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WINNING ISN'T EVERYTHING: CORRUPTION IN SUMO WRESTLING

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ABSTRACT

Although the theoretical literature on corruption is well developed, empirical work in this area has lagged because it has proven difficult to isolate corrupt behavior in the data. In this paper, we look for evidence of corruption in an unlikely place: the highest echelons of Japanese sumo wrestling. This paper provides strong statistical evidence documenting match rigging in sumo wrestling. A non-linearity in the incentive structure of promotion leads to gains from trade between wrestlers on the margin for achieving a winning record and their opponents. We show that wrestlers win a disproportionate share of the matches when they are on the margin. Increased effort can not explain the findings. Winning on the bubble is more frequent when the two competitors have met often in the past. Success on the bubble tends to rise over the course of a wrestler's career, but declines in his last year, consistent with the game theoretic predictions. Wrestlers who are victorious when on the bubble lose more frequently than would be expected the next time they meet that opponent, suggesting that part of the payment for throwing a match is future payment in kind. Systematic differences across wrestling stables suggest that the stables play a role in facilitating the corruption. In times of increased media scrutiny, the match rigging disappears.

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"I would like to believe that sumo matches are clean, but it is difficult to prove it one way or another."

–Mina Hall, author of The Big Book of Sumo (1997)

I. Introduction

There is a growing appreciation among economists of the need to better understand the role that corruption plays in real-world economies. Although some have argued that it can be welfare-enhancing (Leff, 1964), most commentators believe that a willingness to accept bribes (or similar forms of corruption) in either the public or the private sector reduces economic efficiency (Shleifer and Vishny, 1993; Krueger, 1974). As a result, organizations often create incentives to motivate their employees to be honest (Becker and Stigler, 1974) or distort production decisions to reduce the likelihood that corrupt deals will take place (Rose-Ackerman, 1975).

While anecdotal evidence suggests that corruption is widespread not only in developing countries, but also in the United States (e.g. influence buying on the International Olympic committee, Medicare fraud by Columbia/HCA, corrupt judges in Chicago convicted of allowing murderers to go free in return for cash), there is little rigorous empirical research on the subject. Because of corruption's illicit nature, those who engage in corruption attempt not to leave a trail. Systematic empirical substantiation of corrupt practices is unlikely to appear in typical data sources. Rather, researchers must adopt non-standard approaches in an attempt to ferret out indirect evidence of corruption.

To date, there have been only a handful of studies that attempt to systematically document the impact of corruption on economic outcomes. Mauro (1995) uses subjective indices of corruption across countries to conclude that nations with corrupt governments have significantly lower rates of economic growth. Fisman (2000) analyzes how stock price of Indonesian firms fluctuate with changes in former Prime Minister Suharto's health status. Firms with close connections to Suharto, which presumably benefit from corruption within the regime, decline substantially more than other Indonesian firms when Suharto's health weakens. Di Tella and Schargrodsky (2000) document that the prices paid for basic inputs at public hospitals in Buenos Aires fall by 10-20 percent after a corruption crackdown.[1]

In this paper we look for corruption in an unlikely place: among Japan's elite sumo wrestlers. Sumo wrestling is the national sport of Japan, with top wrestlers among the highest paid athletes in Japan. The sport has a more than 1,000 year tradition and a focus on honor, ritual, and history that may be unparalleled in athletics. Nevertheless, in recent years, sumo wrestling has been dogged by allegations of corruption in the form of rigged matches.[2] Officials from the Japanese Sumo Association dismiss these complaints as fabrications on the part of disgraced former wrestlers. Ultimately, despite years of allegations, no formal disciplinary actions have been taken towards any wrestler. The general view, epitomized by the quote that

[1]The behavior uncovered in this paper is also related to past research on collusion. For example, Porter and Zona (1993) find evidence that construction companies collude when bidding for state highway contracts by meeting before the auction, designating a serious bidder, and having other cartel members submit correspondingly higher bids. Unlike in the sumo case presented here, the success of this strategy is constrained by the existence of non-cartel construction firms. McAfee (1992) details a wide variety of bid-rigging schemes.

[2] For instance, a book entitled *Yaocho* ("rigged matches") was published posthumously in 1999 by a former sumo wrestler, alleging that most wrestlers engaged in match fixing while he was active. Three years earlier, that sumo wrestler and another former wrestler who made allegations of match rigging died hours apart, in the same hospital, with the same diagnosis. The two had apparently dined together shortly before developing symptoms. The authors of the current paper hope that these deaths were purely coincidental.

begins this paper, is that charges of corruption simply pit one person's word against another and definitive proof is unlikely to be found.

