FCUT, the fraction of tournaments he entered in which he made the cut during the 1984 tour. Finally, the quality of the other players in the field is proxied by FRACT, the fraction of all players in the tournament who made the cut that were ranked in the top 160 of total prize winners during the 1984 tour and MPERAVE; a measure of the mean "performance average" on the 1984 tour of players in the tournament who made the cut.[13]

Estimates are reported in Table 1. Separate analyses are presented for the entire sample, for the exempt players, and for nonexempt players.[14] A dummy variable for whether a tournament is a "major" tournament (i.e., the U.S. Open, the PGA or the Masters) is also included.[15] Winning a major tournament typically provides substantial opportunities for lucrative endorsements, hence the total price money variable understates the return to winning these tournaments.

Turning to the results, more difficult courses, as measured by PAR, DIST, and RATING are seen to lead to higher scores. Similarly, each day of "bad" weather appear to raise players' scores by over 2 strokes. As expected, poorer players, as measured by SCOREAVE, play worse. Where significant, competing against a better field, as measured by FRACT and MPERAVE, appears to lead to higher scores.

Most striking, the coefficient of TPRIZE is negative as anticipated. TPRIZE is measured in thousands of dollars, hence increasing the total prize money by $100,000 is associated with each player, on average, scoring 1.1 strokes lower during a tournament (col. 1). The results of estimating an equation in which TPRIZE is interacted with exempt status (col. 2) and of estimating separate equations for exempt (col. 1E) and nonexempt players (col. 1N) suggest that the coefficient of TPRIZE is slightly larger (in absolute value) for exempt players. As noted in the previous section and the appendix, this may reflect either that exempt players effort levels <u>are</u> more responsive to financial variables, or that the nonexempt players TPRIZE coefficient is biased towards zero because their marginal return to effort is also based both on how doing well in a tournament increases their probability of being classified as exempt in the next year and on their expected increase in the present value of future income if so classified. Finally, other things equal, scores are lower in major tournaments but significantly so only for exempt players (col. 1E). Since these players are the ones with the greatest chance of winning and thus gaining the endorsement value, this result seems sensible.

Of course the results in Table 1 may be subject to two types of selection bias because the sample is restricted to the subset of players who entered and made the cut in each tournament. Because of this, we may confound the effect of the total prize variable on players' final scores with its effect on their entering and making the cut in a tournament. To control for this possible problem, requires one to have data on the players who entered each tournament and failed to make the cut; fortunately the PGA was able to provide us this information, as well as data on these players' scores during the first two rounds of the tournament.[16]

To model separately the decision to enter a tournament and the probability of making the cut and then to estimate a bivariate selection model is a difficult task. Instead, we approximated this process and estimated a univariate probit probability of entering and making the cut equation.[17] Following the approach initially suggested by James Heckman (1979) estimates from this equation were then used to compute an estimate of the inverse Mills ratio for each individual and the latter entered as an additional explanatory variable in (14) to control for selectivity bias. However, when this augmented final score equation was reestimated, the coefficient of the additional variable never proved significant nor did the TPRIZE coefficients differ from those reported in Table 1. Thus, the estimates in Table 1 do not appear to be subject to selection bias.

B) Score After Second Round Equations

Given the availability of data on the score after two rounds for all individuals who enter each tournament, we can estimate how the level of prize money influences players' performance in the early rounds of a tournament. Table 2 presents estimates similar to those found in Table 1, save that the sample is now all entrants in each tournament (among the top 160 money winners in the year) and the outcome variable is now the player's score after the second round, prior to the cut's being made. In addition, the weather variable now refers to the weather on the first two days of the tournament and the field quality variables to all entrants, rather than to those who made the cut, in each tournament.

The most striking finding is that the total tournament prize money does not appear to influence players' performance during the first two rounds. Only for exempt players in the specification where exempt status is interacted with the prize variable (col. 2), is there any evidence of an effect and, even for this group, an increase in prize money of $100,000 would be associated with scores that were only 0.1 strokes lower per player after the first two rounds. This finding is consistent with the hypothesis offered earlier that a player's difficulty of maintaining concentration occurs primarily in the latter rounds of tournament when fatigue is more likely to have set in.

Of course, the possibility still exists that the results in Table 2 are subject to selection bias because they are based on a sample of tournament entrants; we may be confounding the effect of a tournament's prize level on the probability players enter the tournament, with its effect on their scores. To check for this, Heckman's (1979), two-step procedure was once again employed.

Table 3 presents the results of several probit probability of entering a tournament equations that we estimated. In these equations, entry probabilities are specified to be a function of a player's exempt status (EXMPT), his total career earnings prior to 1984 (PRCASH), his age (AGE), the chronological order of a tournament during the year (TCODE) and its square, whether the tournament is a major tournament (MAJ), the tournaments total prize money (TPRIZE), and the player's scoring average on all rounds in which he played during the 1984 tour (SCORAVE), or on all first and second rounds in which he played during the tour (SCORE12). Separate sets of coefficients are estimated for exempt and nonexempt players; the former are denoted in the table by an "A" before a variable name while the latter are denoted by a "B" in front of the variable name.

The results one observes in this table are of interest in themselves. Exempt players are more likely to enter major tournaments and tournaments with higher prize money and, as a result, nonexempt players (with lower priority) are less likely to enter major and high prize money tournaments (although the latter result is not significant).[18] An income effect on labor supply is evident for exempt players as, ceteris paribus, the greater an exempt player's lifetime earnings, the less likely he is to enter a tournament. The probability a nonexempt player will enter a tournament declines with age, although no such pattern exists for exempt players. The poorer a player is, as measured by higher average scores during the year, the more likely he is to enter a tournament. Finally, the probability of entering tournaments for both groups, ceteris paribus, follows a "u" shaped pattern during the year and is lowest during the hot summer months. This implies that foreign golfers who don't play regularly on the tour and individuals in our category (iv), both groups which are not in our sample, are more likely to enter tournaments during this time.

