The Incentive Effects of Tournaments: An Empirical Study on Poker Tournaments[1]

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ABSTRACT

This paper will test tournament theory in a poker tournament framework. It examines whether higher prize money in tournaments, ceteris paribus, induce higher effort levels by players as well as whether in the final three tables of the tournament, ceteris paribus, a player's performance varies with the marginal return to effort. A simple two-contestant model is applied to the framework of poker and empirical testing is undertaken on that basis. The paper finds that a positive relationship between higher total prize money and effort levels exists. Evidence in support of a positive relationship in the secondary question in not found however.

[1] The author is grateful to Dr. Natalie Chen for her supervision, encouragement and comments throughout the project and to Dr Gianna Boero for her invaluable lectures on how to write such a paper and useful econometric techniques.

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I. INTRODUCTION

"We work our socks off in underpaying jobs in the hope that one day we'll win the rat race and become overpaid fat cats ourselves [like our bosses] ***. Economists call this Tournament Theory****. "*

Tim Hartford, Forbes.com

Tournament theory suggests an alternative way for firms to motivate their employees. Competitions for rewards (promotions) can be run so that relative rather than individual performance matters. The rank order scheme suggested implies that larger prizes will lead to higher performance and increased levels of effort by individuals at any stage on a firm's ladder. Furthermore, it implies that the larger the marginal payoff to effort the better the performance of an individual is expected to be. This is very appealing in the sense that monitoring individual effort is much costlier than observing relative effort. As a result, sufficient empirical evidence that tournament incentives indeed operate, could potentially change future intra-firm compensation structures. Firms that already exhibit such rank-order schemes might propagate them and the ones that don't, could adopt them and "economize by measuring only rank ordering of performances."[2]

Non-experimental evidence on tournament theory is very limited as it is difficult to monitor executives' effort levels; competitive sports however provide a good framework to test the theory. This paper will test tournament theory in a poker tournament setting. The exponential increase in the popularity of poker in recent years, not only has made data available but has also increased the number of tournaments as well as the number of participants, making potential analysis more robust. Hence, the main question of the paper will be whether *higher prize money in tournaments, ceteris paribus, induce higher effort levels by players* and the secondary question will investigate whether *in the final three tables of the tournament, ceteris paribus, a player's performance varies with the marginal return to effort.*

[2] Gibbs(1995)

The general case of two-contestant models will be considered and then will be applied to poker tournaments. The paper concludes that a significant positive relationship between higher rewards (prize money) and higher output/scores exists. However, evidence about a positive relationship between a player's performance and marginal return to effort was not found. The main criticism of our results stems from the fact that a measurable level of output is not available and a different proxy from the one used in the paper could potentially make the results more reliable.

II. LITERATURE REVIEW

Few attempts have been made to test the very elegant and interesting predictions that Lazear and Rosen (1981) made. The authors developed, an original at the time, - *rank-order payment scheme* - that however "seems to be prevalent in many labour contracts."[3] The authors develop a two-player contest, in which two player compete. The rules of the games are ex-ante known to both "workers" and the prizes are W_1 and W_2 for the "winner" and "loser" respectively. For simplicity the authors assume a single period in what follows after the contest. We therefore see the incentive problem in terms of career development and lifetime productivity. The worker's (lifetime) output q is a random variable whose distribution (mean) is chosen by each player. As a result, the worker with the largest drawing of q, wins the contest and gets W_1. Such a scheme is rank-order in the sense that the earnings each player gets do not depend on the margin of the win. "*Performance incentives are set by attempts to win the contest."*[4] Important in our framework of Poker (and in most competitive environments) is that players are assumed to pre-commit to their chosen lifetime output and do not know who their opponent is at the actual time of the contest. Therefore, a player can be seen as competing "against the field."

The paper concludes that the competitive outcome can be achieved by such a scheme. Also, there seems to be a need for ever larger rewards to motivate those competing for the "highest" ranks. Moreover, it predicts that larger prizes induce better performance

[3] Lazear and Rosen (1981), page 842.
[4] Lazear and Rosen (1981), page 842.

as a result of increased effort. Finally, it shows that the greater the return of extra effort the higher the motivation for an individual.

Empirical evidence of the model's predictions is very limited and relevant studies are usually conducted on different contexts other than employees in firms. This is due to the difficulty of measuring effort levels of executives as well as the incentive structures they face. However, a study on the role of the distribution of pay among the top-management team, by Main, O'Reilly and Wade (1993) finds positive evidence for the operation of tournaments. However, "the evidence suggests that "winners" once promoted enjoyed a pay increase of roughly 10%-20%, hardly the magnitude suggested by a tournament."[5] A successful career as a CEO however can be characterized as a substantial prize of $4.6-$6.2 million in total. The paper critically argues that, as senior management in a firm operates as a team, in order to keep the "losers" motivated a sequential tournament framework might be more appropriate. Bull, Schotter and Weigelt (1987) conduct a laboratory study on undergraduate students and found that the latter quickly adapted to a tournament prize structure and produced effort levels consistent with the theory. However, the variance of the students' behaviour was too large, leading them to conclude that "At a gross level the theory of tournaments seems to be able to predict at least some of the qualitative properties of systematic average behavior."[6]

The first attempt to test rank-order tournaments' predictions was made by Ehrenberg and Bognanno who investigated the performance of professional golf players at the 1987 European PGA Tour. Their analysis was based on the two-contestant model described above. The paper essentially revolves around testing whether higher prize money leads to lower scores (in golf, the lower the score the better the performance) for the tournament as a whole and whether a player's performance in the final round depends on the marginal return to effort. They firstly regress final scores, on total prize money awarded, whether the tournament is a major one or not and vectors of variables controlling for own and opponents quality as well as tournament difficulty. Their hypothesis was that if the theory of tournaments is correct then the coefficient on the

[5] Main, Brian ,O'Reilly (1993), page 624
[6] Bull, Schotter, and Weigelt, (1987), page 29.

total prize money should be negative[7] and statistically significant. Indeed, they conclude that a £60,000 increase in the prize leads, on average, to a player scoring about three less strokes. In trying to see the relationship of players' performance and marginal return to effort they run regressions of final round scores on the total prize money, their previous scores in the tournament and their rank before the final round. As expected by the theory they conclude that the poorer a player's relative position is the higher his final round score is.