The key institutional feature of sumo wrestling that makes it ripe for corruption is the existence of a sharp non-linearity in the payoff function for competitors.[3] A sumo tournament (basho) involves approximately 66 wrestlers (rikishi) participating in fifteen bouts each. A wrestler who achieves a winning record (eight wins or more, known as kachi-koshi) is guaranteed to rise up the official ranking (banzuke); a wrestler with a losing record (make-koshi) falls in the rankings. A wrestler's rank is a source of prestige, the basis for salary determination, and also influences the perks that he enjoys.[4]

Figure 1 demonstrates empirically the importance of an eighth win to a wrestler. The horizontal axis of the figure is the number of wins a wrestler achieves in a tournament; the vertical axis is the average change in rank as a consequence of the tournament performance. The change in rank is a positive function of the number of wins. With the exception of the 8th win, the relationship is nearly linear: each additional victory is worth approximately 3 spots in the rankings. The critical 8th win – which results in a substantial promotion in rank (kakuage) rather than a demotion (kakusage) — garners a wrestler approximately 11 spots in the ranking, or nearly 4 times the value of the typical victory. Consequently, a wrestler entering the final match

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[3] Chevalier and Ellison (1997) examine how non-linearities in incentives distort the behavior of mutual fund managers.

[4] For instance, the lowest ranked wrestlers in each wrestling stable (heya) must rise early every morning to clean the building and prepare the food for the main meal of the day. When a wrestler reaches the rank of juryo, placing him among the top 66 sumo wrestlers in Japan, he no longer is required to do chores for other rikishi in his heya. Those in the top 40 (with ranks of maegashira or better) are tended to by lower-ranked wrestlers who are required to act as servants.

of a tournament with a 7-7 record has far more to gain from a victory than an opponent with a record of, say, 8-6 has to lose.[5] According to our rough calculations, moving up a single spot in the rankings is worth on average approximately $3,000 a year to a wrestler.[6] Thus, there may be substantial gains to trade if the wrestlers fix a match. Of course, no legally binding contract can be written and discovery of such a deal would likely result in disgrace and presumably strong censure on the part of the sport's governing board.

In this paper, we examine more than a decade of data for Japan's sumo elite in search of evidence demonstrating or refuting claims of match rigging. Our data set encompasses 67 tournaments and more than 32,000 individual bouts. We uncover overwhelming evidence that match rigging occurs in the final days of sumo tournaments. One important piece of evidence is that wrestlers who are on the margin for attaining their eighth victory win far more often than would be expected. For instance, on the last day of the tournament, wrestlers with records of 7-7 win more than 70 percent of their matches (77 percent when matches involving two wrestlers each with 7 wins are excluded). On the penultimate day of the tournament, wrestlers with 6 or 7 wins (and thus are on the margin for reaching the threshold of 8 wins) are victorious over 60 percent of the time. If all of these excess wins are due to match rigging, then wrestlers on the

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[5] Of course, there also will be incentives for forward-looking wrestlers to rig matches on earlier days of the tournament as well. We explore the issue of timing more formally in the model in Section II.

[6] Wrestlers ranked between fifth and tenth earn an annual income – including official wages, bonuses, and prize money – of roughly $250,000 per year. The fortieth-ranked wrestler earns approximately $170,000. The seventieth-ranked wrestler receives only about $15,000 per year (no official salary, just a small stipend to cover tournament expenses, some prize money, and room and board). All information on annual salaries are based on the authors calculations and information provided in Hall (1997)

margin are rigging 40 percent of their matches on day 15 and 20 percent of their matches on day 14.

High winning percentages by themselves, however, are not indicative of match rigging. Those wrestlers who are on the margin for achieving the eighth win may exert greater effort because their reward for winning is larger. We offer a number of pieces of evidence against this alternative hypothesis. First, the pattern of outcomes is consistent with the predictions of game theoretic models of collusion supported by repeated play. Wrestlers who meet more frequently appear to collude more, and success on the bubble[7] rises with experience but declines in the last year of competition. Second, whereas the wrestler who is on the margin for an 8^{th} win is victorious with a surprisingly high frequency, the next time that those same two wrestlers face each other, it is the *opponent* who has an unusually high win percentage.[8] This result suggests that at least part of the currency used in match rigging is promises of throwing future matches in return for taking a fall today. Third, there are systematic differences in bubble success across stables of wrestlers. Those stables that fare well on the bubble do especially *poorly* when their opponents are on the bubble. These results suggest a role for stables in coordinating the match rigging.[9] Certain pairs of stables appear to have worked out particularly strong reciprocity arrangements. Finally, allegations of rigged matches periodically appear in the press.

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[7]Throughout the paper, a wrestler is defined to be "on the bubble" if, on one of the final three days of the tournament, he has not yet reached eight wins but is not mathematically eliminated from doing so. Thus, wrestlers with a record of 7-7, 7-6, 6-7, 7-5, 6-6, and 5-7 are included in this group.

[8] By the second subsequent meeting, the winning percentages revert back to the expected levels, suggesting that deals between individual wrestlers span only two matches.

[9] Wrestlers in the same stable do not wrestle each other.

Presumably, scrutiny of potentially rigged matches is greater during these times. In tournaments immediately following such press reports, the pattern of match outcomes is far less skewed, suggesting effort is not the explanation for the unusually high win rates for wrestlers on the bubble.

