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Selection of risk and effort levels among low-stakes players : a case study in online poker

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Abstract:

Firms pay workers using a variety of different pay structures. The structure that governs executive pay in many instances is a tournament pay structure. This paper examines the applicability of a tournament pay structure to lower wage workers by examining the effort and risk responses of players to tournament incentives and the role these responses play in determining the tournament's outcome. Players from 19 different tournaments are observed on a hand by hand basis. It is found that players adjust effort and risk taking levels but only in response to certain incentives. This study finds evidence that tournaments are a viable pay structure for low wage workers under certain conditions.

Introduction

The recent financial crisis has led to debate regarding executive compensation. Executives are paid based on a tournament pay structure. The top-level executives get far more money than those who work for them. Although this is a common pay structure for executives, it is only one of many possible structures. Many workers get paid a salary reflective of their perceived value to the firm. Other workers are paid a piece-rate wage equal to the marginal revenue product of their labor. The piece-rate wage is a common form of pay structure for lower earning workers, while tournament pay structures are used mostly for higher earning workers.

This study examines the applicability of a tournament pay structure to lower wage workers by examining how low stakes poker players respond to effort and risk taking incentives and use effort and risk to affect the tournament outcome. While tournament pay has been shown to increase the productivity of skilled workers, no previous studies have examined the effect of similar structures on the behavior of semi-skilled workers. If lower stakes players are sensitive to tournament incentives, an extension of tournament pay structures to semi-skilled workers could be an efficient alternative. To best determine players' sensitivity to incentives, effort and risk taking will be considered as endogenous decisions made by each player in an attempt to maximize his net payout.

Literature Review

Tournament or contest pay structures arguably provide incentives for workers to increase their effort and productivity, consistent with efficiency wage theory. The study of the tournament payment structure reveals that a top-heavy, or accelerated payout structure, leads to the efficient resource allocation under many conditions. For example, tournaments are found to be superior to a piece rate payment structure when it is easier to measure relative output than it is the marginal product of labor. Tournament pay structures lead to increased participant effort by incentivizing players to try and earn the disproportionately high payout for first place relative to all other ranks. The impetus for this enhanced effort has been theorized as the incentive effect. A second effect, the selection effect asserts that the institutional structure of a tournament as well as its payout structure governs who will opt to play and who will select out. The incentive effect motivates individuals who have opted into the tournament to strive hard to earn the disproportionately large rewards at the top. It will be the concern of this paper (Lazear and Rosen 1981).

Lazear and Rosen (1981) find that under ideal circumstances (homogeneous players, risk-neutral firms, and purely effort driven production) tournament contests will produce the same resource allocations as piece rate pay schemes. Thus, either has the potential to increase efficiency. However, tournaments are preferable if it is difficult to measure a worker's absolute output but trivial to ordinally measure a worker's output relative to his peers. Lazear and Rosen find that with risk-averse workers tournaments and piece rate pay schemes lead to different resource allocations. If a worker's production is uncertain, there is inherent risk in accepting compensation based on the marginal product of his labor. Yet, accepting payment based on the relative production rank eliminates the danger of systematic randomness. Telemarketing is an example of this given the variable quality of inputs, potential customers' numbers. In this uncertain production scenario, workers prefer the tournament pay structure because it reduces risk. Alternatively, if productivity is certain, risk-averse workers prefer a wage based on marginal revenue product of labor over the less certain tournament payout structure. In the case of workers of heterogeneous abilities, there is no feasible efficient allocation of resources because there exists an inefficient pooling of low and high ability workers (Lazear and Rosen 1981).

Predicated upon these findings, several works have examined the extent of the incentive effect of tournaments including Rosen (1986) and Ehrenberg and Bognanno (1990). Rosen (1986) finds that elimination tournaments, in which there are sequential rounds of competition and the loser is eliminated in each round, necessitate a large grand prize to sustain motivation. Effort is costly, and thus players exert the level of effort that maximizes the expected value of payoffs net effort costs. Regardless of risk-neutrality or aversion, homogeneity or heterogeneity, and number of rounds, there must be a disproportionately large first prize to sustain effort in later rounds. Rosen demonstrates this is a result of two motivating factors that incentivize a player's effort: the payoff of winning in the given round and the potential payoffs of advancing to the next round. As the tournament progresses, if there is no tournament style first prize, the payoff incentive diminishes and effort slackens.

Ehrenberg and Bognanno (1990) use the PGA tour, controlling for the accelerated prize structure examined by Rosen, and investigate the incentive effect of larger prize pools. Controlling for factors such as course difficulty and weather conditions, they find that for players whose membership on the tour is guaranteed, performance improves significantly with the size of the prize pool. More recent study of this prize pool effect reported by Simmons and Frick (2007) bring into question the reported magnitude of performance improvement and suggest that there is no incentive effect to larger prize pools.