However, as they argue one should be cautious when evaluating these results as in such tournaments not all professional golf players could enter. Moreover, for some players their performance in a tournament was influencing their probability of being able to participate in next year's tournaments. As a result, the tournaments' prize level might not reflect the reward structure those players faced. Furthermore, higher prize levels are expected to attract better players which, on average, would lead to lower scores. The paper also fails to account for different risk strategies players could adopt. Finally, due to the identical prize structure across tournaments the paper did not examine how higher concentration of total prizes at the top affects effort levels.

Golf is traditionally considered a game of skill making golf tournaments a well-suited framework to test tournament theory. A recent paper by Croson, Fishman and Pope (2002) was focused on showing that poker is also a game of skill and not of luck as usually considered. The authors attempt to show that skill differentials between poker players exists by arguing that certain players usually outperform others conditional being in the last two tables. They introduce a forecasting model and find evidence that previous tournament finishes predict future ones. What is more, they conclude that skill differences among top poker players are similar to those across top golfers and poker is therefore a game of skill rather than luck.

To conclude, as empirical testing of tournament theory is very limited it is interesting to assess its applicability in other competitive frameworks with poker, *a game of skill*, being a good example. Finally, in contrast to golf tournaments, participation to such

[7] Remember that a better performance is reflected in a lower score.

tournaments is open to almost everyone reducing the effect of other considerations players may have when choosing their "effort" level

III. THEORETICAL FRAMEWORK AND METHODOLOGY

III. 1 A Two-Contestant Model

We develop here Ehrenberg and Bognanno's[8] simple two-contestant tournament model, which is sufficient to capture the essence of the incentive problem. Assuming, for simplicity, homogeneous players the output for player i in tournament p is given by

$$(1) \qquad q_{ip} = e_{ip} + t_{ip} + \varepsilon_{ip} \qquad i=1,2 \quad p=1,2..n$$

where e_{ip} is $i's$ effort/concentration level, t_p are tournament specific factors affecting output[9] and ε_{ip} is a random component such that $\varepsilon_{ip} \sim N(0,\sigma^2)$. Logically, higher effort/concentration levels are associated with greater output. Players however, cannot always maintain maximal effort/concentration levels since they are assumed to face a cost of effort/concentration function $c(e)$ which is assumed to be convex. Hence, expected utility for player i is given by:

$$E[U] = p[W_1 - c(e)] + (1-p)[W_2 - c(e)] = pW_1 + (1-p)W_2 - c(e$$

where p is the probability of winning and W_1 *and* W_2 are the prizes for winning and losing respectively. Now, p_1 is given by

$$p_1 = prob(q_{1p} > q_{2p}) = prob(e_{1p} - e_{2p} > \varepsilon_{1p} - \varepsilon_{2p} + t_p - t_p)$$
$$= prob(e_1 - e_2 > \theta) = G(e_1 - e_2)$$

where G is the c.d.f. of θ

Players are assumed to choose their effort levels in order to maximize their expected utility. Hence,

$$\frac{\partial E[U]}{\partial e_i} = (W_1 - W_2)(\partial p / \partial e) - c'(e) = 0 \qquad i = 1,2$$

[8] Ehrenberg and Bognanno(1988)

[9] Assumed to affect all players in tournament p equally.

$\frac{\partial p_1}{\partial e_1} = g(e_1 - e_2)$ and $\frac{\partial p_2}{\partial e_2} = g(e_1 - e_2)$

In finding the Nash equilibrium of the model we consider the best response functions, which given the equations above are

$$(W_1 - W_2)g(e_1 - e_2) = c'(e_1)$$
$$(W_1 - W_2)g(e_2 - e_1) = c'(e_2)$$

but since $g(.) \sim N(.) \rightarrow g(\theta) = g(-\theta) \rightarrow c'(e_1) = c'(e_2)$ which leads to $e_1 = e_2$

The above equation can thus reduce to

$(W_1 - W_2)g(0) = c'(e)$ and thus $\frac{\partial e}{\partial (W_1 - W_2)} = (g(0)/c''(e)) > 0$

which shows that increasing the prize differential increases players' effort which from (1) leads to greater output. Hence, we arrive at

$$q_{ip} = e(W_1 - W_2) + t_p + \varepsilon_{ip}$$

The case considered here was the one of homogeneous players, an unrealistic one. However, it illustrates the important dynamics of the model as well as the main result. Variations with heterogeneous players assume different marginal return to effort between the players, different cost of effort functions between the players, or that one player has an absolute advantage over the other player. Deriving such models follows the same logic and including them adds no further intuition into our problem. However, we should note that all of them imply that player $i's$ output is of the form

$$q_{ip} = e_{ip}\left[(W_1 - W_2), A_{io}, A_{ic}\right] + t_p + \varepsilon_{ip} \qquad (2)$$

As a result, output of player i in tournament p depends on his effort level, which depends on the prize differential for winning and his relative ability, on tournament specific factors and a random component.

