Chapter

AGGRESSION IN MIXED MARTIAL ARTS

An Analysis of the Likelihood of Winning a Decision

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Abstract Within the last decade, mixed martial arts has become one of the most popular sports worldwide. The Ultimate Fighting Championship is the largest and most successful organizations within the industry. In the United States, however, the sport is not sanctioned in all states because some politicians view the sport as too violent. The sport consists of many fighting forms and, unlike boxing, winning a decision requires judging in multiple facets including wrestling, boxing, kick boxing and jiu-jitsu. In this study, we estimate the likelihood of winning a decision in the Ultimate Fighting Championship. Using data on individual fights, we estimate the probability of winning based on fighter characteristics. We emphasize power strikes as it relates to aggression to determine the likelihood of winning. Our results indicate that knockdowns, and damage inflicted are all statistically significant determinants of winning a fight and have the largest marginal effect of influencing judges decisions.

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1.1 Introduction

The sport of mixed martial arts (MMA) was introduced in the United States with the Ultimate Fighting Championship (UFC) in 1993. Businessman Art Davie and Brazilian jiu-jitsu black belt Rorion Gracie developed a single elimination tournament between various martial art stylists where there were practically no rules; biting and eye-gouging were not allowed. The fighting was similar to Vale Tudo ("anything goes") that appeared throughout the 20th century in Brazil. UFC 1 was hyped as answering the question about which martial art would win in a real fight. Karate, boxing, wrestling, savate, sumo wrestling and jiu-jitsu were all represented in the inaugural tournament which allowed fighters across all weight classes. Brazilian jiu-jitsu black belt Royce Gracie was crowned the first winner, beating boxer Art Jimmerson, shoot wrestler Ken Shamrock and savate World Champion Gerard Gordeau.

The UFC and mixed martial arts (MMA) received mixed reviews from the U.S. public regarding the anything goes rules. Senator John MCain, R-Arizona, labeled the sport as “Human Cockfighting”, Sandomir (2007). In 1997, McCain contacted the governors of all 50 states and urged them to ban the sport, Silverman (1998). This criticism caused the UFC to make a series of rule changes to increase the number of state athletic commissions and cable television providers that would be willing to host and air events. However, this public criticism and lack of mainstream appeal, not to mention the costly legal processes to secure sanctioning, placed the owners of the UFC in a difficult financial situation. In 2001 Zuffa, LLC, owned by Frank and Lorenzo Fertitta, bought the UFC. Lorenzo Fertitta was a former member of the Nevada State Athletic Commission and was able to secure sanctioning in Nevada for the UFC in late 2001. During the period between 1997 and 2001 the rules were changed significantly to introduce weight classes and prohibit kicks to the head of a downed opponent, hair pulling, fish-hooking, head butting, and groin strikes. Strikes to the back of the head and neck and small joint manipulation were also banned.

The violence presented to the audience in UFC seems to be particularly appealing. Professional wrestling lead by the World Wrestling Entertainment (WWE), boxing and the UFC compete in the U.S. for pay-per-view audiences. Over the past several years there has been a significant reduction in WWE’s pay-per-view numbers as UFC’s popularity has grown and boxing’s popularity has remained steady. The UFC generated $411

million in revenues and 9.145 million "buys" from the 16 events shown on pay-per-view; see Meltzer (2011). The number of UFC buys is up 13.5% from 2009 sales. The WWE saw decreases year to year in buys between 2008-2009 and 2009-2010 of 19.8% and 14.4% respectively. Some in the media attribute this to people's fascination with violence, Rossen (2010).

The focus of the UFC's competitions has been on striking, grappling and submissions. Striking is most commonly associated with the fighters that have boxing and kickboxing backgrounds and fighters using this method are often fan favorites because their fights often end in knockouts. Absent a knockout or submission, a fight concludes at the time limit and the winner is determined by a set of three judges. The criteria are clean strikes, effective grappling, octagon control, and effective aggressiveness. Thus power punches improve the chances of a fighter winning in two ways: power punches may lead to a knockout or they could affect the judges scoring of the rounds.