The incentive effect research also set the framework for the examination of the role of risk in tournaments. Hvide (2002) tests Rosen's (1986) theory that when both risk and effort can be manipulated by the player, the equilibrium would be one of low effort and high risk. Hvide

(2002) studies why the theorized relative performance evaluation hypothesis is not born out in real-world payout structures. He argues that risk taking will predominate and this can have negative consequences to the firm as effort is dropped and variance of production increases. To counter these outcomes, he suggests an alternate pay scheme which sets a reasonable benchmark and those that fall closest to it are rewarded in tournament fashion. Furthermore, Hvide (2002) contends that this benchmark explains the discrepancy between the theory that those who excel ought to get rewarded the most and the empirical reality that mediocrity is often disproportionately rewarded beyond excellence.

Grund and Gurtler (2005) examine the effect risk taking has on outcomes in professional soccer in Germany. They find that when risk is taken by a team, the team earns fewer points and the variance of points earned is higher. In the case of soccer, when a team assumes more risk by adopting an attacking formation, it loses more frequently than otherwise expected and more total goals are scored.

Poker is used to test the theoretical and empirical findings of tournament theory. In order to use the game of poker as a basis for empirical analysis, it must be shown to be a game of skill and not chance. Dreef et. al (2003) study the relative skill level in poker and find that a simplified form of poker does involve more skill relative to other casino games and enough to be considered a game of skill. Dreef et. al used a simple limit two-player game as opposed to the more common many player no limit game. It is reasonable to extend their findings and suggest that due to the greater number of competitors and increased cost of mistakes, many player no limit tournaments are likely to contain greater skill than Dreef et. al find in the simplified version.

Davidson (2007) examines the decision-making of top professionals in prestigious tournaments on the World Poker Tour. Using World Poker Tour data allows Davidson to see the cards each player holds, hole cards. He finds that despite the aforementioned designation of poker as a game of skill, top professionals base their decision making on noise and that Monte Carlo simulations outperform professionals in maximizing chip stack. A distinction is made between the static question of maximizing chip stack and the dynamic question of maximizing payout. Davidson finds elite players to be more risk averse than the Monte Carlo simulations predict. The observed behavior of elite players may be due to the fact that tournament poker is not a game of static optimization but dynamic optimization. Each player must maintain his stack throughout the tournament to avoid elimination. Davidson concludes that top professionals include "noise" in their decision-making process and would likely be better served by using the Monte Carlo odds.

In an attempt to isolate the strategic employment of risk taking, Lee (2004) examines high stakes poker tournaments on the World Poker Tour. He contends that after risk selection, effort is a trivial issue. The amount of risk a player assumes is hypothesized to be impacted by the spread between payouts, relative positioning, and stability of relative positioning. The change in chip stack over time is used to proxy risk taking. Lee finds that the predictions of tournament theory hold in tournament poker. If there are large potential monetary gains, i.e. a player is close to the player ahead, more risk will be taken. Similarly, if there are small expected losses, i.e. a player is well ahead of the player occupying the rank below, more risk will be assumed.

The poker literature provides several key insights for this paper. Poker is a game of skill is an assumption of this work. Were it not, then players could not exert control over their outcome and the theory would disintegrate. However, luck will still play a large role in determining who wins. Davidson's findings also suggest that even the best players are not going to respond perfectly to incentives due to some degree of risk aversion. Finally, Lee offers a theoretical framework from which to begin. However, this paper differs in considering both risk and effort as simultaneous decisions.

Data:

Data was collected from 19 online poker tournaments run on PokerStars.com[1]. The tournament buy-in, amount paid by each player to enter, is $22. Double up tournaments consist of ten players and the tournament begins as soon as ten players register. The ten entrants play until only five players remain. Each of these five players is then awarded forty dollars. A disadvantage of using this data source is that a player's hand is not observable and therefore the quality of a player's cards can not be used to control for effort, risk, and winning. This is the first study of its kind to collect data for each hand within a tournament and over multiple tournaments. This provides a much richer data set for estimation. Additionally, these tournaments involve much lower-stakes players than previously studied tournaments in the field.

Each player begins the tournament with $1500 in chips. These chips may not be translated into currency and are collected from players at the end of the tournament in exchange for their winnings. At the beginning of each hand, two players are forced to make opening bets before they see their cards, and one player is designated as the dealer. The dealer does not actually deal any cards as this is a computerized process. The dealer designation is used to facilitate the betting process. These positions rotate in a clockwise manner around the table each

[1] For full definitions of poker terms see Appendix A. Appendix B provides a screenshot of one hand in the double up tournament.

hand. For example, in the first hand the player in position one will be designated the dealer, the player to his left will be forced to post a small blind, and the next player to his left will be forced to post a big blind. The small and big blinds are wagers that a player is forced to make before the cards are dealt, with the big blind amounting to twice the size of the small blind. In the second hand, the player who posted the small blind becomes the dealer, the player who posted the big blind becomes the small blind, and the player to the left of the big blind in the first hand posts the big blind.

The size of both the small and the big blind change over the course of the tournament in order to facilitate the progress of the tournament and shorten its duration. These changes occur at predetermined intervals, every 10 minutes, and according to a specific incremental dollar structure. The blinds and the timing structure are known to all players ex ante. Additionally, after the second increase in blind levels an ante is introduced so that each player is forced to bet before their hand is dealt and the blinds are assessed in addition to the antes in the amounts indicated[2].