The remainder of this paper is organized as follows. Section II develops a formal model with explicit predictions about the conditions under which one would expect to see match rigging. Section III presents the empirical evidence documenting the strong performance of wrestlers on the bubble. Section IV attempts to distinguish between increased effort and match rigging as an explanation for the observed patterns in the data. Section IV also considers the way in which the market for rigged matches operates, e.g. how contracts are enforced, the use of cash payments versus promises of future thrown matches, and individuals versus stables as the level at which deals are brokered. Section V concludes with a discussion of the broader economic implications of our analysis.

II. A Model of Match Rigging

In this section we examine the incentives of two wrestlers meeting in the late rounds of a tournament to fix a match. The model abstracts from the issue of how such a collusive bargain is struck, taking as given the necessary mechanisms to enforce these illegal agreements.[10]

We make the following assumptions:

A1) Wrestlers are risk neutral expected utility maximizers,

A2) Any win other than the eighth win is worth W to a wrestler. The eighth win is worth $W+W^*$. The utility of a loss is normalized to equal zero.

[10] In the empirical section, we do examine the question of how the collusion might work.

A3) If two wrestlers *i* and *j* agree to rig a match, a cash transfer P_{ij} is made from the winning wrestler *i* to the wrestler *j* who intentionally loses. The magnitude of the transfer is endogenously determined through bargaining.

A4) The bargaining mechanism is one in which a wrestler who wants his opponent to intentionally lose makes a one-time, take it or leave it offer to his opponent.

A5) An exogenous fraction *R* of wrestlers are willing to throw a match if adequately compensated. The other 1-*R* wrestlers refuse to throw a match. Such wrestlers are randomly drawn from the overall set of opponents.

A6) Each wrestler in a rigged match pays a fixed cost *c/2* to participate in the collusion.

A7) In a fair (not-rigged) match between wrestlers *i* and *j*, the probability *i* wins, denoted Π_{ij}, is common knowledge to both wrestlers.

Assumption *A2* is motivated by Figure 1, which suggests that all wins except the eighth have approximately equal value in terms of ranks. Modeling the collusive deal as taking the form of a cash transfer in *A3* is done purely for the sake of simplicity. Allowing for repayment in the form of future intentional losses (for which we uncover some empirical evidence) does not substantively change the logic. Allowing the wrestler who is buying the match to make a "take it or leave it" offer, and consequently to have all the bargaining power, will prove useful in simplifying the notation of the model. Wrestlers who intentionally lose in rigged matches will be indifferent between accepting the bribe or playing fair. This simplifies the model by eliminating any link between a wrestler's willingness to rig a match today and the probability he will face another wrestler in the future who wants to buy a match. Assumption *A5* sacrifices some realism in assuming that the fraction of wrestlers willing to participate in a rigged match is fixed and exogenous.[11] There are many reasons why an opponent may be unwilling to take a fall: he himself may be on the margin for an 8th win, he may be in the running for winning the overall tournament championship or one of the other prizes awarded to wrestlers with strong records (which carry large financial payoffs), he may simply be honest, etc. The fixed cost in *A6* may represent transaction costs, the possibility that the rigged match will be revealed leading to disgrace for the wrestlers, or side payments to a third party (such as the mob) to enforce the agreement.

Matches on the final day of the tournament

We begin by analzying matches occurring on day 15, the final day of the tournament.

Lemma 1: On day 15, matches will not be rigged if both of the wrestlers have exactly seven wins or neither of the wrestlers have exactly seven wins.

The logic behind Lemma (1) is straightforward. If neither wrestler is seeking an eighth win, then both wrestlers derive the same benefit from a win. The same is true if both wrestlers are trying for an 8th win. Because there is a fixed cost to rigging a match, total surplus from a rigged match is negative and such matches will not be rigged.

Given Lemma (1), we limit our attention to matches in which wrestlers *i* and *j* meet and (a) wrestler *i* has exactly seven wins going into the final day, (b) wrestler *j* does not have exactly

[11] One could imagine introducing a distribution of reservation prices across opponents, or allowing the bargaining costs to vary according to how frequently the wrestlers have met in the past or expect to meet again in the future. Given the simple points we are trying to make with the model, however, the added complication does not seem warranted.

seven wins, and (c) wrestler *j* is willing to throw the match if properly compensated (i.e. wrestler *j* is part of the fraction *R* of wrestlers in assumption *A5*). The payoff to wrestler *i* from a victory in a rigged match is

(1) $$W + W^* - P_{ij} - c/2$$

where W+W* is the payoff to winning an eighth match, P_{ij} is the bribe paid from wrestler *i* to wrestler *j* in return for throwing the match, and *c*/2 is the fixed cost incurred by the wrestler to engage in match riging. The amount of the bribe will be determined below.

The expected return to wrestler *i* from a fair match between *i* and *j* is

(2) $$\Pi_{ij}(W + W^*)$$

where Π_{ij}, is the probability that wrestler *i* is victorious in a fair match against *j*. The tradeoff facing wrestler *i* when deciding whether to rig a match is an increased chance of victory versus saving both the bribe and the fixed cost associated with match rigging.

Wrestler *j*'s payoff in a rigged match is

(3) $$P_{ij} - c/2$$

and in a fair match is

(4) $$(1 - \Pi_{ij})W$$

In a rigged match, wrestler *j* receives the bribe, but pays a fixed cost. In a fair match, he wins the payoff *W* with probability 1-Π_{ij}.