The estimates in Table 3 were then used to obtain estimates of the inverse Mills ratio for each individual entered in each tournament and augmented versions of the score after the second round equations then estimated. However, again the coefficients of the estimated inverse Mills ratio never proved significant and the estimated coefficients of the total prize variable were identical to those found in Table 2. Thus, the conclusions that the level of prize money at best only marginally affects the level of effort during the first two rounds for exempt players and does not affect the level of effort during that time for nonexempt players appears to be valid.

C) Final Round Score Equations

Consider a golfer playing in two tournaments with the same total prize money. Suppose he scores a 72 on each of the first three days of both tournaments but, because of random factors that influence his opponents' performance, he finds himself in third place in the first tournament but in twentieth place in the second tournament. Given the structure of PGA tournament prizes (Figure 1), he faces a greater marginal return to effort/concentration in the first tournament, should exert more effort/concentration there and, on average, should have a lower final round score in that tournament. Put another way, we should expect to observe, ceteris paribus, a positive correlation between a player's rank after the third round of tournaments and his final round score.

An initial test of this hypothesis is found in Table 4 in which we present the result of estimating final round score equations, using data pooled across individuals and tournaments. A player's score on the final round of a tournament is specified to be a function of his scores on the first three days of the tournament (SCORE1, SCORE2, SCORE3), measures of whether the weather adversely affected players' performance on the first three days (WAVE123) and on the final day of the tournament (WAVE4), the player's rank after the third round (SCR3RANK), and the total tournament prize money (TPRIZE). Given the weather, a player's scores on the first three days, which are probably the best predictor of how well he is currently playing, should be positively associated with his score on the final day. Given his scores on the first three days, the poorer the weather was on them, the lower his score should be on the final day. However, the poorer the weather on the final day, ceteris paribus, the higher his final day score should be.

A player's scores on the first three days of a tournament are not exogenous, but rather depend (from equation (14)) on the prize differential for winning, measures of his and his opponents ability, and tournament specific factors such as course difficulty and the weather on those days. Similarly, a player's rank after the third round is also not exogenous. It depends upon his scores and his opponents' scores on the first three days; both of which depend in turn on the factors described above. As such, we treat SCORE1, SCORE2, SCORE3, and SCR3RANK as endogenous and the estimates in Table 4 are obtained using an instrumental variable method.[19]

Quite striking, as expected, Table 4 indicates that the higher the rank of a player (the poorer his relative position) after the third day of a tournament, the higher his final round score will be (col. 1A, 3A). However, as in Table 1, this relationship is found only for exempt players (col. 1E, 1N).[20]

Of course, entering a player's rank after three rounds and total tournament prize money separately only approximates the marginal return to effort/concentration that he faces if he improves a given number of ranks. Such a specification also does <u>not</u> take into account how closely his competitors are "bunched" around him. To obtain more precise measures of the relevant marginal returns, we defined six different variables, these are all illustrated in Figure 2.

Referring to the figure, suppose that the curve PP shows the relationship between a player's final rank in a tournament and the prize money he will be awarded. Consider an individual who after the third round is at rank R. If he remains at that rank, he will be awarded the amount OA at the end of the tournament.

The first three marginal return variables we compute ignore how tightly bunched competitors are around the player and are based on the return to improving performance, or of having it get worse, by one rank. DPRIZE3 is the estimated marginal increase in prize money if the individual's rank at the end of the tournament was one better than his current rank. It is based on the slope of PP at R and is given by AB.

UPRIZE3 is the actual increase in prize money the individual would gain if he improved his rank by one; this is given by AC in the figure. MIDPRIZ3 assumes the individual takes into account the cost of losing one rank, as well as the benefit from improving one rank. It is defined as the actual average absolute change in prize money if the rank at the end of the tournament is either one lower or one higher than R and it is given in the figure by the average of the lengths of AC and AD.

Presumably, increased effort/concentration directly affects a player's score not his rank. The effect of increased concentration on rank then depends upon the number of competitors closely bunched around the player. The next three measures take this into account; they are the actual increase in prize money the individual would receive if he improved his scores relative to his competitors by one stroke (LES1PRIZ), two strokes (LES2PRIZ), or three strokes (LES3PRIZ). Assuming that improvements of one, two, and three strokes would cause the individual's rank to improve respectively to S, T, and U in the figure, these variables' magnitudes in turn would be given by AE, AF, and AG.

Each of these six variables was computed for each individual in each tournament. Each variable in turn was substituted for SCR3RANK and TPRIZE and equations similar to those reported in Table 4 reestimated. Because each of these marginal return to effort variables depends upon a player's rank after the third round and the latter is endogenous, instruments were also used for each of these variables.[21]

Estimates of the coefficients of the marginal return to effort variables from these equations are reported in Table 5. The pattern of results is remarkably consistent across specifications. The marginal prize variables do affect players' scores on the final round, but again only for exempt players.

Table 6 presents descriptive statistics for each of the marginal prize variables. Focusing on the exempt sample, one can use these data and the estimates in Table 5 to get estimates of the influence of these variables on players' performance. For example, ceteris paribus, one can compute, for each variable, how much better exempt players, whose marginal prize is one standard deviation above the mean marginal prize in the exempt sample, will play by multiplying the standard deviation in Table 6 by the corresponding regression coefficient in Table 5. For five of the six marginal prize variables, the calculations imply that such exempt players will score 1.5 to 2.0 strokes lower on the final round of the tournament.[22]

D) Average Score Per Round Equations for the 1984 Senior PGA Tour

The evidence presented above is strongly supportive of the notion that professional golfers' effort/concentration level respond to the financial incentives they face and that these response occur primarily in the last rounds of tournaments when fatigue is more likely to have set in and thus the difficulty of maintaining concentration is harder.