In this paper we use UFC data from November, 2000 - 2009. Data were provided by FightMetric, a company founded in 2007. FightMetric collects data scientifically, using strict definitions, slow motion, a single scorer per fight and data validation tests. The company is the official statistics provider for the UFC. More information can be obtained at www.fightmetric.com.

Since UFC 28, fights have been governed by a common set of rules. The data includes information on fight and fighter characteristics. Fight characteristics include attempted and landed punches and kicks (which we aggregate into total strikes) overall and for power strikes. We analyze the effect of a variety of variables on the win/loss outcome of the fight. Of particular interest we investigate the effect of power strikes. Our results indicate that knockdowns and damage inflicted are the variables with the largest marginal impact on the probability of winning a fight. This is not surprising for two reasons. One, knockdowns and damage inflicted occur very frequently in a fight relative to the other strikes used in our data, thus we would expect them to have a larger impact. Secondly, this result is consistent with the story told in Downey (2007), where fighting strategies became more obviously violent in response to the many rules changes in UFC.

Interestingly, we have found no published research analyzing the impact of fighting strategies/characteristics on the probability of winning a professional fight. Some research does exits on the theoretical relationship

between boxing contracts and the effort exerted by the boxers (see e.g., Tenorio (2000), Amegashie and Kutsoati (2005) and Sanders (2008)), but nothing empirical (known to these authors). However, there is a vast history of research modeling the determinants of winning other sporting contests. European football seems to be the most heavily researched.

Carmichael and Thomas (2005) is one example of research on the impact of home-field advantage on the probability of winning a football match. Similarly, de Dios Tena and Forrest (2007) estimated the effect of replacing a manager during the season on the team's chances of winning games following the replacement. Other examples of studies estimating factors impacting the probability of winning a football match include (but are not limited to) Koning (2000), Forrest, Goddard and Simmons (2005) and Chumacero (2009). This type of analysis is certainly not limited to football, with other researchers analyzing everything from tennis (Gilsdorf and Sukhatme (2008)) to cricket (Allsopp and Clarke (2004)).

The remainder of the paper is organized as follows. Section 2 presents a probit regression model to predict winning based on the attributes of the fighters and the fight. Section 3 describes the analysis of the FightMetric data focusing on UFC events and discusses the results of our regression model developed in section 2. Two separate regressions are considered depending on the outcome of the fight. We first consider all fights including those that ended either due to submission or knockout. In our second regression, we consider only those fights that were decided by the judges. This allows us to focus on those factors that are most important to the judges in deciding the outcome of each fight. Marginal effects are calculated to determine the marginal impact that each characteristic has on the probability of winning. Section 4 provides some concluding remarks.

1.2 Methodology

Our goal is to determine which aspects of a fight (e.g. head punches versus other body blows) are most important in determining a winner. We use the full sample of all fights in the FightMetric database and a sub-sample limited to those fights that end in judges' decisions in order to focus on the subjective weight that judges attach to certain acts of aggression. We estimate a binary response model to estimate the impact of fighter characteristics on the probability of winning. The general model takes the form:

$$P(w = 1 \mid X) = G(X\beta), \tag{1}$$

where w is an indicator variable for whether the fighter won the fight, X is a vector of fighter characteristics, β is a vector of coefficient estimates, and G is a nonlinear function producing a value between zero and one. We specify G as the standard normal cumulative distribution function (called a probit model), which is expressed as the following:

$$G(z) = \Phi(z) = \int_{-\infty}^{z} \phi(v)dv, \tag{2}$$

where $\phi(z)$ is the standard normal density

$$\phi(z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}z^2}. \tag{3}$$

The coefficient estimates from this model do not give us any meaningful information other than the direction of the effect of *x* on the probability of winning. We obtain the marginal impact of a change in *x* on the probability of winning by taking the partial derivative:

$$\frac{\delta p(x)}{\delta x_i} = g(X\beta)B_i, \tag{4}$$

where $g(z) = \frac{dG}{dz}(z)$. For more information on the probit model see Greene (2008).

The marginal effects that we show and discuss in the results section indicate the change in the probability of winning a fight resulting from a one unit increase in the dependent variable, evaluated at its mean. For example, a finding of a marginal effect of 0.12 on the variable age would mean that increasing a fighter's age by one year above the average age would increase the fighter's probability of winning by 12 percent. It is important to recognize that the size of the marginal effect will change with the size of the dependent variable in question, which is why marginal effects are typically evaluated at the mean of the dependent variable.