Each player's chip stack, the number of players remaining, the player's rank, and the chip spread between players of adjacent ranks are also observable values. Whether values for each variable are collected at the beginning or end of the hand has an impact on the relevant frame of reference for the player. Each player has a predicted behavior based upon their initial position. The impact of those behaviors is measured at the end of each hand. Variable values are recorded at the beginning of each hand and used to construct the rank variable binaries and standardized chip counts. The big blind value is used to standardize chip counts because it serves as a minimum betting increment. In each round of betting a player must bet at least the amount of the big blind or not bet at all. Therefore, as the big blind increases over time, the interpretation of

[2] See Appendix C for blind structure details

the bet size is biased upward and so too is the change in player's chip stacks. For complete variable definitions, calculations, and descriptive statistics refer to Table 1.

(Insert Table 1)

In addition to the observed variables mentioned above, an additional collection of variables are defined in order to control for different situations a player experiences throughout the tournament. These variables include a set of dummy variables identifying each of the 19 tournaments, a player identification number which is held constant across all hands, and the number of players remaining. Additional variables are constructed to capture the chip spread between adjacent ranks.

Identifying incentives inherent in the tournament structure are important for predicting effort and risk. The first effort instrument (Leading_Group_Binary) measures whether or not a person has enough chips that they are highly likely to finish in the winning cohort. If a person is securely in the money, they have an incentive to solidify their position and assume less risk until this position is guaranteed. The leading group binary equals one when a player is ranked in the top three, giving a two rank cushion, and no players outside of the top three have more chips than they started the tournament with (implying a non-positive trend in the accumulation of chips). In order to meet these conditions a player must break away from the pack. Players who are in a break-away group are highly likely to finish in the winning cohort. Therefore, the returns to effort are low for players who have broken away from the pack.

The clustered chip stack binary variable is designed to account for the impact on effort of how closely clustered players are. If the value of a player's chip stack is very close to that of several of his competitors', then small gains can result in huge positional changes and the returns to effort are high. The clustered chip stack variable takes a value of one when players a given player is within +/- three bets of three or more competitors. A player who is three bets behind an opponent may make up this difference by winning a pot containing only the blinds, while his opponent forfeits the blinds. This is a trivial difference to overcome. Under these conditions, rank returns to effort are high and a player could place himself in a strong position relative to many opponents with moderate gains.

The big chip stack binary variable captures a player who has a chip stack that is large enough to make him a contender. Such a player has the ability to both bet a hand without getting so short on chips that they are forced to commit all their chips to the hand and stave off elimination in the short term. The big chip stack binary variable has a value of one when a given player has more than sixteen times the big blind in chips. (This threshold is selected because given the average blinds and the average chip stack, this position is average and in one hand a given player can go from average to well above average making the player highly likely to finish in the winning cohort.) In cases where the binary has a value of zero, a player must be careful because any hand in which they lose chips will cost them a large percentage of their chip stack and make becoming a factor in the tournament a much more difficult task.

Model:

Theoretical Model:

Winners in a double up tournament are determined by end of the tournament chip stack, with each of the top five players receiving an equal payout. Thus, players strive to be above the threshold which places them in the winning cohort. As such, the degree to which a player enhances their likelihood of winning can be measured absolutely or relatively. The greater the positive change in chip stack a player experiences over a given hand the greater his likelihood of winning because he is gaining a greater share of the fixed amount of chips. Alternatively, one might define the progress towards a winning position by measuring a player's relative proximity to the current threshold number of chips to be among the winning cohort.

The likelihood of winning is impacted by chip stack, whether a player is in the blinds, effort, and risk taken. The greater the number of chips a player has at the beginning of a hand, the less likely he is to be eliminated during the hand and the more likely he is to finish the hand in a strong chip position relative to the threshold. A player who is forced to post either the small or big blind will be less likely to win as they will have chips committed to a hand regardless of the strength of their hand. It is likely for a player in the blinds to be faced with a raise in the first round of betting while holding poor cards. This player will likely fold his hand, and lose the chips he is forced to invest. The effort that a player exerts during a hand is likely to have a positive impact on winning. Effort enhances the player's ability to perceive more information leaked by opponents, or tells, realize which pots are easier to win, and better know the optimal sized bet. The more risk a player takes, the more chips he will either win or lose in a given hand. However, since increasing risk is defined with an expected value of 0 it will not have a significant impact on a player's chances of winning[3]. Whether the risk is realized as a gain or a loss will strongly impact a players likelihood of winning not risk. Thus, an estimate of the impact on winning is:

$$\text{Winning} = f\{\underset{(-)}{\text{Small\_Blind}},\ \underset{(-)}{\text{Big\_Blind}},\ \underset{(+)}{\text{Std\_CS}},\ \underset{(?)}{\text{Risk}},\ \underset{(+)}{\text{Effort}}\}$$

How much effort to exert is an endogenous decision. A player may choose to exert more or less effort at any juncture based upon how close they are to other players or their relative rank.