The PGA operates a separate Senior Tour for golfers age 50 and older. Given the players' ages, it seems reasonable to assume that fatigue will be higher, as will be the difficulty of maintaining concentration, on the senior tour. Thus, one might expect to observe larger marginal responses to the reward structure by these players.

Table 7 presents some results that are consistent with this hypothesis. Estimates are presented of equations in which the average round score of a senior player in a tournament is specified to be a function of the prize money in the tournament (either total prize money (TPRIZE) or winner's prize money (WINPRIZ)), the difficulty of the course, as measured by its par (PAR) and length (DIST), the player's ability as measured by his scoring average in all rounds played during the year (SCOREA), and a measure of field quality, the number of competitors in the tournament who finished among the top 10 money winners on the senior tour in 1984 (TOP10).[23] Some tournaments on the senior tour only lasted three rounds and hence the number of rounds in the tournament is added as an additional explanatory variable (ROUNDS). The sample is confined to the top 25 money winners during the year on the tour and to 22 tournaments that had similar prize structures.[24]

The results in Table 7 suggest that fatigue plays an important role on the senior tour. Ceteris paribus, players' scores are about 2 strokes <u>per round</u> higher on 4 day tournaments than they are on 3 day tournaments. Furthermore, one observes that higher winners' prizes (col. (1)) or total tournament prizes (col. (2)) both lead to lower scores per round.[25] Indeed, the results in column (2) suggest that an increase in the total prize money of $100,000 would lead to scores that averaged .8 strokes lower per round. Over a three and four day tournament, respectively, this would correspond to lower total tournament scores of 2.4 and 3.2 strokes per player. These numbers should be contrasted to the 1.1 stroke reduction in total tournament score per $100,000 increase in total prize money that we observed for exempt players in Table 1.

Of course, the individuals who play on the senior tour are, for the most part, the individuals who in their younger years were very successful on the regular PGA Tour. If better players are more responsive to financial incentives, as some of the results above suggest, and the senior tour is comprised disproportionately of players who previously were among the better players on the regular tour, then one might expect to observe larger responses to financial incentives on the senior tour.

Some evidence supportive of this explanation is found in columns (3) and (4) of Table 7 in which the coefficients of the winner's prize and total prize money in a tournament are interacted with the total career tournament earnings of each player (WPRINT, TPRINT). The negative coefficients of these interaction terms suggest that better players', as measured by higher career earnings, effort/concentration levels are more responsive to financial incentives.

V. Concluding Remarks

This paper has provided nonexperimental evidence that tournaments have incentive effects. Our analysis of data from the 1984 Men's PGA Tour and the 1984 Senior Men's PGA Tour suggest that the level and structure of prize money does influence players' performance. Higher prize levels do lead, ceteris paribus, to lower scores but this effect occurs primarily in the later rounds of a tournament when fatigue has set in and it is more difficult for players to maintain concentration. Given a player's performance on the first three rounds of a tournament, his performance on the last round also appears, ceteris paribus, to depend on the marginal returns to effort he faces, with players who face larger marginal returns scoring lower. The level of prize money in tournaments also influence who enter the tournaments, with higher prize money attracting better (exempt) players.

The influence of tournament prizes on performance was observed primarily for exempt players. As described in the text and the appendix, this may reflect either that exempt players are more responsive to the reward structure or that a tournament's prize level does not adequately reflect the reward structure that nonexempt players face, since these players must be concerned with how their finish in a tournament will influence their probability of qualifying for exempt status on next year's tour. Evidence from the senior tour provides some support for the former hypotheses -- that better players are, in fact, more responsive to financial incentives.

Our work is only an initial empirical study of the incentive effects of tournaments and there are a number of directions in which future research might proceed. First, replication using data from other sports in which absolute measures of output are available (e.g., bowling) and for other years in which the level and structure of prizes on the PGA tour differed would obviously be desirable.

Second, all of our analyses are derived form simple two-person models that yield implications for the output/scores of an individual player. Generalization to n-person tournaments would yield implications about the entire distribution of scores one might expect to observe and empirical analyses of the distribution of final scores could then be undertaken.

Third, our analyses assumed that the tournament prize structure influences output/scores through its effect on effort/concentration levels. Players can also choose conservative (e.g., hit down the center of a fairway) or risky (e.g., try to cut across a dogleg) strategies and depending upon a player's ability relative to the rest of the field and/or his rank after each round, different strategies may be pursued. Models that also included the choice of strategies that differ in risk undoubtedly would yield additional empirical implications.

Fourth, there are normative issues relating to the level and structure of prizes that we actually observe in tournaments. Can we infer from this structure, what the objective functions of the PGA Tour and tournament sponsors actually are? Can we estimate whether the marginal cost to sponsors of higher prize tournaments is less than, equal to, or greater than the marginal benefits they receive? To answer such questions will require one to go far beyond the scores of players in tournaments and to analyze more generally the operations of the PGA Tour and its sponsors.

Finally, while analyses of sports tournaments are of interest in themselves, there is the broader question of the extent to which tournament theory can help to provide an explanation for the structure of mpensation we observe among corporate executives. Devising ways to address this question should rank high on the research agenda of economists interested in compensation issues.