III. 2 A Two-Contestant Model in a Poker Framework

Poker tournaments are of an elimination nature. That is, the tournament finishes when only one player is left. Tournaments can have from a minimum of two, to thousands of players and depending on the number of the players, each tournament has more stages. A participating player must pay at the start of the tournament a fixed amount of money, the *buy-in,* to receive a number of chips in exchange. Each player buys in the same amount and therefore all players start with the same number of chips. A player is eliminated when he loses all his chips. Depending on the number of players, a tournament has one or more tables typically consisting of nine players each. As players are eliminated tables are merged to keep an equal number of players per table.

The most difficult part of applying the two-contestant model into poker tournaments is finding a suitable measure for the output of each player. Players compete for chips in order to stay in the tournament and eliminate their opponents. However, as poker tournaments are of an elimination nature there is no such thing as a players' count of total chips in the end of the tournament since by definition all players but the winner will have zero chips. As a result, a proxy for the output/score of a player was created. Since tournaments proceed in stages and a chip count occurs at the start of each stage we define a player's score as follows:

$$Score_{ip} = \sum_{s=1}^{n} \mathrm{Prob}(win_s)(\%Chips_s)$$

Where,
n=the maximum stage player I in tournament p reached

$\mathrm{Prob}(win_s)$= 1/(number of players left)$_s$

The score of player i in tournament p is given by the sum of the percentage of total tournament chips he owned at the start of each stage, s, weighted by the probability of winning at that stage[10]. The probability of winning is given by $1/(\text{number of players left})_s$ implicitly assuming that each player has an equal chance of winning. Note that it has no relation to the probability of winning as defined in the two-contestant model, but only serves as a weighting mechanism so that to account for the fact that reaching a higher stage s in the tournament should be associated with higher scores. Owing for example 0.003% of total tournament chips in stage 1 should contribute less than doing so in the next stage since reaching the next stage is an achievement by itself reflecting greater effort levels and in extent a higher score.

Another important property of poker tournaments is that they are very similar in their payout structure. This means that the prize differential, as a percentage of the total prize money, between finishing at place r and $r-1$ was almost the same for all tournaments. What varies is the *level* of the prize differential. This implies that if we focus on the tournament as a whole, ceteris paribus, a higher total prize should lead to higher effort levels and in extent higher scores. We can therefore ignore prize differentials and focus on total prize money in a tournament. The output(score) equation is given by:

$$Score_{ip} = a_0 + a_1 x_i + a_3 z_p + a_4 Prize_p + \varepsilon_{ip} \qquad (3)$$

where,

$x_i =$ vector of variables controlling for player i's ability
$z_p =$ vector of variables controlling for tournament p's specific factos(difficulty)
$Prize_p =$ Total Prize money at tournament p
$\varepsilon_{ip} =$ random component

Note that since only a small fraction of total players participating is monitored it was impossible to obtain control variables for "the rest of the field" participating in tournament p .

[10] A similar proxy but with differences between stages was initially considered however, it was found to be suboptimal since that method penalized a player for staying in the tournament and gradually losing his chips, rather than losing in say the first stage.

III. 3 Empirical Strategy

Players' ability is controlled by including an individual's World-Ranking and Age. The former reflects his performance over his career. The latter proxies his experience regardless of actual achievements. Measures such as the total number of tournaments an individual has participated in or the years he is a professional player would be preferable, however such information was not available. Difficulty of any given tournament is controlled by including the number of players ranked amongst the top 20 participating, how many days it lasts as well as the number of participating players. Note that long-lasting tournaments are typically considered more exhausting since players are forced to stay in hotels and operate under tight schedules for a longer period of time.[11] Finally, we include a dummy variable for tournaments' that were part of the World Series of Poker. Scores are expected to be on average higher on these tournaments due to their reputation as the most prestigious events. If tournament incentives operate higher prize money should be associated with higher scores and estimates of β_1 below should be positive:

$$Ln(Score_{ip}) = a + \beta_1 Tprize_p + \beta_2 Age_i + \beta_3 WRanking_i + \beta_4 Days_p + \beta_5 Players_p + \beta_6 Top20_p + WSOP + \varepsilon_{ip}$$

We consider the natural logarithm of the score, not only to normalize the data but also to make interpretations easier since score is not measured in any "meaningful" unit. Furthermore, score is measured up to the three final tables stage, the final twenty-seven players that is[12].Considering the final table would be optimal but since only nine players participate at that stage our panel would be highly unbalanced.

The second question of the paper will be addressed by considering individually the three final tables stage were players compete to get to the final table. To illustrate how

[11] Organizers can to a significant extent facilitate the rate at which players are eliminated by changing the rate at which the blinds, a fee (in chips terms) players pay at the start of each hand, increase. If blinds increase more frequently players must play more hand rather than fold else they are going to run out of chips faster .By playing though some have to win and some have to lose. Hence, the pace of elimination is higher. Hence, the number of days can be seen as a proxy for the blind structure.

[12] Typically a table consists of 9 players and a professional dealer.

performance could vary with the marginal return to effort consider the same player for two tournaments of same prize money obtaining the same score but due to random factors in the first case the player is ranked (according to relative percentage of chips he has at that stage) third where as in the second case he is ranked eleventh. In the first case the player is closer into getting to the final table (thus enjoying *at least* the prize for the ninth place) and hence the marginal return to effort is greater than in the second case. The player is thus expected to exert more effort. Thus, a positive correlation between the rank of the player, as of the start of the three final tables, and his performance at that stage is expected. To test that, we redefine a player's score so that it measures an individual's performance at that stage of the tournament.