[3] Davidson (2007) shows that risk can affect winning. A player who bets everything and loses will necessarily lose, but should they win (equal risk) they will not necessarily win. However, this effect is estimated to be insignificant.

Likewise, at any betting juncture a player may choose to minimize risk, folding, or increase risk, betting large depending upon how much ground they need to make up and the number of chips they have. Therefore, both risk and effort selection must be modeled as endogenous factors.

A player will exert greater effort when either the returns to effort are higher; holding the cost effort constant. The closer a player is to the adjacent higher ranked player in terms of chip stack, the greater the potential payout to effort since that player has a greater chance of improving their relative rank and strengthening their relative positioning. The returns to effort are also larger when gaining a rank changes the position of a player in comparison to the winning cohort. For example, one would expect effort to be greater for players of ranks four, five, and six as they try to break into or stay in the winning cohort.

In addition to the relative rank of a player, effort is also influenced by the absolute position as measured by chip stack. There is a diminishing marginal utility to earning chips. A player needs his first few chips to remain alive in the tournament. Additional chips then add to the size of his stack with large percentage changes in the size of his stack due to the first few chips and smaller percentage changes as he accumulates more and more chips. Therefore, the returns to effort will decrease with size of a player's chip stack. A player who holds a large chip stack relative to the winning threshold is in a strong position and will need to exert less effort to remain in the winning cohort. Thus, a player in the leading group will exert less effort. Conversely, a player whose chip stack is very close in size to multiple players will be able to greatly improve his relative rank with small increases in his chip stack. Therefore, if a player's chip stack is very near that of a cluster of players, he will exert more effort. As time progresses the blinds increase, fewer bets are available to the table (as total chips are fixed), larger bets occur and thus a player's tournament life is more precarious. Additionally, surviving later hands in a tournament increases the probability of receiving a payout. Thus, effort may be modeled:

$$\text{Effort} = f\{\underset{(+)}{\text{Time}}, \underset{(?)}{\text{Rank}}, \underset{(-)}{\text{Leading\_Group}}, \underset{(+)}{\text{Clustered\_CS}}, \underset{(-)}{\text{Big\_CS}}, \underset{(-)}{\text{Std\_CS}}, \underset{(-)}{\text{Std\_Spd}}, \underset{(-)}{\text{Play\_Rem}}\}$$

As is characteristic of risk/reward tradeoffs, the more risk a player assumes, the greater the variance of the player's outcomes. It is important to distinguish between the baseline level of risk inherent in the tournament and the marginal risk assumed by players. For simplicity, risk refers to the marginal risk assumed by players beyond the risk inherent in the tournament. Examples of marginal risk taking include bluffing and calling bets while holding weak hands.

Risk taking will decrease when either the returns to risk are lower or the costs of risk are higher. A player who is several ranks behind the winning cohort will be unlikely to finish in the winning cohort without assuming marginal risk. Therefore, for players of lower ranks, the returns to risk are high. The further a player is behind the player of adjacently lower rank, the more risk he will need to take to have a chance to catch up. A player forced to post either blind will have higher risk because of not only the forced bet, but because the bet changes the relative price of playing. Players will want to assume more risk as they exert more effort. Effort increases a player's chances of winning or knowing when he is beat. Therefore, a player will want to increase the variance of his outcomes knowing he will be more likely to win the hand, or know when to fold and minimize losses.

The level of risk taking will also respond to changes in the cost of risk. If in the first round of betting a player raises the bet to twice the size of the big blind, the player in the big blind must only commit half as many chips as others, and the small blind only 75% as many.

Therefore, a player does not need as strong of cards to justify playing out of the blinds because it is relatively cheaper to play while the potential returns are just as large. As blinds increase, given the fixed nature of total chips in the tournament, the number of bets available declines. This causes eliminations to occur more rapidly and shrinks the time until the winning cohort is named. The consequences of losing a great number of chips in the latter stages of the tournament will likely be severe. Therefore, risk is expected to decrease with the number of hands played; all else equal. As players are eliminated, one's chances of finishing in the winning cohort increase. Risk is more costly given a greater chance of winning. A big win still increases one's probability of winning but a big loss severely reduces ones probability of finishing in the winning cohort. A player who has barely more chips than the adjacent lower ranked player faces a high cost of risk. If he is to lose chips he will fall in rank whereas, all else equal, he is less likely to move up a rank with similar gains. Thus risk levels are expected to be lower when the (-) Spread is small. As the (+) Spread increases, the returns to risk are higher, as a player will need to assume risk to catch the adjacently higher ranked player.