Because we assume that the wrestler offering the bribe has all of the bargaining power, the equilibrium bribe paid in a rigged match is easy to derive:

Lemma 2: In rigged matches, the bribe paid to the losing wrestler is $P_{ij} = (1-\Pi_{ij})W + c/2$.

By assumption A4, wrestler *i* will make an offer such that wrestler *j* is indifferent between throwing the match and having a fair bout. Setting equation (3) and (4) equal to one another and solving for P_{ij} yields the result in Lemma (2). The price paid in rigged matches depends on the likelihood that the bribed wrestler could have won a fairly fought match, the payoff to a win (other than the 8th win), and the fixed cost of rigging a match. Wrestlers who are more likely to win a fair match must be compensated more to be willing to throw the match.

Substituting the size of the bribe in Lemma (2) into equation (1) and subtracting equation (2) yields the conditions under which wrestler *i* prefers to rig the match

(5) $$(1-\Pi_{ij})W^* - c \geq 0$$

Because the wrestler offering the bribe has all the bargaining power, the left-hand-side of equation (5) also corresponds to the joint surplus from rigging the match. Equation (5) provides us with two predictions that we will investigate empirically:

Prediction 1: The greater the chances that the wrestler seeking an 8th victory could win a fair match against his opponent, the lower the likelihood he will attempt to rig the match.

Prediction 2: Fewer matches will be rigged when the fixed cost associated with corrupt bargains is higher.

Note that Prediction 1 hinges on the existence of fixed costs in match rigging. If there were no fixed costs, one would expect all matches when one wrestler is seeking an eighth win to be rigged, since the joint surplus is always positive. Prediction 2 is straightforward, but the question arises how one could test it empirically. We offer two possible tests. First, when media allegations of match rigging are circulating, the risk of detection may be higher, raising the expected costs of a collusive bargain. Second, to the extent that particular stables of wrestlers have frequently arranged such deals in the past, the costs of match rigging may be lower today.

Examining the incentives to rig matches on day 14 of a tournament

Characterizing the behavior of wrestlers in earlier rounds of the tournament involves added challenge because decisions will depend on expectations of outcomes of future matches. Consequently, we require an additional assumption about the distribution of potential opponents, and how expectations are formed:

A8) Opponents in future matches are unknown at the time the current match takes place. Future opponents are a random draw from the set of possible opponents.

A9) $(1-\overline{\Pi}_i)(W^*-W) - c \geq 0$, where $\overline{\Pi}_i = \arg\max_j(\Pi_{ij})\ \forall_j$.

The assumption that future opponents are unknown corresponds to the actual institutional detail of sumo. Opponents for the next day's matches are not announced until the completion of the current day's matches. Because there are roughly 60 competitors in a tournament, the range of possible pairings is enormous. Assumption A9 is the necessary condition for a crooked wrestler needing an eighth win on the final day to be willing to bribe any opponent he faces. This assumption greatly simplifies the algebra by making offering the bribe to any willing opponent a dominant strategy on the final day of the tournament. Relaxing this assumption does not materially change our results.

As was the case with matches on the 15th day, there will be no incentive on the 14th day to rig a bout if neither of the wrestlers are on the margin for achieving an eighth win (i.e. if neither of the wrestlers have either 6 or 7 wins going into the 14th day). In contrast to the last day of the tournament, however, there may actually be possible gains from trade if both wrestlers are on the margin for achieving eight wins.[12] In the analysis that follows, however, we will limit ourselves to the simpler case in which one wrestler is on the margin and the other wrestler is not.

<u>The incentives facing wrestlers with seven wins entering the next to last day</u>

We begin with the case of wrestlers with seven wins entering day 14. Defining notation, let $E^i_{d,w}$ be the continuation payoff for wrestler *i* if he enters day *d* with *w* wins. For instance, $E^i_{15,7}$ is the increment to utility that a wrestler expects to gain on the fifteenth day, conditional on having seven victories entering the final day. Then the expected utility of wrestler *i* with seven wins entering day 14 from rigging a match is

(6) $$W + W^* - P_{ij} - c/2 + E^i_{15,8}$$

and that wrestler's expected utility of engaging in a fair match is

(7) $$\Pi_{ij}(W + W^* + E^i_{15,8}) + (1 - \Pi_{ij})E^i_{15,7}$$

As long as the wrestler being offered the bribe is not on the margin for an eighth win, the equilibrium price to throw the match from Lemma 2 continues to hold. Substituting for the price and subtracting (7) from (6) gives the conditions under which a wrestler with seven wins wants

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[12] For instance, take two wrestlers: one who is very good and one who is very bad. The good (bad) wrestler each have seven wins going into the 14th day as a result of a series of negative (positive) shocks in earlier matches. The good wrestler is both likely to win the match on day 14 and on day 15, whereas the bad wrestler is likely to lose both matches. In this case, there is joint surplus associated with rigging the match because a victory has greater value to the bad wrestler.

to offer a bribe to his 14th opponent, namely:

$$(8) \qquad (1-\Pi_{ij})W^{*} - c + (1-\Pi_{ij})(E^{i}_{15,8} - E^{i}_{15,7}) \geq 0$$