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Footnotes

1. See Edward Lazear (1979, 1983), for a discussion of deferred payment schemes; Joseph Stiglitz (1987), Jeremy Bulow and Lawrence Summers (1986), Lawrence Katz (1986) and George Akerloff (1984) for discussions of efficiency wage theories; Edward Lazear (1986) for a discussion of piece-rates, and Edward Lazear and Sherwin Rosen (1981), Lorne Carmichael (1983), Jerry Green and Nancy Stokey (1983), James Malcomson (1984), Barry Nalebuff and Joseph Stiglitz (1984), Mary O'Keefe, W. Kip Viscusi and Richard Zeckhauser (1984), Sherwin Rosen (1986) and Kenneth McLaughlin (1988) for discussions of tournament theory.

2. See Ronald Ehrenberg and George Milkovich (1987), for a summary of what we know empirically about how compensation policy affects firm performance. Daniel Raff and Lawrence Summers (1987) provide an historical attempt at testing efficiency wage theory. Attempts to test whether piece-rate schemes lead to higher productivity, for example John Pencavel (1977) and Eric Seiler (1984), that involve comparisons of the earnings of piece-rate and hourly workers run into well-known (including by these authors) problems that workers are not randomly assigned to piece-rates in these studies and that piece-rate workers may receive compensating wage differentials for the more variable earnings streams they face. Finally, Andrew Weiss (1987) finds that within a single firm, the shift from individual to group incentives after workers were employed for a specified period led to lower productivity for the best workers and higher propensities to quit for workers in both tails of the productivity distribution.

3. See Clive Bull, Andrew Schotter and Keith Weigett (1987).

4. In fact the PGA Tour's 1984 Player's Handbook (1984) states that "In making a commitment to play in a PGA Tour cosponsored or approved event, a player obligates himself to exercise his maximum golf skill and to play in a professional manner" (p. 58).

5. Details are found in Michael Bognanno (1988), Chapter II and the appendix.

6. See Official 1985 PGA Tour Media Guide (1984). Of the 39 tournaments actually used in the study (the British Open was excluded for reasons that will be made clear shortly), 9 offered total prize levels between $200,000 and $350,000, 16 had a total prize level of $400,000, 8 had a total prize level of $500,000, and 6 offered total prize money in the $565,000 to $800,000 range.

7. Official 1985 PGA Tour Media Guide (1984), p. 288.

8. See 1984 Player's Handbook (1984). In addition, among other things, the system required members of the tour to play in a minimum number of tournaments, to declare their intent to participate in a tournament at least a week in advance, to pay a minimal entry fee ($100) per tournament, and limited the ability of players to withdraw from a tournament once a commitment to enter had been made.

9. As we describe below, our sample includes only individuals in categories (i), (ii), and (iii).

10. We are grateful to Robert Gibbons and Kevin Lang for stressing the need for this appendix.

11. The restriction to players who entered and made the cut leads to potential selectivity problems and we discuss this issue below.

12. As a result, virtually no individuals from category iv are included in the sample.

13. A player's "performance average" is a measure of how well he placed in the tournaments he entered during the year, with high performance averages indicating better players. PAR, DIST, SCOREAVE, FCUT, FRACT and MPERAVE were obtained from The 1985 Golf Digest Almanac. One paragraph descriptions of the weather conditions that players faced each day of each tournament were obtained from the Official 1985 PGA Tour Media Guide; an average of three raters' perceptions of whether the weather each day adversely affected player performance was then constructed. Finally RATING was obtained for a majority of the courses from Mr. Jay Matolla of the Metropolitan Golf Association and for the other courses through telephone calls to state golf associations. Substitution of the number of players among the top 20 money winners in the year as a measure of field quality led to estimates that are marginally less significant than those that follow.

14. When a nonexempt player won a tournament, we changed his status to exempt for subsequent tournaments in the year.

15. The British Open, the fourth major golf tournament, was included from the analyses both because RATING was not available for it and because relatively few of the top U.S. players enter it. As a result, our sample actually includes 39 tournaments.

16. These data come from the 1984 PGA Tour Player Record (1985); a complete record of the performance of each of the almost 300 players who played in at least one PGA event during the year.

17. For brevity these results are not reported here; they are available from the authors upon request. The probits included as explanatory variables, the individual's exempt status, his total career earnings prior to 1984, his age, the chronological order of the tournament during the year (1 to 40) and its square, whether the tournament was a major tournament, the tournament's total prize money, and the player's scoring average on all rounds during the 1984 tour (and/or in some specifications his scoring average over the first two rounds of all tournaments during the year). Each variable was interacted with the player's exempt status. The explanatory variables all were collected from the 1985 PGA Tour Media Guide and the 1985 Golf Digest Almanac.

18. We also estimated specifications that included a dummy variable for tournaments the week before major tournaments. They suggested that exempt players are less likely, and nonexempt players more likely, to enter such tournaments.

19. The specific variables used to obtain the instruments are listed in the notes to Table 4. Formal specification tests conducted using the sample of exempt players permit one to reject the hypothesis that this set of variables should be treated as exogenous. See J.A. Hausman (1978) for these tests.

20. The insignificance of TPRIZE (which does not vary across individuals in the same tournament) may be due to its effects being captured through the instruments for SCORE1, SCORE2, and SCORE3, or to the functional form estimated (TPRIZE and SCR3RANK were entered separately). WAVE4 is highly positively correlated with WAVE123 and this may explain its negative coefficient.