The level of risk taken also depends upon the risk tolerance of individual players in a given tournament. Therefore, the player must be controlled for in evaluating risk selection. Each tournament consists of a different group of players with only eight players appearing in more than one tournament. Therefore, the player binary will be used to control for fixed effects within each tournament. Thus, risk may be modeled:

Risk = f{Rank, Std_CS, Std_Spd, Small_Blind, Big_Blind, Tourn, Player, Hand,
(+) (-) (+) (+) (+) (?) (?) (-)
BB_Level, Play_Rem, Effort}
(-) (-) (+)

Empirical Model:

A player bases how much risk to take in part upon the endogenous selection of risk as previously discussed. The likelihood of winning is endogenously affected by both risk and effort. Therefore, in order to estimate effort, risk, and winning, a three-stage least squares model is needed. The leading group binary, the clustered chip stack binary, and the big chip stack binary instrument for effort. These variables capture specific incentive structures present for a given player in a given hand. The big blind level variables, number of hands played, and player serve as instruments for risk. These variables describe risk incentives in any given hand.

Results:

Winning:

The White corrected results for the winning regression are presented in Table 2. The results are consistent with expectations. Whether or not a player is forced to post a blind has no significant impact on a player's chances of winning. The number of bets a player has in his chip stack significantly and positively impacts his ability to win. Players who try harder place themselves in a better position relative to the winning cohort than players who exert less effort. The results also indicate that the more risk a player assumes, the better position he places himself in relative to the winning cohort. Davidson (2007) found that top professionals were risk averse in tournaments and did not maximize the expected size of their chip stack. They left expected value on the table[4]. If this result extends to lower stakes players, then it stands to reason that players who assume more risk than their more conservative opponents are able to pick up the expected value left on the table by their opponents. If players gain extra expected value for

[4] This clearly holds in the case of static maximization. However, as Davidson notes, tournaments are a dynamic game and it is unclear if this conservative play relative to static maximization is an optimal strategy in the dynamic case. By extension, the same caveat will apply in the low stakes game.

taking more risk, then risk will significantly increase one's chances of winning. Consistent with theory, the size of a player's chip stack, the effort exerted, and risk taken were found to be the most significant predictors of winning.

(Insert Table 2)

Effort:

The robust results for the effort regression are presented in Table 3. The results are generally consistent with expectations, with a few exceptions. Players who hold the top position in the rankings exert significantly less effort as may be expected given the lower marginal gains to effort. Players with larger chip stacks also exhibit less effort. This is consistent with expectations as there is a diminishing marginal utility to chips. At the margin it is less critical for a player who has more chips to gain chips than a player who has fewer chips and is thus in greater danger of being eliminated and not making the winning cohort. Similarly, players who are in a leading group that has broken away from the pack exert significantly less effort than those who are not in so comfortable of a position. This is consistent with the expectation as the returns to effort for those who are highly likely to win are small relative to other players' returns. Players with values of their chip stacks very close to many of their competitors' try significantly harder than other players as predicted given the increasing rank returns to effort for players with clustered chip stacks. Results also indicate that the further a player is behind the player ranked immediately ahead, the significantly less effort they will exert. This is consistent with expectations as the rank returns to effort are larger when a player is very close to surpassing the player ranked adjacently ahead of him. However, unexpectedly, the further ahead the player is, the significantly harder he tries. This is inconsistent with the idea that the rank returns to effort are lower as a player gets further and further ahead of the player ranked adjacently below him.

Additionally, results indicate that the longer a tournament lasts and the more players that are eliminated, the significantly less effort a player will exhibit, contrary to expectations. The returns to effort are higher as the time the winning cohort is formed draws nearer. However, the longer a tournament goes, the more fatigue becomes a factor. With sixteen of nineteen tournaments lasting longer than forty minutes, players may fatigue, significantly reducing the level of effort exerted with time. Furthermore, as players are eliminated, one's probability of winning increases. Thus the potential lower returns to effort may explain the significant decrease in effort with the number of players remaining.

(Insert Table 3)

Risk:

Table 4 presents the White corrected results for risk. In order to fully capture the impact of tournament progress on risk taking a dummy variable for each hand is included. The results show that risk decreases significantly over hands with a large drop in risk taking after hand 12, and a small but significant decrease over the life of the tournament thereafter. More than 80% of the hand binaries are significant at the 5% level. This is consistent with expectations as the longer a tournament goes the fewer the total bets remaining in the tournament, and the faster eliminations will occur. Therefore, the cost of risk is higher the longer the tournament goes. A player with more chips will assume significantly less risk as expected because there are lower returns to risk as a player's chip stack increases. The returns to chips are lower as chip stack increases because at the margin it is less vital for a player with more chips to gain chips than a player with fewer chips because the player with fewer chips is closer to elimination and in a relatively weaker position relative to the winning cohort.

As expected, a player will take significantly more risk the greater the cushion a player has on the adjacently ranked trailing player (negative spread) or the greater gap a player faces between himself and the adjacent higher ranked player (positive spread). As a player falls further and further behind the adjacently better ranked player, he must assume more risk in order to catch up. Similarly, the further and further ahead a player gets from the adjacently worse ranked player, the lower the rank cost of risk as the less likely he is to be caught by the trailing player. Players in the role of the small and big blind take significantly more risk than other players. A player who assumes the role of the small blind or the big blind is forced to commit some chips to pot, and the thus the relative price of calling a bet in the first round of betting is lower to them than to any other player in the tournament. As a result, one would expect them to take on significantly more risk. The degree to which players take on risk should decrease as the number of players remaining in the tournament decreases, because the cost of risk is greater given the increased likelihood of winning when there are fewer players remaining. Results indicate a significant decrease in the level of risk as players are eliminated. Consistent with theory, the most significant explanatory variables in the risk model were the spread variables, the amount of time elapsed, and the number of players remaining.