1.3 Empirical Application

1.3.1 Data

Data for UFC fights were obtained from FightMetric. We considered only fights that occurred in the UFC under the current rules, which were established in November 2000. Our dependent variable is either 0 (loss) or 1 (win) and we consider numerous fighter and fight characteristics to estimate the probability of winning the fight. Among the fighter characteristics, we use fighter height (*Height*), weight (*Weight*) and age (*Age*). Descriptive statistics are reported in Table 1.

We would expect that younger fighters would have a higher probability of winning and that this effect would increase with the difference in the two fighters' ages. Weight differences could affect the probability of winning in either direction. A lower weight could proxy speed advantage while a higher weight might indicate more power. We note that advantages in weight are mitigated by weight classes and the fact that too much weight loss can lead to stamina problems. In general, we would expect height to be an advantage.

We also include a number of fight variables. We are forced to aggregate round data into total fight data in order to align with judges' decisions on a fight basis. We include variables measuring performance standing (i.e., boxing and kickboxing) and on the ground (wrestling and jiu-jitsu). Fighter activity is measured by the number of punches and kicks (which we aggregate into strikes) attempted and landed on the feet (*Jabs Attempted*, *Jabs Landed*, *Power Attempted* and *Power Landed*) and on the ground (*Ground Jabs Attempted*, *Ground Jabs Landed*, *Ground Power Attempted* and *Ground Power Landed*). Successful strikes that lead to knockdowns are measured by *Clinch Knockdowns*, *Knockdowns* and *Damage*. Wrestling (and judo and jiu-jitsu) are concerned with taking a fight to the ground in order to submit or to inflict damage via ground and pound. We include *Take Downs Attempted*, *Take Downs Successful*, *Slams, and Sweeps* to measure this part of the fight game. Submissions are reflected by *Choke*, *Tight Sub* (i.e., submission attempts that did not end the fight) and *Lock*. *Standups* reflect the ability of a fighter to stand up after being taken down; the variable does not include non-contested stand ups (for example, when the controlling fighter voluntarily stands.)

Since we observe two fighters in a given fight, we use the difference in fighter characteristics for most of our explanatory variables in the probit

model. For each fight, we generate a random number for each fighter and choose the fighter with the higher value as the first fighter with the remaining fighter positioned as the second fighter. This is essentially the same as flipping a coin to randomly position the fighters in our database. We then subtract the second fighter's characteristics from the first fighter's characteristics in each fight (*e.g.*, the difference in age would be the first fighter's age minus the second fighter's age). Finally, we estimate the probit model with the indicator variable for whether the first fighter won the fight as a function of the differenced fighter characteristics.

Our methodology is very similar to the method used in Gilsdorf and Sukhatme (2008) in their analysis of the probability of winning a tennis match, only they positioned players based on tournament seed. Much of the analyses of the determinants of winning football matches also use similar techniques, often positioning teams based on home vs. away team (see e.g., Carmichael and Thomas (2005), Forrest, Goddard and Simmons (2005) and Chumacero (2009)).

Before we present our probit results, we first consider differences in fight characteristics for fights that ended in a decision versus those fights that ended via knockout, technical knockout or submission (non-decision). Summary statistics for the difference in fighter characteristics are presented in Table 2. The statistics are defined relative to the winning fighter by subtracting the losing fighter's characteristics from the winner fighter's characteristics. Note that this is different than what we use in our analysis below, but this makes for an easier interpretation here.

Interesting results emerge from the summary statistics. T-tests confirm that the means of some of these variables are statistically different between the two categories. The following variables were found to have a significantly *smaller* difference between the winner and loser of a fight in decisions than in non-decisions: tight submissions, clinch knockdowns, knockdowns, chokes, locks and fighter height. This means that, for example, on average, the difference between the number of knockdowns by the winner and the number of knockdowns by the loser was greater in fights that did not end in a decision. These are not surprising findings, given that most of the maneuvers in this list are all ways to end a fight in a knockout or submission. What is somewhat surprising is that the difference in the fighters' weights are similar across decisions and non-decisions, while the difference in the fighters' height is larger in fights that end in a knockout or submission. Conversely, the following variables were found to have a significantly *greater* difference between the winner and loser of a fight in