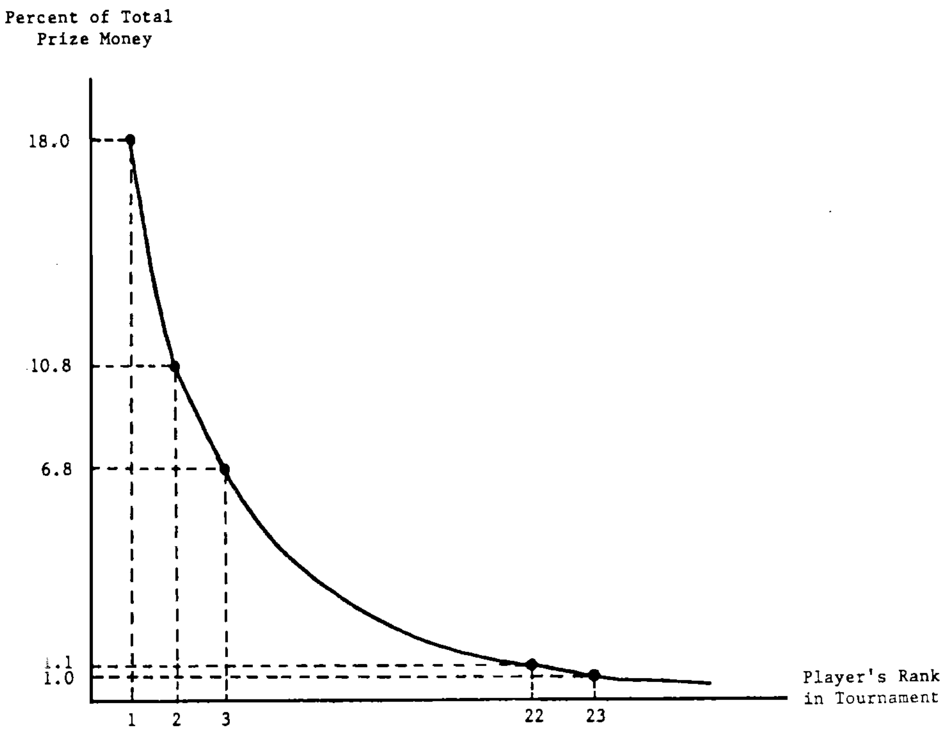

Figure 1

Share of Total Prize Money Going to Players of Different Ranks:
1984 Men's PGA Tournament in the Sample

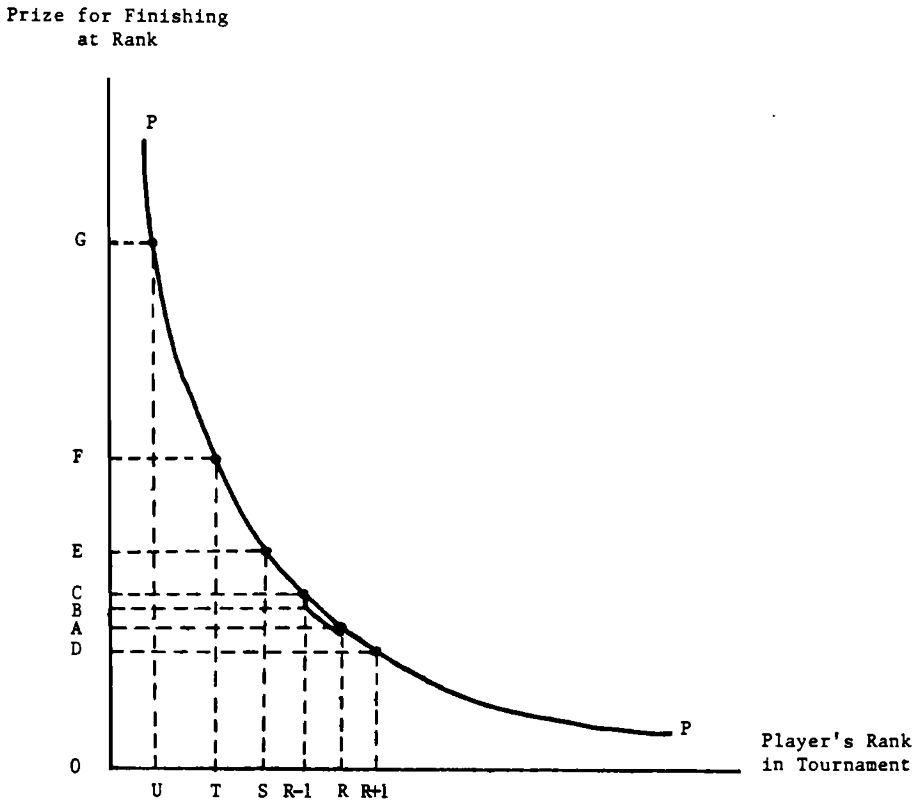

Figure 2

Alternative Measures of Marginal Return
to Effort/Concentration in a Tournament

Table 1

Final Score Equations for the 1984 Men's PGA Tour:
Data Pooled Across Tournaments and Players
(absolute value t statistics)

	(1)	(2)	(IE)	(IN)
CONSTANT	-324.099 (13.1)	-312.030 (12.6)	-334.619 (9.4)	-281.102 (8.1)
TPRIZE	-.011 (6.9)	-.010 (6.1)	-.011 (4.9)	-.010 (3.9)
TPRIZE*EXMT		-.002 (4.4)		
PAR	1.495 (8.5)	1.470 (8.4)	1.637 (6.5)	1.152 (4.7)
DIST	.006 (7.4)	.006 (7.7)	.004 (3.5)	.009 (7.8)
RATING	.211 (20.5)	.210 (20.5)	.233 (15.0)	.185 (13.4)
WAVE	2.394 (13.3)	2.360 (13.1)	2.524 (8.7)	2.155 (9.3)
MAJ	-.698 (1.3)	-.654 (1.2)	-1.103 (1.7)	-.811 (0.9)
SCOREAVE	4.059 (14.0)	3.906 (13.5)	3.948 (9.6)	3.831 (9.4)
FCUT	4.346 (3.0)	4.651 (3.3)	4.026 (1.9)	5.114 (2.6)
FRACT	4.277 (2.1)	3.515 (1.7)	9.622 (3.2)	-4.064 (1.3)
MPERAVE	.042 (10.6)	.045 (11.1)	.039 (7.5)	.055 (8.5)
$\bar{R}^2$	.421	.426	.436	.410
n	2432	2432	1030	1401

where:

TPRIZE	total tournament money (in 000's)
EXMT	1=automatically qualify to enter tournaments on the <u>1985</u> men's PGA 0=not automatically qualify
PAR	par for the tournament course
DIST	course yardage
RATING	course rating - PGA evaluation of the playing difficulty of the course as it was set up for the tournament (expressed in strokes)
WAVE	average of 3 raters' perceptions of the number of days the weather significantly influenced player performance during the tournament
MAJ	1=U.S. Open, PGA, or Masters, 0=other
SCOREAVE	player's scoring average on all rounds played during the 1984 tour
FCUT	fraction of tournaments entered in which the player made the cut on the 1984 tour
FRACT	fraction of players in the tournament who made the cut that were ranked in the top 160 in total prize money won during the 1984 tour
MPERAVE	mean "performance average" on the 1984 tour of players in the tournament who made the cut. A player's "performance average" is a measure of how high he placed in the tournaments he entered, with high performance averages indicating better performance (see the text for details)

Table 2

Score After Second Round Equations for the 1984 Men's PGA Tour:
Data Pooled Across Tournaments and Players
(absolute value t statistics)[a]

	(1)	(2)	(IE)	(IN)
CONSTANT	-128.429 (7.0)	-121.571 (6.6)	-148.561 (5.6)	-93.279 (3.6)
TPRIZE	-.001 (0.8)	-.000 (0.2)	-.001 (0.6)	-.000 (0.0)
TPRIZE*EXMT		-.001 (3.4)		
PAR	.558 (4.4)	.556 (4.4)	.759 (4.0)	.359 (2.1)
DIST	.000 (0.2)	.000 (0.3)	-.000 (0.8)	.001 (1.6)
RATING	.112 (16.2)	.111 (16.1)	.110 (10.3)	.110 (12.0)
WAVE2	2.148 (14.7)	2.129 (14.7)	2.106 (9.2)	2.068 (10.5)
MAJ	.430 (1.2)	.462 (1.3)	.857 (1.9)	-.673 (1.0)
SCORE12	1.913 (9.0)	1.820 (8.5)	2.083 (6.9)	1.561 (5.1)
FCUT	-1.855 (1.7)	-1.825 (1.6)	-1.001 (0.6)	-2.751 (1.7)
FRACT2	11.683 (6.3)	11.088 (5.9)	10.383 (3.8)	8.543 (2.8)
MPERAVE2	.008 (3.0)	.009 (3.5)	.008 (2.5)	.017 (3.2)
$\bar{R}^2$	.286	.288	.292	.270
n	3449	3449	1378	2070

[a]All variables are defined as in Table 1, save for WAVE2 which now refers to the weather during the first two rounds of the tournament, and FRACT2 and MPERAVE2 which now refer to all entrants in the tournament.

Table 3

1984 Men's PGA Tour Probit Probability of Entry Equations
(absolute value t statistics)

	(1)	(2)
CONSTANT	-9.119 (3.3)	-8.946 (3.2)
EXMPT	3.435 (0.9)	3.549 (0.9)
APRCASH[d]	-.159 (3.3)	-.187 (3.5)
AAGE[b]	-.471 (0.6)	-.184 (0.3)
ATCODE[a]	-.620 (6.3)	-.619 (6.3)
ATCODE2[b]	.108 (4.4)	.107 (4.7)
AMAJ	.329 (2.6)	.327 (2.6)
ATPRIZE[b]	.230 (7.9)	.231 (7.9)
BPRCASH[d]	.077 (0.7)	.081 (0.7)
BAGE[b]	-.995 (1.9)	-.978 (1.8)
BTCODE[a]	-.450 (5.30)	-.451 (5.4)
BTCODE2[b]	.101 (6.9)	.102 (5.0)
BMAJ	-.680 (6.9)	-.680 (6.9)
BTPRIZE[c]	-.321 (1.4)	-.321 (1.4)
ASCORE12	.082 (2.0)	-.142 (1.3)
BSCORE12	.143 (3.7)	.038 (0.3)
ASCORAVE		.218 (2.3)
BSCORAVE		.102 (1.0)
P = 0	2178	2178
P = 1	3516	3516
χ^2(DOF)	434.55 (15)	440.91 (17)

where:

a - coefficient has been multiplied by 10
b - coefficient has been multiplied by 100
c - coefficient has been multiplied by 1,000
d - coefficient has been multiplied by 1,000,000

and

An "A" before a variable name indicates the variable's coefficient for exempt players (those who automatically qualify to enter the next year's tournaments), while a "B" before a variable name indicates the variable's coefficient for nonexempt players.

and

PRCASH	total career earnings prior to 1984
AGE	age
TCODE	tournament code, in chronological order, equals 1 for the first tournament and 40 for the last
TCODE2	TCODE squared
MAJ	1=U.S. Open, PGA, or the Masters, 0=other
TPRIZE	total tournament prize money (in 000's)
SCOREAVE	player's scoring average on all rounds played during the 1984 tour
SCORE12	player's scoring average on all first and second rounds played during the 1984 tour