Results indicate that effort also impacts risk taking. Rosen (1986) and others theorize that risk is substituted for effort. Therefore, effort should have a negative relationship with risk. However, results indicate that increases in effort lead to significant increases in risk taking. One plausible explanation for this result is that low stakes poker players' motivations may differ from those of executives on which previous studies based their analysis. Additionally, players may identify that they are increasing their effort and therefore also try and significantly increase the variance of their outcomes because they expect a more favorable outcome.

(Insert Table 4)

Caveats:

Caution must be taken in drawing generalized conclusions from this study of double up tournaments. The models explain only a portion of winning as well as effort and risk selection. While skill plays a significant role in determining the outcome, luck is also a significant component as found by Dreef et al (2003). Therefore, prediction of winning, no matter how measured, will be of limited power. This level of randomness imposes a ceiling on the degree of variation that can be explained by the model. The R squared for effort (.0164), risk (.1005), and winning (.0252) indicates that the full effect has either not been captured or not been explained. This could be due to measurement error with regard to the dependent variables or due to an incomplete theoretical framework.

The results presented rely on accurate measurements of effort and risk. Effort is proxied by a comparison of the outcome of a hand versus an average of the player's hand outcomes. Players with an early negative rolling average, potentially just from being in a blind early in the tournament, will have much higher measured effort all else equal. The converse also holds. Hole cards dealt and community cards dealt are also random components that will influence effort measurement. These chance occurrences will affect measured effort without corresponding effects on actual effort. Measurement error is also indicated in effort by the results: as time elapsed had a more significant effect on effort than any other variable.

The same logic applies to the measurement of risk. Risk is measured as the absolute standardized change in chip stack of a player in a given hand. However, a player who is dealt few decent cards will generally show less "risk" than a player with average cards who will exhibit less risk, as measured, than a player with great cards. Furthermore, the way effort and risk are proxied leads to a correlation between them. This is a possible explanation for the positive relationship between risk and effort found in the prediction of risk taking.

Conclusions:

This study sheds light on the degree to which risk and effort influence winning amongst low stakes players operating under a tournament pay scheme. The study applied the theory of tournament pay, to the selection of risk and effort by low stakes players in double up tournaments in order to explain winning. Results are generally as expected. Effort was demonstrated to have a significant and positive impact on winning. Effort was demonstrated to be positively correlated with risk taking in a departure from theory in the field (Rosen 1986). This result is mitigated by this study's inability to explain effort. Risk taking was found to be negatively impacted by proximity to adjacently ranked players and decreased as the number of players remaining in the tournament decreased and as a player's chip stack increased.

These results suggest that risk is not a substitute for effort as predicted by Rosen (1986). In this vane, tournaments do appear to be a viable alternate to piece rate wages for low stakes workers when faced with otherwise similar conditions as high stakes workers. This conclusion must be qualified by the potential measurement error in proxying for both risk and effort, and the degree to which the determinants of winning were unidentified.

A natural extension of this work would be an examination of different types of low stakes tournaments to determine if the effects found in this study extend beyond this tournament structure. Future studies that obtain hole card information would be better able to proxy for both effort and risk. Additionally, obtaining data for each round of betting rather than each hand would allow for better estimation of risk and effort. A player is able to reselect effort and risk at each betting juncture within each given hand. The combination of observable hole cards and intermediate betting rounds would allow for better proxying and prediction of risk and effort.

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Table 1:

Variable Name	Definition	Calculation	Min	Max	Mean	Time Collected
Player	A number assigned to each player depending upon their location at the table. Player 1 is at 1 o'clock on the table and players are numbered clockwise through 9.	Observed Value	1	10	5.40	Beginning of hand
Tournament	A number assigned to each individual tournament starting with the first observed and going to the last observed (Tournament 18)	Observed Value	1	19	9.81	Beginning of hand
Chip Stack (CS)	The number of "chips" that a player has. Chips are given in dollar amounts and a player may only bet the chips he has. $1 in chips does not equal $1USD. There is no conversion rate as no conversions are allowed. The data is collected at the end of each hand.	Observed Value	0	15000	1848.8	Beginning of hand
Big Blind Level	The big blind is a forced bet made by 1 player each hand before cards are dealt. The big blind rotates clockwise around the table. It increases at 10 minute intervals.	Observed Value	20	300	94.78	Beginning of hand
Small Blind Level	Exactly half of the size of the big blind. Structurally the same as the big blind. Made by the player on the right of the big blind.	Observed Value	10	150	47.39	Beginning of hand
Big Blind	A binary variable with value 1 when a given player is forced to post the big blind in a given hand	IF(Big Blind)=1	0	1	.123	Beginning of hand
Small Blind	A binary variable with value 1 when a given player is forced to post the small blind in a given hand.	IF(Small Blind)=1	0	1	.123	Beginning of hand
Standardization Factor (SF)	The size of the big blind. If the big blind is 30, then the standardization factor is 30. It is a unit free measure	=Big Blind	20	300	94.78	Beginning of hand