decisions than in non-decisions: standups, damage, power landed to the head, power landed to other, ground jabs attempted and landed to both head and other, ground power attempted and landed to both head and other, takedown attempts, takedowns successful, slams and age. It is interesting here that the difference in the fighters' ages is larger in fights that go to a decision. As a point of caution, we remind the reader that these are simply differences in characteristics of those fights that go to a decision versus those that do not. These differences do not necessarily have any predictive power. We will now discuss our probit results, which can tell us if any of the characteristics make a fighter more or less likely to win.

1.3.2 Probit Results

Our probit model using all 946 fights with complete information results in a pseudo R-squared of 0.634, meaning that our model explains about 63-percent of the variation in outcomes of these matches. Our probit model of the 323 fights that went to decisions and have complete information results in a similar pseudo R-squared of 0.701. The complete set of results for all fights are displayed in the first two columns of Table 2, while the complete set of results for the fights that went to decisions are displayed in the last two columns of Table 2.

For the sake of brevity, we will only discuss coefficient estimates that are either statistically significant or surprising results. First we will discuss the results for the model with all fights. Then we will discuss differences between these results and the results using only fights that went to decisions.

Using the data with all fights, the coefficient estimates on the variables for damage, clinch knockdowns, stand ups, knockdowns, power to head landed, ground power to head landed, power other landed, take downs successful, slams, sweeps, chokes, locks, and height are all positive and statistically significant at the five-percent level. This means that we are at least 95-percent sure that these variables have a positive impact on the probability of winning. Additionally, the coefficient estimates on jabs to head attempted and ground jabs to head attempted are positive and statistically significant at the ten-percent level. Remember however, that these variables used in our model are measured as the difference between the original values of these variables for the two fighters involved in a particular fight. Thus, the fighter who has a higher value for any of these variables has a greater probability of winning the fight.

Two surprising results, of the statistically significant estimates, are that the fighter with a greater number of jabs to head and ground jabs *attempted* has a higher probability of winning, but the fighter with the greater number of jabs to head or ground jabs *landed* does not. One interpretation of these results is that the number of jabs to head and ground jabs attempted are serving as a proxies for which fighter has greater control of the fight, while actually landing these jabs has no real impact on the outcome.

The most surprising result is that none of our age variables held any statistical significance in the model. We hypothesized that a greater difference in age would increase the probability of winning for the younger fighter and that this effect would increase as the difference became larger. However, our results indicate that, after controlling for all the other variables in a fight, age does not impact a fighter's probability of winning. One explanation for this result is that our other variables include measures that are probably accounting for age differences. For instance, a younger fighter is likely to be quicker and thus more likely to be successful in takedowns. We found that the fighter with more successful takedowns has a higher probability of winning. Thus a younger fighter does have a higher probability of winning, but not just because they are younger. They are more likely to win because they are quicker and more likely to be successful in takedown attempts.

Looking at our results for the sample that only includes fights that went to decisions, we see that seven of our coefficient estimates are positive and statistically significant: knockdowns, power to head landed, ground jabs to head attempted, ground power to head attempted, other jabs attempted, and other power landed. Two variables, ground jabs to head landed and other jabs landed, result in negative and statistically significant coefficient estimates. Thus, it can be said that these are the variables that are most important to the judges.

We find a number of these results to be very surprising. It is extremely curious that ground jabs to head *attempted* and other jabs *attempted* are both positively associated with the probability of winning a decision, while ground jabs to head *landed* and other jabs *landed* are negatively associated with the probability of winning a decision. Similarly, ground power to head *attempted* is positively correlated with winning a decision, while power to head *landed* does not seem to be related to the decision. We have two possible explanations for these results: (i) the difference in punches attempted is a proxy for the fighter that dominated the fight (especially on the ground), or (ii) the judges had a difficult time determining which ground and body punches actually landed, thus punches attempted dominated their

visibility. As a point of fact, the judges in our sample do not have access to television monitors, leading to a clear lack of vantage point.