Hence,

$$F3score_{ip} = \%Chips\_start_{ip} - \%Chips\_end_{ip} \qquad (4)$$

where,

$\%Chips\_start_{ip}$= Percentage of total tournament chips an individual has at the start of the final three tables stage

$\%Chips\_end_{ip}$ = Percentage of total tournament chips an individual has at the end of the final three tables stage

Since only nine players progress to the final table most of our scores would be negative. To account for that we added the highest, in magnitude, negative number to all data points to have a zero minimum score. Such a transformation in the data makes intuitive sense[13] and does not change relative performance, as only the constant term will be influenced. A player's score[14] at that stage is therefore assumed to depend at his rank at the start of the stage, his score up to this stage (lnscore), probably the best predictor of how he is playing in the tournament and finally on the total tournament prize (Tprize). Hence, we run

$$Ln(F3score_{ip}) = \delta + a_1 Rank_{ip} + a_2 \ln(score_{ip}) + a_3 Prize_p + u_{ip}$$

[13] To have positive rather than negative scores.

[14] Note that scores are again considered in logs to normalize the data and make interpretation easier.

Such a specification however is potentially subject to endogeneity problems since the score of a player depends from equation (2) on his ability as well as total prize money. In the same sense rank is also not exogenous. As a result coefficient estimates will be biased. We will therefore test for endogeneity and use 2SLS if the latter is indeed the case. Potential instruments will be Top20,Age, Players, Days, Mscore and World Ranking.

IV. DATA PRESENTATION AND ANALYSIS

A relevant dataset for such a study did not exist. As a result a panel dataset was constructed to meet the needs of the paper. Examining the same set of individuals over different tournaments rather than using cross –sectional data enables us to capture within as well as between variation in our data and hence make our results more robust. As a result, 50 players were monitored over 10 major poker tournaments,[15] enough to consider our results reliable if we assume that 30 observations per explanatory variable are needed[16].

The most prestigious and well-attended tournaments were chosen since such tournaments would increase our chances of creating a balanced panel. Furthermore, they attract mostly *professional* poker players thus minimizing the lack component in our regressions. Players were chosen in a semi-random fashion. Since by taking purely random samples always yielded unbalanced datasets, we restricted the number of players to the ones that have 7 or more appearances to the relevant tournaments and then drew a random sample. Data was then collected for these individuals from *pokerpages.com.* Table 1 summarizes our variables

[15] See Appendix A for details about tournaments chosen.

[16] Note that for question 2 sample was reduced to include 27 players over 7 tournaments due to unbalanced panel.

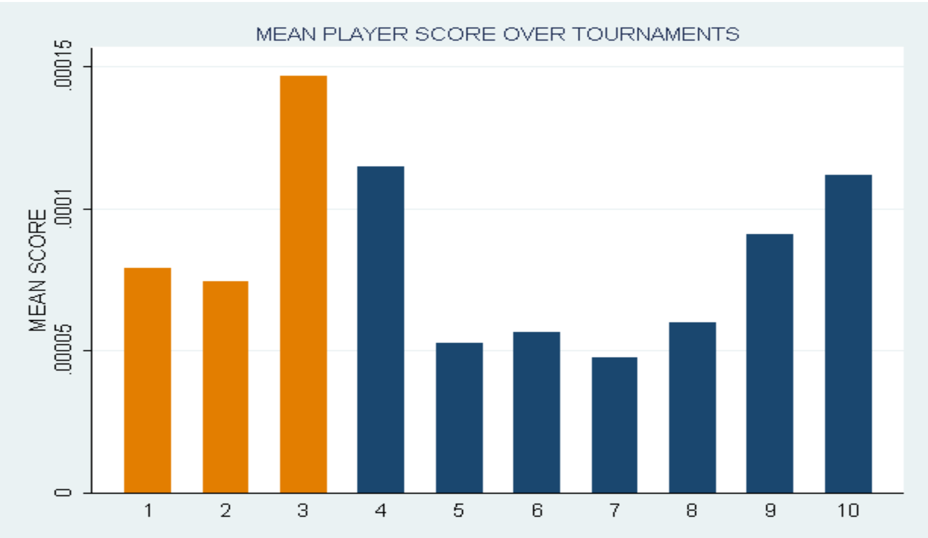
TABLE 1

*Descriptive Statistics**				
Variable[a]	*Mean*	*Standard Deviation*	*Minimum Value*	*Maximum Value*
Prize(in 100,000 of dollars)	342.96	323.34	36.55	826.76
Age	41	14	23	85
WRanking	674	943	1	4895
Days	6	1.5	5	9
Players	3625	3457	368	8773
Top20	8	3	5	13
Score	0.0000829	0.0001539	0.000000704	0.0016435
F3score	0.0443951	0.0965844	0	0.5665423