With the exception of the final term in equation (8), the incentives to rig a match are identical for wrestlers with seven wins going into the 14th day and the 15th day (see equation 5). The only difference is that the wrestler on the 14th day must take into account the impact of rigging the match today on his future payoffs. It is straightforward to demonstrate that the term involving the continuation payoffs in equation (8) is always negative. Even if wrestler *i* never rigged a match on day 15, his expected continuation payoff entering the day with seven wins would be larger than the continuation payoff entering the day with eight wins. This is because a win on the last day is worth $W+W^*$ if the wrestler has seven wins, but is only worth W if the wrestler already has eight wins.[13] Allowing a wrestler the option of rigging the match on day 15 makes the term in equation (8) involving the continuation payoffs even more negative.[14]

The intuition as to why rigging the match on day 14 is less attractive than on day 15 is that there is option value in waiting to rig the match until the final day. If the wrestler can win the match fairly on day 14, he will achieve 8 wins, but saves the fixed cost and the bribe associated with buying a match. If he loses the fair match on day 14, he still has a chance to rig

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[13] This result relies on assumption *A8*, which implies that a wrestler's record thus far in the tournament does not affect the quality of the opponent assigned.

[14] The precise formula for the difference in continuation payoffs, taking into account the fact that by assumption only a fraction *R* of opponents are willing to throw the match on day 15, is:
$E^{i}_{15,8} - E^{i}_{15,7} = -\overline{\Pi}_i W^{*} - R[(1-\overline{\Pi}_i)W^{*} - c]$, where $\overline{\Pi}i$ the mean winning probability for wrestler *i* over all possible opponents.

the match on day 15 (although with some uncertainty since only *R* percent of opponents will rig a match).[15] More generally, it is straightforward (but tedious) to demonstrate that a similar intuition holds for all earlier days of the tournament. The earlier in the tournament one rigs the eighth victory, the greater the likelihood that the victory would have been attained by fighting fair, saving the fixed cost of rigging the match.[16] Thus, the payoff to match rigging is monotonically increasing over time for a wrestler with seven wins. This provides us with the third prediction of the model:

Prediction 3: For wrestlers with seven wins, the fraction of matches that are rigged will increase as the tournament gets closer to completion.

<u>The incentives facing wrestlers with six wins entering the next to last day</u>

A wrestler with six victories entering day 14 needs to win both of his final matches to achieve eight wins. Following the same approach used above, it can be shown that the wrestler with 6 wins entering day 14 will want to rig the match against an opponent (who is not on the margin for getting an eighth win) if and only if

$$(9) \qquad -c + (1 - \Pi_{ij})(E^{i}_{15,7} - E^{i}_{15,6}) \geq 0$$

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[15] Indeed, if a wrestler with seven wins going into day 14 can rig the match on day 15 with certainty, he would *never* want to rig the day 14 match.

[16] It is, of course, possible to demonstrate this claim formally. The easiest case in which to verify this is in the special case where if the wrestler does not rig the match today, he will never have another chance to rig a match – the scenario which maximizes the value of early match rigging for a wrestler with seven wins. In this scenario, conditional on having seven wins on day *t* of the tournament, eight wins will be obtained without any match rigging $1-(1-\overline{\Pi}_i)^{(15-t)}$ percent of the time, where $\overline{\Pi}_i$ the mean winning probability for wrestler *i* over all possible opponents.

Equation (9) differs from equations (5) and (8) in that there is no immediate benefit to rigging the match. The rigged victory does provides wrestler *i* with his 7th win. But the 7th win has exactly the same value to *i* as the win that his opponent had to forego, and the opponent must be fully compensated, via the bribe, for sacrificing the win. The only benefit to rigging the match is that it increases the continuation payoffs for day 15 by increasing the likelihood that the wrestler is positioned to achieve an 8th win (either legitimately or through a second rigged match). The last term in equation (9) is always positive because a win on the 15th day is worth $W+W^*$ if the wrestler enters the last day with seven wins, but is only worth W if the wrestler has six wins entering day 15.[17] It may or may not be the case that the continuation payoff in (10) is sufficiently positive to offset the cost c associated with rigging the match.

Deriving the precise formula for $E^i_{15,7}$ helps to shed insight on the conditions under which match rigging is most attractive:

$$
\begin{aligned}
E^i_{15,7} &= R[W^* - (1-\overline{\Pi}_i)W - c)] + (1-R)\overline{\Pi}_i(W^* + W) \\
&= \overline{\Pi}_i(W^* + W) + R[(1-\overline{\Pi}_i)W^* - c)]
\end{aligned}
\tag{10}
$$

where $\overline{\Pi}i$ is the mean winning percentage across all potential opponents for wrestler *i*. The first term of the equation on the second line of equation (10) is the expected payoff to the wrestler if he always fights fair. The second term, which is positive by assumption A9, is the surplus associated with rigging matches when the opponent is willing. By assumption A5, only a

[17] Any surplus associated with possible rigged matches on day 15 further increase the benefits of having rigged the match on day 14, since victories on both days are required to achieve eight wins.

fraction R of opponents are willing to throw the match. Note that, for a given wrestler i, $E^i_{15,6}$ and $E^i_{15,8}$ are simply equal to $\overline{\Pi}_i W$ since wrestlers with either six or eight wins entering day 15 will not have any incentive to rig the match.