The other interesting finding here is that knockdowns, power to head landed, and other power landed are all found to be positively associated with winning a decision. These types of blows seem to be the most obviously violent and harmful of the blows we have accounted for. Thus, it appears that judges are swayed in favor of the fighter who is more successful in these harmful strikes.

1.3.1 Marginal Effects

As we discussed in Section 1.2, the coefficient estimates tell us the direction of the relationship between the explanatory variables and the probability of winning, but their magnitudes do not have any meaningful interpretation. Thus, we transform the coefficient estimates into marginal effects so we can understand the impact of a one unit increase of an explanatory variable (at its mean) on the probability of winning the fight. Table 3 displays the marginal effects measured using all available fights and only fights that end in decisions.

Increasing the difference in the number of knockdowns created by the two fighters from its average of -0.026 by one knockdown would increase a fighter's probability of winning by 16.6-percent. This is the largest marginal effect (measured at its mean) of all the variables included in our model. The difference in the number of slams and sweeps also have marginal effects estimated to be slightly greater than ten-percent and are the next greatest in magnitude, with clinch knockdowns following closely behind at 9.8-percent. Although we found that a larger difference in the number of jabs to head and ground jabs to head attempted have positive and statistically significant impacts on the probability of winning, the marginal effects are only 0.1-percent and 0.6-percent, respectively. The former is the smallest marginal effect of all of the variables we find to have statistically significant coefficient estimates. We should note here that the scale of the variables mentioned above is significantly different. The average number of knockdowns for a fighter is 0.183, while the average number of ground jabs to head attempted is 15.125. Thus, knockdowns occur much less frequently and so it is not surprising that one more knockdown for a fighter will have a significant increase in their probability of winning.

The last two columns of Table 3 display the coefficient estimates and standard errors for out model of fights that end in decisions. Using this sample o f the data, we find that the difference in the number of knockdowns

again has the largest marginal increase in the probability of winning a fight. Here, a one unit increase in the difference in the number of knockdowns from its average of -0.026 increases a fighter's probability of winning a decision by 9.5-percent. The marginal effect of a one unit increase in the difference in damage, from its average, results in a 4.4-percent increase in a fighter's probability of winning a decision. Lastly, the marginal effects of the other statistically significant characteristics are all less than 2-percent. Again, the same caveat about the scale of the variables applies. Additionally, we should mention that damage and tight submission are binary indicator variables for each round. This means they can never have a value of greater than one in any round, hence never have a value of greater than the number of rounds in the fight in our aggregated data.

1.4 Conclusions

In this chapter, we estimate probit models to identify the effect of fighter and fight characteristics on the probability of winning a fight in mixed martial arts. Using data provided by FightMetric, we include only fights from the UFC. We estimated two probit models, using the full sample of fights with complete data and a sub-sample that only included fights that end in judges' decisions. Most of the results were expected. The only fighter characteristic that was statistically significant was height (only in the full sample of data), but the marginal effect was relatively small. Age and weight were not statistically significant.

The fight variables that were statistically significant in both models were knockdowns, ground jabs to the head attempted, and power strikes landed (both to the head and other parts of the body). Ground power strikes to the head landed were significant in the full sample but not in the sub-sample; this might result because successful ground power strikes to the head typically end fights. The variables with the largest marginal effects in the sub-sample of fights that go to a decision were damage and knockdowns, which is not surprising given their limited frequency in a fight.