**Discrete variables are rounded to one decimal place.*
[a]See Appendix A for definitions of the variables.

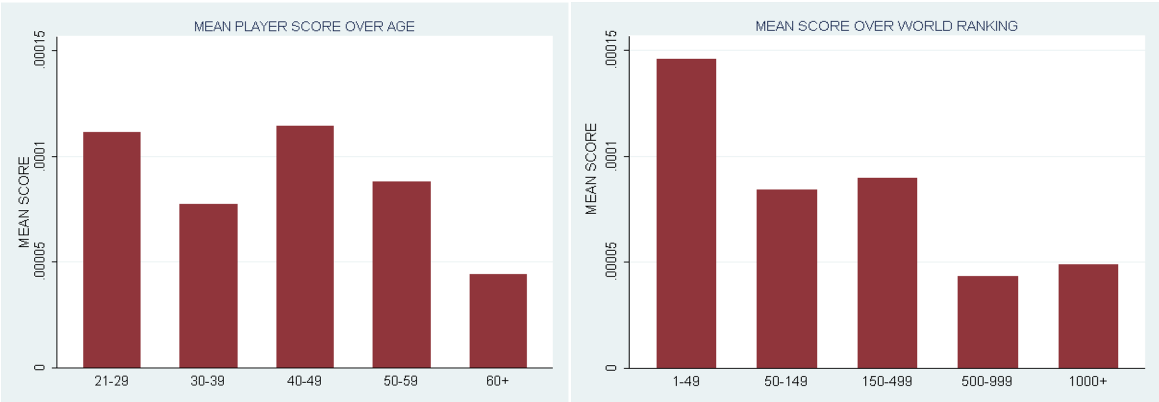
Figure 1 below shows the mean score in each tournament. Note that tournament 3 which offers the highest total prize money ($82,676,084) is associated with the highest mean score. Bars in orange represent the 3 highest paying tournaments.

Figure 1



Charts of mean score over different age and world ranking groups also show some interest. For example in the case of world ranking there is a clear negative relationship between higher rank groups and mean score. As far as different age groups are considered we cannot draw clear conclusions but data suggests that mean score for individuals over 50 seems to be declining.

Figure 2



An important feature of our data is that the tournaments chosen have a payout structure similar to the one proposed by tournament theory so that individuals are kept motivated. Table 2 below summarizes this structure:

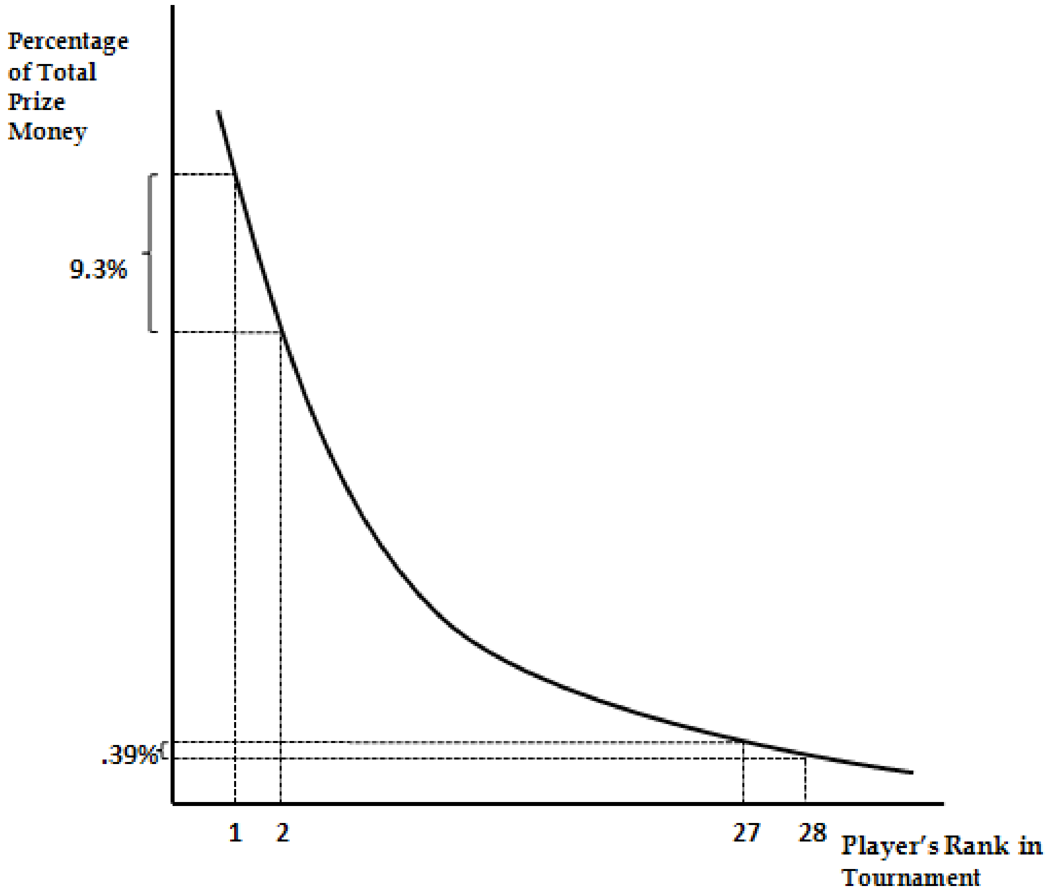
TABLE 2

Rank-Prize Relationships' Statistics			
Final Rank	*Mean Percentage of total Prize*	*Mean Level of Prize Money (in Dollars)*	*Marginal Payoff as a Percentage of total Prize**
1	21	5,171,366	9.3
2	12	2,970,603	5.2
3	7	1,950,076	1.5
4	5	1521887.1	1.01
5	4	1,241,572	2.6
9	2	562,734	1.04
27	1	189,118	0.39

*Marginal payoff for the rth place are calculated as $\frac{Prize_r - Prize_{r-1}}{TPrize_p}$

Mean payout statistics for the first five places of the tournaments as well as for ninth place, -the minimum one earns in the final table- as well as the twenty-seventh place-the minimum one earns if reached the final three tables- are given. The statistics obtained confirm the desired increasing relationship between lower rank and higher prize payout. However, one could argue that the marginal payoff (prize differential) for the fourth and third place ruin the incentive structure since both have a marginal payoff less that 2.6 the one for the fifth place. We illustrate the relationship between rank and prize money in Figure 3 below:

Figure 3



V. RESULTS

Part I - Does higher prize money in tournaments, ceteris paribus, induce higher effort levels by players?