Table 4

Final Round Score Equations for the 1984 Men's PGA Tour: Data Pooled Across Tournaments and Players[a]
(absolute value t statistics)

	(1A)	(2A)	(3A)	(1E)	(1N)
CONSTANT	-.996 (0.2)	-5.098 (1.1)	-.929 (0.2)	.409 (0.0)	.259 (0.0)
SCORE1	.198 (2.4)	.186 (2.2)	.197 (2.3)	.098 (0.6)	.210 (2.1)
SCORE2	.700 (6.6)	.658 (6.4)	.701 (6.5)	.699 (3.9)	.674 (5.2)
SCORE3	.122 (1.3)	.246 (3.0)	.121 (1.2)	.198 (1.2)	.126 (1.0)
WAVE123	-2.292 (5.0)	-2.040 (4.7)	-2.295 (4.9)	-1.974 (2.7)	-2.304 (4.0)
WAVE4	-1.155 (1.9)	-1.232 (2.1)	-1.154 (1.9)	-1.692 (1.7)	-.941 (1.2)
SCR3RANK	.022 (2.5)		.023 (2.5)	.029 (1.8)	.004 (0.3)
TPRIZE		-.000 (0.7)	.000 (0.0)	.000 (0.2)	.000 (0.2)
$\bar{R}^2$	.110	.117	.110	.112	.097
n	2390	2390	2390	1018	1371

where:

SCORE1	player's first round score in the tournament
SCORE2	player's second round score in the tournament
SCORE3	player's third round score in the tournament
WAVE123	average of 3 raters' perceptions of the number of days the weather significantly influenced players' performance during the first three days of the tournament
WAVE4	average of 3 raters' perceptions of whether the weather significantly influenced players' performance on the last day of the tournament
SCR3RANK	player's rank after the third round of the tournament
TPRIZE	total tournament prize money (in 000's)

and

A - all players

E - exempt players (players who have already qualified for <u>next</u> year's PGA tour)

N - nonexempt players

[a]Instruments for SCORE1, SCORE2, SCORE3, SCR3RANK were obtained using: TPRIZE, MAJ, PAR, DIST, RATING, FRACT, MPERAVE, FCUT, SCOREAVE (which are all defined in Table 1) and

SCORE12 - player's scoring average on all first and second rounds he played on the 1984 tour
SCORE3A - player's scoring average on all third rounds he played on the 1984 tour
WAVE1) average of 3 raters' perceptions of whether the weather significantly
WAVE2) influenced player performance during the first, second, third and
WAVE3) fourth rounds respectively of the tournament
WAVE4)
PERAVE - player's performance average on the 1984 PGA tour (see Table 1)

Table 5

Coefficients of Marginal Return to Effort Variables in Final Round Score Equations for the 1984 Men's PGA Tour: Various Specifications (absolute value t statistics)

Specification	All	Exempt	Nonexempt
(1) DPRIZE3	-.042	-.042	-.032
	(2.7)	(1.8)	(0.9)
(2) UPRIZE3	-.236	-.310	-.070
	(3.5)	(2.6)	(0.6)
(3) MIDPRIZ3	-.212	-.278	-.088
	(3.3)	(2.5)	(0.8)
(4) LES3PRIZ	-.049	-.052	.009
	(2.0)	(1.3)	(0.3)
(5) LES2PRIZ	-.088	-.135	.025
	(2.6)	(2.4)	(0.5)
(6) LES1PRIZ	-.181	-.306	.105
	(2.7)	(2.5)	(1.0)

where:

DPRIZE3 — estimated marginal increase in prize money (in 000's) if rank at the end of the tournament is one lower than individual's third round rank

UPRIZE3 — actual marginal increase in prize money (in 000's) if rank at the end of the tournament is one lower than the individual's third round rank

MIDPRIZ3 — actual average marginal absolute changes in prize money (in 000's) if rank at the end of the tournament is one lower or one higher than individual's third round rank

LES3PRIZ — actual marginal increase in prize money (in 000's) if the individual improved his rank after the third round by reducing his score by 3 strokes relative to the rest of the field (LES2PRIZ - 2 strokes, LES1PRIZ - 1 stroke)

and

[a] All specifications also include SCORE1, SCORE2, SCORE3, WAVE123 and WAVE4 and use instruments used for SCORE1, SCORE2, SCORE3 <u>and</u> the marginal return to effort variables.

Table 6

Descriptive Statistics - Marginal Prize Variables[b]

	SCR3RANK	DPRIZE3	MIDPRIZ3	UPRIZE3	LES3PRIZ	LES2PRIZ	LES1PRIZ
			Entire Sample (n=2458)				
Mean	32.6	5.1	1.5	1.6	8.9	5.5	2.4
Std. Dev.	21.4	25.9	4.7	5.6	12.3	9.4	5.2
Min. Val.	1.0	a	a	a	a	a	a
Max. Val.	87.0	339.0	44.8	57.6	92.4	78.4	52.7
			Exempt Sample (n=1053)				
Mean	27.3	8.9	2.4	2.4	10.6	6.9	3.1
Std. Dev.	19.9	35.3	6.0	7.0	13.8	11.2	6.5
Min. Val.	1.0	a	a	a	a	a	a
Max. Val.	87.0	339.0	44.8	57.6	92.4	78.4	52.8
			Nonexempt Sample (n=1405)				
Mean	36.5	2.2	0.9	1.0	7.7	4.4	1.8
Std. Dev.	21.6	14.7	3.4	4.2	11.0	7.6	3.7
Min. Val.	1.0	a	a	a	a	a	a
Max. Val.	85.0	239.8	28.0	36.0	92.4	71.6	52.8

[a]Less than 0.5.