Table 1: Descriptive Statistics

	All Fights (N = 946)		Fights with Decisions (N = 646)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Win	0.500	0.500	0.500	0.500
Damage	0.177	0.461	0.268	0.577
Tight Sub	0.079	0.287	0.124	0.365
Clinch Knockdowns	0.044	0.227	0.033	0.177
Standups	0.760	1.360	1.423	1.862
Knockdowns	0.183	0.464	0.135	0.434
Jabs to Head Attempted	14.317	20.698	26.269	26.615
Jabs to Head Landed	5.079	8.388	9.009	9.844
Power to Head Attempted	20.096	23.721	35.379	29.116
Power to Head Landed	6.044	7.794	9.885	8.999
Ground Jabs to Head Attempted	15.125	23.630	27.365	31.285
Ground Jabs to Head Landed	13.361	21.001	24.081	27.756
Ground Power to Head Attempted	8.605	13.578	12.226	16.434
Ground Power to Head Landed	4.966	7.836	6.667	9.062
Jabs Other Attempted	3.543	7.079	6.426	9.876
Jabs Other Landed	3.013	6.505	5.469	9.164
Power Other Attempted	7.586	9.609	12.876	12.450
Power Other Landed	5.973	7.656	10.033	9.810
Ground Jabs Other Attempted	4.697	10.478	9.056	14.518
Ground Jabs Other Landed	4.666	10.427	9.000	14.452
Ground Power Other Attempted	0.924	2.851	1.729	4.232
Ground Power Other Landed	0.871	2.677	1.627	3.948
Takedowns Attempted	2.521	3.591	4.500	4.750
Takedowns Successful	1.031	1.645	1.814	2.196
Slam	0.134	0.439	0.217	0.591
Sweep	0.178	0.471	0.308	0.612
Choke	0.365	0.769	0.432	0.900
Lock	0.284	0.709	0.354	0.824
Height	71.526	3.289	71.053	2.885
Weight	186.122	29.300	180.896	26.368
Age	28.793	4.183	28.514	4.009

All calculations by authors.

Table 2: Mean Differences in Explanatory Variables

	No Decisions (N = 323)		Decisions (N = 623)		T-test
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Pr(|T| > |t|)
Damage	0.269	0.755	0.127	0.506	0.001
Tight Sub	-0.050	0.490	0.030	0.322	0.003
Clinch Knockdowns	0.034	0.253	0.074	0.346	0.068
Standups	-1.087	2.709	-0.098	1.138	0.000
Knockdowns	0.102	0.599	0.340	0.641	0.000
Jabs to Head Attempted	0.700	23.057	1.894	12.614	0.303
Jabs to Head Landed	1.003	10.554	1.390	7.790	0.523
Power to Head Attempted	3.545	20.788	2.315	11.597	0.243
Power to Head Landed	3.548	7.683	2.589	6.601	0.046
Ground Jabs to Head Attempted	14.409	39.617	7.425	17.314	0.000
Ground Jabs to Head Landed	11.709	35.677	6.705	15.710	0.003
Ground Power to Head Attempted	14.811	20.279	8.048	14.861	0.000
Ground Power to Head Landed	8.084	11.079	5.507	8.928	0.000
Jabs Other Attempted	1.043	12.418	0.148	5.087	0.118
Jabs Other Landed	0.845	11.345	0.204	4.581	0.219
Power Other Attempted	2.303	14.021	1.361	6.315	0.155
Power Other Landed	2.424	11.349	1.242	5.479	0.031
Ground Jabs Other Attempted	8.570	19.384	1.632	8.947	0.000
Ground Jabs Other Landed	8.520	19.284	1.612	8.897	0.000
Ground Power Other Attempted	2.319	5.188	0.465	2.195	0.000
Ground Power Other Landed	2.176	4.850	0.432	2.100	0.000
Takedowns Attempted	1.167	7.996	-0.136	3.209	0.000
Takedowns Successful	1.604	3.276	0.276	1.549	0.000
Slam	0.235	0.827	0.067	0.456	0.000
Sweep	-0.009	0.685	0.035	0.430	0.221
Choke	0.015	1.267	0.327	0.912	0.000
Lock	-0.127	1.187	0.202	0.886	0.000
Height	0.136	2.711	0.541	3.779	0.088
Weight	0.344	10.899	0.228	12.443	0.888
Age Squared	819.758	245.199	819.461	228.714	0.985
Age Difference	-0.354	4.968	-1.156	5.674	0.032

All variables are defined relative to the winner of each fight.