We estimate our principal equation with and without the WSOP dummy.

Table 3 – Specification without WSOP

Variable	**OLS**	**Fixed Effects (Using Robust s.e.)**	**Random Effects (Using Robust s.e.)**
Prize	.0392417**	.0326974*	.0376983**
	(.018857)	(.0174403)	(.0172079)
WRanking	-.0007414***	Dropped	-.000741***
	(.0000894)		(.0001022)
Age	-.0023739	Dropped	-.0023645
	(.0068001)		(.007429)
Players	-.0036979**	-.0030839*	-.0035531**
	(.0017626)	(.0016352)	(.0016084)
Days	.2762766**	.2727445**	.2756599**
	(.0940575)	(.0890277)	(.0969748)
Top20	-.0348673	-.0311141	-.0340292
	(.0497266)	(.0506569)	(.0490134)
Constant Term	-11.50178	-12.03104	-11.50386
	(.5324167)	(.4223715)	(.5442219)
N	358	358	358
R-squared	.2041	0.0381	0.2041
Adjusted R-squared	.1905		
rho		.292678	.03589534

* represents significance at the 10% level, ** at the 5% level, *** at the 1% level.

Before interpreting the coefficients of the variables, and evaluate the impact they have on the scores of players, some general comments about our estimates should be made. As expected, using three different estimators to obtain results leads to disparities between the estimates as well as to the conclusions one can draw from them. Most importantly however, it leads to some common points. To start with, our results suggest that higher total prize money leads to higher scores, implying that players indeed exert higher effort levels. This is found to be significant at the 5% level except for the case of the Fixed Effects estimator. Furthermore, we observe a highly significant (to the 0.1% level) negative relationship between the world ranking of a player and his score. Surprising is the high impact that the number of players seems to have on scores. It's coefficient, as expected is found to be negative, however in the case of the FE significant only at the 10% level. Additionally, our results suggest that a positive relationship between the number of days and scores exist. This comes in contrast to our predictions since more days in theory should make a tournament more difficult and hence lead, on average, to lower scores.

Moreover, the coefficient on WSOP suggests that tournaments that were part of the World Series of Poker are associated with surprisingly lower scores. Moreover, upon inclusion of WSOP although coefficients do not change dramatically the coefficient of Players and Days are no more significantly different from zero except for the Random Effects case.

Table 4 – Specification Including WSOP

Variable	OLS	Fixed Effects (Using Robust s.e)	Random Effects (Using Robust s.e)
Prize	.0370734**	.0300437*	.0353305**
	(.0188479)	(.0171243)	(.0172422)
WRanking	-.0007451***	Dropped	-.0007449***
	(.0000892)		(.000103)
Age	-.0020474	Dropped	-.0020203
	(.0067841)		(.0074604)
Players	-.0033014*	-.0026148	-.0031312*
	(.001773)	(.0015885)	(.0016224)
Days	.2749756	.2713041**	.2742923**
	(.0938028)	(.0884382)	(.097056)
Top20	-.0419363	-.0386585	-.0411808
	(.0497618)	(.0514266)	(.0491688)
WSOP	-1.283086*	-1.464968*	-1.328195**
	(.7493183)	(.7470191)	(.6782366)
Constant Term	-11.502***	-12.04215***	-11.505***
	(.5309574)	(.4215167)	(.5455939)
N	358	358	358
R-squared	.2107	0.0432	0.2107
Adjusted R-squared	.1949		
rho		.29717092	.03839993

* represents significance at the 10% level, ** at the 5% level, *** at the 1% level.

Although we cannot conclude which estimation method or specification is superior some arguments can be made in favour of the Random Effects method. According to Verbeek[17] using Fixed Effects makes intuitive sense when individuals are "one of a kind" and cannot be viewed as a random drawing from a population. As this usually applies to entities such as countries or industries it is not very suitable in our case. Furthermore, the low value of the rho statistic[18], reported for the Random Effects model in both table

[17] Verbeek, (2000)
[18] Reflects the proportion of total variance contributed by the panel aspect of the data.

3 and 4, indicates that our control variables have done a good job in driving out heterogeneity and using Fixed Effects to eliminate individual effects altogether at the expense of the World Ranking and Age variables is not needed. Also since, rho>0 our Random Effects estimator is more efficient than the Fixed Effects one.[19] Hence, the Random Effects, including WSOP, specification will be used to interpret the results.

The coefficient on our main explanatory variable Prize, implies that a hundred thousand dollar increase in total prize leads, on average, to 3.53% increase in scores. A very strong relationship between total prize money and scores is implied since 100,000 dollars only accounts for ≈0.3% of mean total prize money. Ehrenberg and Bognano's results suggest a much weaker impact of total prize money on player scores. Moreover the coefficient on World Ranking suggests that if player i is placed 100 places above player j he is expected to score 7.45% less .Turning attention to our "surprising results" now, we see that increasing a tournaments number of players by 100 leads, on an average decrease of 31.3% in scores whilst an extra day in a tournament leads to an average increase of 27.5% in scores. Finally, a WSOP tournament is associated with a 132.8% decrease in scores relative to a non WSOP event. Concluding we should note that Top20 and Age were found to be insignificant but kept in the regression as their sign indicates that they capture some part of variation.[20]

Although our results seem supportive of tournament incentives one should be skeptical about their robustness. More specifically, the implied effect of an increase in total prize money is significantly higher than the ones found in previous studies. As a result, the fact that an absolute measure of output was not readily available and a proxy had to be used might biases our results. Other measures such as the ratio of number of hands won to number of hand played could serve as a better proxy for a player's performance. However such data was not available. Furthermore, using the probability of winning as our weighting mechanism for stage relative importance although the most intuitive one, it might undermine players' effort at lower stages. Furthermore, the fact that the WSOP dummy has a negative and highly economically significant effect can be attributed to the

[19] See Verbeek(200), page 350.
[20] The joint significance test of variables points to that direction as well.

fact that the real incentive structure players face is more complicated[21]. Sponsorships could serve as an example. However, it might also be capturing the effect of an omitted variable. Additionally, a sample selection bias is highly probable since we only draw a random sample from players with 7 or more appearances. Another possible source of bias stems from our failure to control for opponents' ability. Finally, one can attribute the insignificance of Days and Top20 to the fact that there is not much variation in these variables to be explained.