Time Elapsed	The amount of time elapsed from the beginning of the first hand until the beginning of the current hand. This will not be included as it is perfectly multicolinear given the big blind.	IF (big blind = 20) = 0
		IF (big blind = 30) = 10
		IF (big blind = 50) =20…
			0	70	25.71	Beginning of hand

Players Remaining	The number of players who have not been eliminated from the tournament at the beginning of a given hand	Observed Value	6	10	8.36	Beginning of hand
Rank_1	A binary variable that equals one if the player has the most chips at the end of a given hand.	IF(Rank=1) =1 If not = 0	0	1	.12	Beginning of hand
Rank	An ordinal variable that reflects the relative positioning of a player. If a player has the most chips of any player, rank =1, if the second most, rank =2. This continues through rank 9. There are no ties in rank, if two players have the same number of chips, the one with the lowest (best) rank entering the hand will get the lower (better) rank. Once a player has folded out they are assigned the rank that they finish the hand in. If two or more players bust, they are ranked based upon the number of chips they had entering the hand as per tournament rules.	Observed Value	1	10	4.68	Beginning of hand

(+) Spread	The number of chips a player would need to gain to have the same number of chips as the player ranked immediately ahead. A player ranked number 1 has a (+) spread of 0.	|rank(i+1)'s CS – rank(i)'s CS|	0	8875	340.58	Beginning of hand
Standardized (+) Spread	The (+) spread divided by the standardization factor.	[(+) Spread] / SF	0	108.75	4.52	Beginning of hand
(-) Spread	The number of chips a player would have to lose to have the same number of chips as the player one rank behind. The 9th ranked player is assigned a (-) Spread equal to 0.	rank(i)'s CS – rank(i+1)'s CS	0	8875	426.71	Beginning of hand
Standardized (-) Spread	The (-) Spread divided by the standardization factor.	[(-) Spread] / SF	0	108.75	5.74	Beginning of hand
Leading Group	A binary variable that equals one when a player is ranked in the top three and there are three or fewer players with more than 1500 chips.	IF(Rank<=3) and IF(…) = 1	0	1	0.22	Beginning of hand
Clustered Chip Stack	A binary variable that equals one when a player is within +/- 3 big blinds worth of chips of at least three other players.	1 IF: Count(CS_i-CS_j<=3SF)>=3	0	1	0.36	Beginning of hand
Big Chip Stack	A binary variable that equals one when a player has greater than 15 bets remaining	IF(St.CS>15) = 1 If not = 0	0	1	0.67	Beginning of hand
Standardized Chip Stack	The chip stack divided by the size of the big blind. The standardization is done at the end of the hand with the big blind that was played in the hand.	CS / SF	0.43	189.75	34.41	Beginning of hand
Change in Chip Stack	The difference between a player's chip stack in one hand from the hand before. This is also measured at the end of the hand.	$CS_{n+1} - CS_n$	-4040	4200	0.00	End of hand
Standardized Change in Chip Stack	The difference between a player's chip stack in one hand from the hand before divided by the standardization factor	$(CS_{n+1} - CS_n)$ / SF	-75	104	0.00	End of hand
Absolute Change	The absolute value of the change in a player's chip stack from hand n to hand n+1	$\|CS_{n+1} - CS_n\|$	0	4200	91.22	End of hand
Standardized Absolute Change **(Risk)**	The absolute value of the change in a player's chip stack from hand n to hand n+1 divided by the standardization factor to get the absolute value of the change in bets from one hand to the next.	Absolute Change / SF	0	104	1.25	End of hand
Chips to Threshold (**Winning**)	The difference between a given player's chip stack and the chip stack of the 5th ranked player. The number of chips a player is away from joining the winning cohort.	CS_i-CS_5 CS_5=5th ranked player's CS	-1795	8830	364.57	End of hand
Hand	The number of hands that have been dealt in the given tournament including the current hand	Observable	1	106	33.93	Beginning of hand
%Change in Chip Stack	The percentage change in the chips a given player has from the beginning of the hand to the end of the hand.	$(CS_{k+1} - CS_k)$ / (CS_k)	-1	3.14	0.01	End of hand
Effort	The difference between the percent change in chips a player experiences in a given hand and the average percent change in chips that they have had up to that point.	(%CHG_CS) – (AVG%_Chg_CS)	-1.04	3.11	-0.01	End of hand

Table 2:

Variable	**Coefficients**	**Std. Coefficients**
Intercept	151.2412*** (9.69)	
Small_Blind	50.6096 (1.56)	0.0161
Big_Blind	47.2649 (1.44)	0.0150
Std_CS	5.3852*** (15.73)	0.1416***
Risk	12.2197*** (3.57)	0.0496***
Effort	187.9870*** (2.88)	0.0302***
R Squared	.0252	