Table 3: Probit Results

	All Fights (N = 946)		Fights with Decisions (N = 323)	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	-0.019	2.955	-5.683	7.514
Damage	0.341**	0.134	0.393	0.24
Tight Sub	-0.140	0.215	0.572	0.354
Clinch Knockdowns	0.695**	0.258	-0.232	0.546
Standups	0.429**	0.083	-0.048	0.16
Knockdowns	1.178**	0.145	0.835**	0.397
Jabs to Head Attempted	0.009*	0.005	0.009	0.007
Jabs to Head Landed	-0.013	0.011	-0.013	0.014
Power to Head Attempted	-0.007	0.006	-0.001	0.008
Power to Head Landed	0.111**	0.018	0.154**	0.032
Ground Jabs to Head Attempted	0.043*	0.025	0.111**	0.056
Ground Jabs to Head Landed	-0.037	0.028	-0.105*	0.06
Ground Power to Head Attempted	-0.016	0.015	0.069**	0.033
Ground Power to Head Landed	0.116**	0.029	-0.006	0.062
Jabs Other Attempted	0.048	0.037	0.125**	0.054
Jabs Other Landed	-0.055	0.040	-0.132**	0.058
Power Other Attempted	-0.026	0.025	-0.052	0.033
Power Other Landed	0.068**	0.031	0.084**	0.043
Ground Jabs Other Attempted	0.183	0.282	0.161	0.365
Ground Jabs Other Landed	-0.168	0.283	-0.151	0.366
Ground Power Other Attempted	-0.169	0.206	-0.138	0.302
Ground Power Other Landed	0.271	0.226	0.273	0.329
Take Downs Attempted	-0.013	0.019	-0.009	0.025
Take Downs Successful	0.359**	0.079	0.014	0.15
Slams	0.746**	0.149	0.376	0.243
Sweeps	0.736**	0.150	0.079	0.293
Choke	0.427**	0.074	0.067	0.12
Lock	0.377**	0.074	0.081	0.158
Height	0.054**	0.027	0.026	0.058
Weight	-0.005	0.006	-0.011	0.014
Age	0.020	0.202	0.437	0.52
Age Squared	-0.001	0.003	-0.008	0.009
Age Difference	-0.009	0.016	0.044	0.036
Pseudo R^2	0.634		0.701	

Dependent variable is Wins. ** indicates significance at the 5 percent level; * indicates significance at the 10 percent level.

Table 4: Marginal Effects

	All Fights (N = 946)		Fights with Decisions (N = 323)	
Variable	Marginal Effect	Std. Error	Marginal Effect	Std. Error
Damage	0.048**	0.019	0.044*	0.027
Tight Sub	-0.020	0.030	0.065	0.039
Clinch Knockdowns	0.098**	0.036	-0.026	0.062
Standups	0.060**	0.011	-0.005	0.018
Knockdowns	0.166**	0.018	0.095**	0.043
Jabs to Head Attempted	0.001*	0.001	0.001	0.001
Jabs to Head Landed	-0.002	0.002	-0.001	0.002
Power to Head Attempted	-0.001	0.001	0.000	0.001
Power to Head Landed	0.016**	0.002	0.017**	0.003
Ground Jabs to Head Attempted	0.006*	0.004	0.013**	0.006
Ground Jabs to Head Landed	-0.005	0.004	-0.012*	0.007
Ground Power to Head Attempted	-0.002	0.002	0.008**	0.004
Ground Power to Head Landed	0.016**	0.004	-0.001	0.007
Jabs Other Attempted	0.007	0.005	0.014**	0.006
Jabs Other Landed	-0.008	0.006	-0.015**	0.006
Power Other Attempted	-0.004	0.004	-0.006	0.004
Power Other Landed	0.010**	0.004	0.01**	0.005
Ground Jabs Other Attempted	0.026	0.040	0.018	0.041
Ground Jabs Other Landed	-0.024	0.040	-0.017	0.041
Ground Power Other Attempted	-0.024	0.029	-0.016	0.034
Ground Power Other Landed	0.038	0.032	0.031	0.037
Take Downs Attempted	-0.002	0.003	-0.001	0.003
Take Downs Successful	0.051**	0.011	0.002	0.017
Slams	0.105**	0.020	0.043	0.027
Sweeps	0.104**	0.020	0.009	0.033
Choke	0.060**	0.010	0.008	0.014
Lock	0.053**	0.010	0.009	0.018
Height	0.008**	0.004	0.003	0.007
Weight	-0.001	0.001	-0.001	0.002
Age	0.003	0.028	0.049	0.059
Age Squared	0.000	0.000	0.005	0.004
Age Difference	-0.001	0.002	-0.001	0.001

** indicates significance at the 5 percent level; * indicates significance at the 10 percent level. Standard errors are calculated using the delta method.

1.5 References

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