Part II-In the final 3 tables of the tournament, ceteris paribus, does a player's performance vary with the marginal return to effort?

The expected negative coefficient on rank of player i in tournament p as of the start of the three final tables stage is not empirically justified. Moreover, all variables except for prize are found to be insignificant regardless of the estimator used. Tests for endogeneity in our regressors[22] were thereefore conducted for the case of all estimators but we could not find statistical evidence of endogeneity.[23] As a result we concluded that endogeneity was not the source of the problem.[24]Table 5 below summarizes our results:

[21] Note that one would expect players to try more during the World Series of Poker the most advertised and prestigious series of events.
[22] See Appendix C for tests of endogeneity
[23] Note that for the cases of the Fixed Effects and Random Effects we use a generalised Hausman that tests for significant differences between the estimates obtained by the IV regression and the standard regression. Hence, instruments that are not good might lead the test to point us to the wrong direction since intuitively one would expect endogeneity.
[24] One can see Appendix C for the estimates obtained using 2SLS.

Table 5

Variable	Pooled OLS	Fixed Effects (Using robust s.e)	Random Effects (Using robust s.e)
Rank	-.0555157	-.0351202	-.0440046
	(.0495297)	(.0576049)	(.0443776)
Prize	.0019245*	.0013586*	.0015826***
	(.00069)	(.0004792)	(.0004288)
Ln(score)	.1746755	.258566	.2205235
	(.2047353)	(.2266738)	(.1754308)
Constant Term	-2.968554	-2.065039	-2.514837
	(1.795553)	(1.816465)	(1.453116)
N	107	107	107
R-squared	0.2668	0.2628	0.2654
Adjusted R-squared	0.2454		
rho		.41238365	.31219497

* represents significance at the 10% level, ** at the 5% level, *** at the 1% level.

Again one should be skeptical before rejecting the case that the marginal return to effort does not significantly affect a player's performance. First, it might be that our simplistic specification fails to accurately model the situation. For example rank only serves as a proxy for the marginal return to effort. A more complete measure would also include how close other players around an individual are. More sophisticated techniques would require capturing the fact that increased effort levels only affect score, which only in extent influences rank since how close(in terms of percentage of chips) the other players are is also important. To capture that, Ehrenberg and Bognanno include such variables as the estimated average increase in prize money the individual would receive if he improved his rank by improving his score by one stroke relative to the field. Such measures were too complicated to be considered in this paper so to extend our analysis.

VI. CONCLUSIONS AND EXTENTIONS

This paper tests the main predictions of tournament theory in a poker tournament framework. The general two contestant model is applied to this setting and panel data is used to carry out the empirical investigation. The paper confirms that a higher total prize money leads to increased effort levels. More specifically, a 100,000 dollar increase in total prize money is found to lead to a 3.53% increase in scores. However, evidence in support of a positive relationship between marginal return to effort and performance is not found.

Criticism on the strength of these results revolves around two main axes. First, due to the eliminative nature of poker tournaments, an absolute measure of output did not exist making our results highly dependent on the proxy used. Also one could not employ analysis on players' performance when competing for the highest ranks(final table) where according to theory marginal payoffs would differ more significantly. Secondly due to selectivity bias, as well as the lack of controlling for other players' ability, our results are possibly overestimating the effects of total prize on scores. Possible extensions would involve using data from online poker tournaments where one could possibly obtain better proxies for output such as the ratio of hands won over hands played. Finally, one could also incorporate different risk strategies that players possibly follow by monitoring for example the times a player went all-in[25] or betted over a specific benchmark amount.

[25] To bet all your chips as a threatening device.

APPENDIX A

Table 1- Description of Variables

Variable	Description	Source
$Score_{ip}$	Proxy used for output of player i at tournament p until the final 3 tables stage.	www.pokerpages.com
$F3score_{ip}$	Proxy for the score of player i at tournament p at the final 3 table stage.	www.pokerpages.com
$Prize_p$	The total prize money distributed to players finishing in the "winning" places.(measured in 100,000 dollars)	www.pokerpages.com
$WRanking_i$	The world ranking of a player based on his achievements in major poker tournaments.	www.worldpokerrank.com
Age_i	The age of a player.	www.pokerpages.com
$Days_p$	The number of days tournament p lasted.	www.pokerpages.com
$Players_p$	The number of players that participated in tournament p	www.pokerpages.com
$Top20_p$	The number of players ranked amongst the top 20, that participate in tournament p .	www.worldpokerrank.com
$WSOP_p$	A dummy variable obtaining the value of 1 if a tournament is a World Series of Poker event 0 otherwise.	www.pokerpages.com
$Mscore_i$	Player $i's$ mean score over the 10 tournaments.	