[b]See Tables 4 and 5 for variable definitions. SCR3RANK is an integer between 1 and 87. All other variables are measured in thousands of dollars.

Table 7

Average Score Per Round on the 1984 Men's Senior PGA Tour:
Data Pooled Across Tournaments and Players
(absolute value of t statistics)

	(1)	(2)	(3)	(4)
CONSTANT	10.395 (0.8)	2.961 (0.2)	18.022 (1.3)	12.796 (1.0)
SCOREA	.744 (7.7)	.786 (8.4)	.630 (5.3)	.644 (5.7)
ROUNDS	2.121 (9.8)	2.159 (11.6)	2.147 (9.9)	2.178 (11.7)
PAR	-.201 (1.3)	-.117 (0.8)	-.202 (1.3)	-.120 (0.8)
DIST	.002 (5.1)	.002 (4.8)	.003 (5.2)	.002 (5.0)
TOP10	.035 (0.5)	.056 (0.9)	.034 (0.5)	.057 (0.9)
WINPRIZ	-.045 (2.7)		-.039 (2.3)	
TPRIZE		-.008 (6.0)		-.007 (4.9)
WPRINT[a]			-.802 (1.7)	
TPRINT[a]				-.150 (2.2)
$\bar{R}^2$	.347	.396	.350	.403
n	349	349	349	349

[a]Coefficient has been multiplied by 10^8.

where:

SCOREA	player's scoring average on all rounds played during the 1984 tour
ROUNDS	number of rounds in the tournament
PAR	par for the tournament course
DIST	course yardage
TOP10	number of competitors in the tournament who were among the top 10 money winners during 1984 on the seniors' tour
WINPRIZ	winner's prize (in 000's)
TPRIZE	total tournament prize money (in 000's)
WPRINT	winner's prize interacted with the player's career earnings prior to 1984
TPRINT	total tournament prize money interacted with the player's career earnings prior to 1984

Appendix

Suppose w_1 is the prize for winning and $w_2 = \alpha w_1$ is the prize for losing, where α is less than one. Suppose also for exempt players, that the relationship between their output (y) and their marginal reward for winning is given by

$$(A1)\quad y = B_0 + B_1(w_1 - w_2) + \epsilon = B_0 + B_1(1-\alpha)w_1 + \epsilon$$
$$= B_0 + B_2 w_1 + \epsilon \qquad\qquad B_1, B_2 > 0 .$$

Here all other factors that influence a player's output are subsumed in B_0 and the response of output to the prize spread is given by $B_2/(1-\alpha)$. If the error term ϵ is uncorrelated with w_1, least squares estimates of (A1) will yield an unbiased estimate of B_2 (ignoring any other econometric problem).

Now consider nonexempt players and let p represent the probability they qualify as exempt players on next year's tour and w_3 their expected increase in present value of earnings if they so qualify. Their marginal reward for winning (R) is given by

$$(A2)\quad R = w_1 + p(w_1)w_3 - w_2 - p(w_2)w_3 = (w_1 - w_2) + w_3(p(w_1) - p(w_2))$$
$$= (1-\alpha)w_1 + w_3(p(w_1) - p(\alpha w_1))$$

Assuming that nonexempt players' effort and output response to the marginal reward for winning is the same as that of exempt players

$$(A3)\quad y = B_0 + B_1 R + \epsilon = B_0 + B_1[(1-\alpha)w_1 + w_3(p(w_1) - p(\alpha w_1))] + \epsilon$$
$$= B_0 + B_2 w_1 + \epsilon^*$$

where

$$(A4)\ \epsilon^* = \epsilon + B_1[w_3(p(w_1) - p(\alpha w_1))]$$

If the error term, ϵ^*, is positively (negatively) correlated with w_1, estimation of (A4) by least squares will yield estimates of B_2 (call these $\hat{B}_2$) that are biased in a positive (negative) direction. The correlation of w_1 and ϵ^*, however, depends only on the sign of $p'(w_1) - \alpha p'(\alpha w_1)$. In particular

$$(A5)\ p'(w_1) - \alpha p'(\alpha w_1) \gtreqless 0 \Rightarrow E(\hat{B}_2) \gtreqless B_2$$

Now consider three possible scenarios for how p varies with the prize won. First, suppose p increase linearly with the individual's winnings until the certainty of being classified as exempt next year is reached. In this case, p' will be a positive constant, say c, and

$$(A6)\ p'(w_1) - \alpha p'(\alpha w_1) = (1-\alpha)c > 0$$

Hence $\hat{B}_2$ will be biased upwards.

Second, suppose p' is increasing in the size of a prize won in a tournament. In this case,

$$(A7)\ p'(w_1) - \alpha p'(\alpha w_1) > (1-\alpha)p'(w_1) > 0$$

So again $\hat{B}_2$ will be biased upwards.

Finally, suppose p' is decreasing in the prize won in a tournament. In this case

$$(A8)\ p'(w_1) - \alpha p'(\alpha w_1) \gtreqless 0 \qquad \text{as} \qquad \frac{p'(w_1)}{p'(\alpha w_1)} \gtreqless \alpha$$

Hence, in this last case is it possible that $\hat{B}_2$ will be biased towards zero.

Of course, all of the above assumes that the actual responses of exempt and nonexempt players to the marginal reward for winning are equal. It is possible that exempt players are exempt because their effort levels are <u>more</u> responsive to financial variables. Hence, if one observes smaller (in absolute value) values of $\hat{B}_2$ for nonexempt players (as we in fact do in section III), it may reflect either differences in true response functions or that $p'(w_1) - \alpha p'(\alpha w_1) < 0$.