Given equations (9) and (10), it is clear that for a wrestler with six wins entering day 14, rigging the match is increasingly attractive as R (the probability of meeting an opponent willing to rig another match on day 15) increases. If the wrestler who rigs the match on day 14 fails to win on day 15, then he has squandered the fixed cost associated with the day 14 bribe, so he would like to offer a bribe on day 15 also. A lower fraction of opponents willing to rig a match on day 15, in contrast, makes match rigging on day 14 for a wrestler with seven wins *more* attractive. The lower the chance that tomorrow's opponent will be willing to rig the match, the greater the payoff of a wrestler who only needs one more win over the last two days to rig the match on day 14. As noted earlier, If all opponents are willing to rig matches on day 15, then a wrestler with seven wins entering day 14 would never elect to rig the day 14 match.

The payoff to rigging the day 14 match for a wrestler with six wins is always less than the expected payoff to rigging the day 15 match for a wrestler with seven wins. The easiest way to prove this is to take the most favorable case for day 14 rigging, namely R=1. Substituting equation (10) into equation (9) under the assumption R=1 yields the condition under which the wrestler is willing to offer a bribe:

(11) $$(1-\Pi_{ij})(W^*-c)-c \geq 0$$

So even under the most favorable conditions (R=1), equation (11) is identical to equation (5) except that there is an extra cost term in equation (11), making the payoff to rigging the match smaller on day 14.

Following a parallel logic, it can be demonstrated that for a wrestler who needs to win all of his remaining matches to achieve eight wins, the benefit to match rigging increases monotonically as the tournament gets closer to completion. Thus, we have a fourth prediction of the model

Prediction 4: For wrestlers who need to win all of there remaining matches, the fraction of matches that are rigged will increase as the tournament gets closer to completion.

A final implication that emerges from the model relates to the distribution of wins across wrestlers at the conclusion of the tournament. If wrestlers engage in match rigging, then a disproportionate number of wrestlers will end with eight wins, and there will be a shortage of wrestlers finishing with seven wins. To the extent that there is bout rigging on earlier days of the tournament, we might also expect to see an unusually large number of wrestlers achieving nine wins as a result of wrestlers purchasing an eighth win on day 13 or 14, and then winning fair matches afterwards. The tendency for wrestlers to finish with nine wins would likely be exacerbated if either (1) wrestlers are risk averse (as opposed to being risk neutral in the model presented here), or (2) if the two wrestlers share the bargaining surplus, rather than the briber making a take-it-or-leave-it offer. If the wrestlers share the surplus, then it is likely that the bargaining power of the wrestler being bribed rises as the tournament comes to a close (since there are fewer substitutes for his services as the number of remaining rounds shrinks), making the price for buying a victory lower in the earlier rounds.

III. Evidence of Strong Performance on the Bubble

Our data set consists of almost every official sumo match that took place in the top rank (Sekitori) of Japanese sumo wrestling between January 1989 and January 2000. Six tournaments are held a year, with nearly 70 wrestlers per tournament, and 15 bouts per wrestler.[18] Thus, our initial data set consists of over 64,000 wrestler-matches representing over 32,000 total bouts (since there are two wrestlers per bout). A small number of observations (less than 5 percent of the total data set) are discarded due to missing data, coding errors, or early withdrawal from the tournament. A total of 281 wrestlers appear in our data, with the average number of observations per wrestler in a randomly selected match equal to 554, and a maximum of 990. The average number of total matches between the same two wrestlers competing in a randomly selected match is 10, thus we often have many observations involving the same two wrestlers at different points in time.

For each observation, we know the identity of the two competitors, who wins, the month and year of the tournament, and the day of the match (tournaments last 15 days with one match per wrestler per day). For roughly 98 percent of the sample, we also know what wrestling stable (known as a heya) the wrestlers belong to; information is missing for some wrestlers in the early part of our sample who had only a short stint in the top ranks.

We begin the analysis by looking at the distribution of wins across wrestlers at the end of tournaments. Our model predicts that a disproportionate number of wrestlers should finish with eight wins because of the high payoff associated with the eighth win (see Figure 1). To the

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[18] On average, less than 2 wrestlers withdraw over the course of a tournament because of injury. These wrestlers are excluded from our data. Occasionally, wrestlers complete more than 15 matches if the top wrestlers are tied at the end of the fifteenth day. These extra matches comprise only 0.2 percent of the total matches in the sample.

extent that wrestlers are rigging matches not only on the final day, but also in the days immediately preceding the end of the tournament, extra weight should also be observed on nine wins, as wrestlers who are close to the margin on days thirteen or fourteen may buy wins that ultimately were not needed to reach eight wins due to subsequent victories. Figure 2 presents a histogram of final wins for the roughly 4,000 wrestler-tournament observations in which a wrestler completes exactly 15 matches. For purposes of comparison, we also present the expected pattern of results assuming that all wrestlers are identical and that match outcomes are independently distributed.