This table presents coefficient estimates with robust t-values below in parentheses. All results are two tail test results.
* indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Table 3:

Variable	Coefficients	Std. Coefficients
Intercept	0.1112*** (3.62)	
Time	-0.0018*** (-3.50)	-0.1761***
Rank_1	-0.0259* (-1.68)	-0.0456*
Rank_2	-0.0018 (-0.10)	-.0032
Rank_3	-0.0178 (-1.09)	-0.0312
Rank_4	-0.0224 (-1.38)	-0.394
Rank_5	-0.0224 (-1.34)	-0.394
Rank_6	-0.0260 (-1.48)	-0.0457
Rank_7	-0.0264 (-1.47)	-0.0425
Rank_8	-0.0059 (-0.31)	-0.0086
Rank_9	-0.0207 (-0.99)	-0.0245
Leading Group	-0.0126* (-1.70)	-0.0278*
Clustered CS	0.0113** (2.27)	0.0290**
Big CS	-0.0047 (-0.67)	-0.0117
Std CS	-0.0015*** (-5.67)	-.2117***
Std Spd Pos	-0.0010*** (-2.85)	-0.0507***
Std Spd Neg	0.0013*** (4.46)	0.0711***
Play_Rem_9	-0.0096* (-1.91)	-0.0213*
Play_Rem_8	-0.0100* (-1.76)	-0.0226*
Play_Rem_7	-0.0007 (-0.07)	-0.0013
Play_Rem_6	0.0121 (1.12)	0.0222
R Squared	.0164	

This table presents coefficient estimates with robust t-values below in parentheses. All results are two tail test results.
* indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Table 4:

Variable	Coefficients	Std. Coefficients
Intercept	5.1871*** (4.01)	
Time	-0.0425 (-0.78)	-0.1666
BBLevel	0.0102 (0.96)	.15822
Std CS	-0.0303** (-2.02)	-0.179**
Std Spd Pos	0.0832*** (5.02)	0.1692***
Std Spd Neg	0.1098*** (4.30)	0.2492***
Small Blind	0.7050*** (6.01)	0.0507***
Big Blind	1.2749*** (10.47)	0.0917***
Play_Rem_9	-1.1624*** (-3.75)	-0.1059***
Play_Rem_8	-1.7124*** (-4.86)	-0.1585***
Play_Rem_7	-2.1870*** (-5.35)	-0.1646***
Play_Rem_6	-2.4216*** (-5.55)	-0.1810***
Effort	2.1090*** (2.80)	0.0865***
R Squared	.1005	

This table presents coefficient estimates with robust t-values below in parentheses. All results are two tail test results.

* indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Hand, player, tournament, and rank binaries were also included as controls.

Appendix A:

Term	Definition
Big Blind	The big blind is a forced bet made by 1 player each hand before cards are dealt. The big blind rotates clockwise around the table. It increases at regular intervals (often 10 minutes).
Buy-in	The amount of money a player must pay to enter into a tournament. It includes money that will go into the prize pool and an entrance fee taken by the casino/site.
Chip Stack	The total number of chips that a given player holds. Every player has a starting chip stack of 1500.
Chips	The unit of account in a poker tournament. A player is issued chips in exchange for his buy-in into the tournament. At tournaments there is no exchange rate to translate chips into dollars. When a player has no chips remaining he is eliminated. Chips are recollected from winners at the end of the tournament in exchange for their payout.
Dealer	A designation given to one player in each hand. This player bets last in each round of betting after the first round. The player designated the dealer does not actually deal the cards as this is conducted automatically. A player is only the dealer for one hand before the designation rotates to the player to his left.
Hole Cards	Every player is dealt two cards face down at the beginning of every hand. These two cards are referred to as the player's hole cards.
Pot	The sum of the chips that have been bet by all players in a given hand.
Small Blind	Exactly half of the size of the big blind. Structurally the same as the big blind. Made by the player on the right of the big blind.

Appendix B:

LEAVE TABLE
VIEW LOBBY
Game #36167184488
Previous #36167151985
$500k Depositor Freerolls
POT $30
Captrips07 $1,500
DamianD1 $1,500
dutchfroggy $1,590
bdiddy910 $1,490
Fold
PokerStars
TOURNAMENT TABLE
plmadman $1,460
mnakas $1,170
YoupaymyDB9 $1,990
akfa $1,060
Devil1983 $1,740
Biggary16 $1,470
Chat
Notes
Stats
Info
T217221581 under the Tourney/Satellite/Cash tab.
Dealer: Game #36167096113: YoupaymyDB9 wins pot (940)
Dealer: Game #36167128409: dutchfroggy wins pot (170)
Dealer: mnakas, it's your turn. You have 12 seconds to act
Dealer: Devil1983 has two pair, Eights and Threes
Dealer: mnakas has a pair of Threes

Appendix C:

Duration	Small Blind Amount	Big Blind Amount
0-10	10	20
10-20	15	30
20-30	25	50
30-40	50	100
40-50	75	150
50-60	100	200
60-70	125	250
70-80	150	300

No tournament lasted longer than 80 minutes.