Table 2- Tournaments Included in the Sample and Their Total Prize Money

Tournament	*Total Prize Money (In dollars)*
1. World Series of Poker 2009(Event 57)	61,043,600
2. World Series of Poker 2008(Event 54)	64,379,439
3. World Series of Poker 2006(Event 39)	82,676,084
4. World Series of Poker 2005(Event 42)	52,819,610
5. World Series of Poker 2007(Event 55)	59,784,954
6. Legends of Poker(Event 25)	3,655,400
7. Borgata Poker Open(Event 13)	5,000,000
8. North American Poker Championship	4,374,475
9. Festa al Lago(No Limit Hold'em Championship)	5,354,410
10. Foxwood World Poker Finals(No Limit Hold'em Championship)	3,876,507

APPENDIX B[26]

Pooled- OLS Specification Tests

Ramsey RESET Test:

Specification	(1)		(2)
F-statistic:	1.73	F-statistic:	0.87
Probability:	0.1602	Probability:	0.4558
Conclusion: No omitted variables		**Conclusion**: No omitted variables	

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Specification	(1)		(2)
F-statistic:	0	F-statistic:	0.18
Probability:	0.9449	Probability:	0.6710
Conclusion: No Heteroscedasticity		**Conclusion**: **No Heteroscedasticity**	

[26] (1) Represents the specification without the WSOP whereas (2) the one with.
Also * represents significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table 4 –Fixed Effect Estimates With and Without WSOP

(Using normal standard errors)

Variable	**(1)**	**(2)**
Prize	.0326974*	.0300437
	(.018442)	(.0184029)
WRanking	Dropped	Dropped
Age	Dropped	Dropped
Players	-.0030839*	-.0026148
	(.0017238)	(.0017317)
Days	.2727445**	.2713041**
	(.0919021)	(.0914709)
Top20	-.0311141	-.0386585
	(.0485719)	(.0484899)
WSOP		-1.464968**
		(.7336745)
Constant Term	-12.03104**	-12.02157**
	(.4511798)	(.449074)
N	358	358
R-squared	0.0381	0.0432
Adjusted R-squared		
rho	.292678	.29717092

Tests for Heteroscedasticity* in the Fixed Effects estimation.

Modified Wald test for Groupwise Heteroskedasticity

Specification	(1)		(2)
F-statistic:	188.54	F-statistic:	219.53
Probability:	0	Probability:	0
Conclusion: Heteroscedasticity		**Conclusion**: Heteroscedasticity	

*On the specification using normal standard errors.

Tests for correlation in the Fixed Effects estimation, using robust standard errors.

Wooldridge test for autocorrelation in panel data

Specification	(1)		(2)
F-statistic:	0.115	F-statistic:	0.035
Probability:	0.7365	Probability:	0.8521
Conclusion: No Serial Correlation		**Conclusion**: No Serial Correlation	

Pesaran's test of cross sectional independence

Specification	(1)		(2)
Statistic:	1.691	Statistic:	1.043
Probability:	0.0908	Probability:	0.2971
Conclusion: No Cross Sectional Correlation		**Conclusion**: No Cross Sectional Correlation	

Tests for correlation in the Random Effects estimation, using robust standard errors.

Wooldridge test for autocorrelation in panel data

Specification	(1)		(2)
F-statistic:	0.115	F-statistic:	0.035
Probability:	0.7365	Probability:	0.8521
Conclusion: No Serial Correlation		**Conclusion**: No Serial Correlation	

Pesaran's test of cross sectional independence

Specification	(1)		(2)
Statistic:	1.660	Statistic:	0.988
Probability:	0.0969	Probability:	0.3231
Conclusion:		**Conclusion**:	
No Cross Sectional Correlation		No Cross Sectional Correlation	

Test for the appropriateness of the Random Effects Model.

Breusch and Pagan Lagrangian multiplier test for random effects

Specification	(1)		(2)
Statistic:	3.49	Statistic:	4.04
Probability:	0.0617	Probability:	0.0445
Conclusion:		**Conclusion**:	
Random Effects not appropriate		Random Effects appropriate	

APPENDIX C[27]

Pooled-OLS Specification Tests:

Ramsey RESET Test:	**Breusch-Pagan / Cook-Weisberg test for heteroskedasticity**
F-Statistic: 1.30	F-Statistic: 0.02
Probability:0.2791	Probability: 0.8961
Conclusion: No omitted Variables	Conclusion: No Heteroscedasticity

Tabel 423- IV 2SLS ESTIMATES FOR POOLED- OLS, FIXED- EFFECTS and RANDOM EFFECTS.

	Pooled- OLS	**Fixed-Effects**	**Random- Effects**
Rank	-.0638682	-.0857737	-.0694094
	(.0812639)	(.0870758)	(.0741639)
Prize	.0022512	.0023311	.0022715*
	(.0009328)	(.0009448)	(.0008307)
Ln(score)	.2570777	-.2974197	.0023046
	(.3606412)	(.7284976)	(.426723)
Constant	-2.056797	-7.52913	-4.689604
Term	(3.395584)	(7.533804)	(4.248498)
N	90	90	90
R-squared	0.2564	0.1191	0.2582
rho		.39432181	.32028904

Instrumented: Rank, Ln(score)
Instruments: Prize, Mscore ,Top20, Age, Days, Players Worldranking

27 * represents significance at the 10% level, ** at the 5% level, *** at the 1% level.

TESTS FOR ENDOGENEITY

Pooled- OLS

Durbin		**Wu-Hausman**	
Chi Squared Statistic:	.282223	F-Statistic:	.132118
Probability:	.8684	Probability:	.8764
Conclusion:		**Conclusion:**	
No Endogeneity		No Endogeneity	

Hausman Test for Endogeneity

	Fixed- Effects	Random Effects
Chi Squared Statistic:	1.91	1.82
Probability:	0.5907	0.6105
Conclusion:	No Endogeneity	No Endogeneity

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