Figure 2 provides clear visual evidence in support of the model's prediction. Approximately 26.0 percent of all wrestlers finish with exactly eight wins, compared to only 12.2 percent with seven wins.[19] The binomial distribution predicts that these two outcomes should occur with an equal frequency of 19.6 percent. The null hypothesis that the probability of seven and eight wins is equal can be rejected at resounding levels of statistical significance. Nine victories also appears more often than would be expected. Although this distortion is far less pronounced visually, nine victories are significantly more likely than six (16.2 percent versus 13.9 percent).

Table 1 presents the likelihood of a victory on the final day of the tournament for wrestlers with seven wins up to that point as a function of the number of wins that the opponent

[19]This distribution is similar to one found by Quetelet in 1846. He documented that the height distribution among French males based on measurements taken at conscription was normally distributed except for a puzzling shortage of men measuring 1.57-1.597 meters (roughly 5 feet 2 inches to 5 feet 3 inches) and an excess number of men below 1.57 meters. Not coincidentally, the minimum height for conscription into the Imperial army was 1.57 meters (Stigler, 1986).

has earned entering the last day. Column 1 reports the number of observations falling into each category. The second column has the actual win percentages. For purposes of comparison, column 3 presents the expected win percentage if these were fair matches, based on regression predictions of winning percentages in earlier rounds of tournaments (when collusion is less likely to occur) using winning percent thus far in the tournament and the rank differential between the wrestlers. The fourth column shows the differential between the first two columns.

Wrestlers on the bubble on day 15 have very high win percentages (>70 percent) against all opponents except those with ten or more wins and (by definition) against other wrestlers who also are on the bubble. The gap between actual and predicted victories is small (4.6 percent) when the opponent has less than three wins through the first fourteen days of the tournament. This is consistent with the prediction of the model that rates of match rigging fall when the wrestler on the bubble is likely to win a fair match. For opponents with 3-9 victories, the gap between actual and predicted win percentages is between 24 and 30. If all these excess wins are due to rigged matches, then these numbers imply that roughly half of such matches are rigged. Interestingly, there is no evidence of match rigging when opponents have ten or more wins. Although this result is superficially at odds with the prediction of our model, the explanation lies in the fact that wrestlers with ten or more wins are vying for the tournament championship and other special awards for good performance and thus have much to gain from an additional victory. Thus, even though the demand for buying a rigged match from a top opponent should be high, the actual number of rigged matches appears to be low because there is no supply.

We extend the analysis of the preceding paragraphs by estimating regressions of the general form

(12) $Win_{ijtd} = \beta Bubble_{itd} + \gamma Rankdiff_{ijt} + \lambda_{ij} + \delta_{it} + \epsilon_{ijtd}$

where *i* and *j* represent the two wrestlers, *t* corresponds to a particular tournament, and *d* is the day of the tournament. The unit of observation is a wrestler-match. *Bubble* is a vector of indicator variables capturing whether wrestler *i* or *j* is on the margin for reaching eighth wins in the bout in question. The *Bubble* variable is coded 1 if only the wrestler is on the margin, -1 if only the opponent is on the margin, and 0 if neither or both of the combatants are on the margin in the match. *Rankdiff*, is the gap between the official ranking of wrestler's *i* and *j* entering tournament *t*. In some regressions, we include fixed effects for each wrestler and each opponent; in other specifications we include wrestler-opponent interactions. In all cases, we estimate linear probability models, with standard errors corrected to take into account the fact that a match is included in the data set twice – once for wrestler *i* and once for wrestler *j*.

Table 2 reports the excess win percentages for wrestlers on the margin, by day, for the last five days of the tournament. On day 15, only wrestlers with exactly seven wins are on the margin; on day 14 wrestlers with either six or seven wins are on the margin, etc. The six columns correspond to different regression specifications. The even columns include the differences in ranks for the two wrestlers entering this tournament. The first two columns have no wrestler-fixed effects; columns 3 and 4 include wrestler-fixed and opponent-fixed effects. The final two columns add wrestler-opponent interactions so that the identification comes only from deviations in this match relative to other matches involving the same two wrestlers.

The results in Table 2 are quite similar across specifications. Wrestlers on the bubble on day 15 are victorious roughly 25 percent more often than would be expected. Win percentages are elevated about 15 percent on day 14, 11 percent on day 13, and 5 percent on day 12 for wrestlers on the margin. There is no statistically significant evidence of elevated win rates for wrestlers on the bubble on day 11. The pattern of coefficients is consistent with the prediction of the model that the frequency of match rigging will rise as the tournament comes to a close. If all of the excess wins are due to rigging, then the table implies that on day 15 half of the bubble matches are crooked. For days 12-14, the estimated percentage of rigged matches is roughly 10, 22, and 28 percent respectively.

Adding the difference in ranks has little impact on the other coefficients in the regression. The difference in ranks is an important predictor of match outcomes when wrestler-fixed effects are excluded from the model. The top-ranked wrestler facing an average wrestler would be expected to win about 70 percent of the time. Once we control for wrestler-fixed effects, however, the explanatory power of the difference in ranks disappears.

Table 3 breaks down excess win probabilities more finely for wrestlers on the bubble, e.g. seven wins entering day 14 versus six wins entering day 14. Indicator variables for wrestlers who are just off the margin (e.g. wrestlers with eight wins or six wins entering day 15) are also included for purposes of comparison. The day 15 results are similar to that of the previous table. On day 14, excess wins are evident for wrestlers with both six and seven wins, but are slightly higher for wrestlers with seven wins. Wrestlers entering day 13 with either six or seven victories win about ten percent more bouts than would be expected, but wrestlers with five wins – meaning they need to win three matches in a row – do not exhibit inflated win probabilities.

Those wrestlers who are just off the bubble (the bottom panel of Table 3) show no statistically significant deviations from expected wins, except for wrestlers with eight wins, who systematically perform worse than expected by 4-11 percentage points. Their poor performance is consistent with the fact that these wrestlers are especially likely to be matched against wrestlers on the bubble, and also would be likely to beat the wrestlers on the bubble in a fair bout, making match rigging more attractive.

IV. Distinguishing between Match Rigging and Effort

The empirical results presented thus far are consistent with a model in which opponents throw matches to allow wrestlers on the margin to achieve an eighth victory. The results, however, are also consistent with a scenario in which effort is an important determinant of the match outcome, and wrestlers on the bubble, having more to gain from a win, exert greater effort.[20] In this section, we present a wide variety of analyses that appear to confirm the corruption story and rule out effort as the explanation.

What characteristics influence the likelihood of winning when on the bubble?

We begin by analyzing the personal characteristics of the wrestlers involved in the match that influence the success rate of the wrestler on the bubble. The literature on repeated-play games (e.g. Fudenberg and Tirole 1991) suggests that the ability to sustain collusion should be positively related to the frequency with which two wrestlers expect to meet in the future since more future meetings imply the availability of more severe punishments for wrestlers who do not cooperate. Empirically, we proxy the expected frequency of future matches using two variables:

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[20] The results are also consistent with a model in which wrestlers show altruism for one another, sacrificing their own outcomes to help an opponent who has more to gain. Given the nature of athletics and the non-trivial cost to the wrestler of losing the match (roughly $10,000), the altruism story strikes us as unlikely explanation.

(1) the number of meetings between the two wrestlers that took place in the preceding year, and (2) whether the wrestler is in the last year of his career. Although the precise ending of a wrestler's career is not known in advance to the participants, it is likely that signals of retirement are available (e.g. declining performance, injuries, etc.).[21] If it takes time to establish a reputation as a wrestler who is willing to collude and who can be trusted, then one might predict that the longer a wrestler has been active in the top ranks of sumo, the better he will do when he is on the bubble, and also, the worse he will perform when the opponent is on the bubble.

The incentives to win a match may also be a function of the wrestlers' ranks. Within broad categories of ranks such as maegashira (roughly rank 10 to 40) and juryo (rank 40-66), pay scales are flat. Between these categories, however, there are substantial pay differences. A wrestler who is on the very last rungs of the rankings and thus at risk for falling out of a category, or at the very top with a chance to rise up to the next highest rank, might care more about winning an eighth match than a wrestler in the middle of juryo. Finally, because there are a series of monetary prizes given to wrestlers who have good records in a given tournament, wrestlers in the running for such prizes are less likely to be willing to throw matches.[22] The overall tournament champion wins $100,000; the juryo champion wins $20,000. In addition,

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[21] In order to minimize endogeneity, we exclude the very last tournament of a wrestler's career. It is possible that a loss on the bubble may drop the wrestler out of the top-level of wrestlers, inducing retirement. Including the last tournament of a wrestler's career slightly increased the magnitude and statistical significance of the coefficient.

[22] Although we do not directly observe which wrestlers might be under consideration for these prizes, having one of the five best records (plus ties) up until that point in the tournament is an excellent predictor. Wrestlers with one of the five best records in the tournament entering days 13, 14, or 15 win a prize 50 percent of the time. Less than five percent of wrestlers with records outside the top five on days 13-15 eventually win a prize.

$20,000 awards are distributed to the two wrestlers who have the best “fighting spirit” or the most “outstanding technique” during the tournament. In order to win those prizes, wrestlers must compile very strong records. The potential value of a victory for a wrestler in the running for such prizes is likely to be at least as great as the value to a wrestler on the margin for an eighth win. A similar argument may be true for the handful of very top-ranked wrestlers, who are expected to win a high fraction of their matches.

These various hypotheses are tested in Table 4. The table reports only the coefficients on the *interactions* between these various factors and the outcome of bubble matches. Also included in the specifications, but not shown in the table, are the main effects. Thus, the values in the table reflect the impact that a variable has on winning percentages when a wrestler is on the bubble, above and beyond any impact that variable has in non-bubble contests. Column 1 of the table does not include wrestler-opponent interactions as controls; the second column does. The results are categorically similar across the two columns of the table, although there are some differences in the magnitudes of some coefficients. The number of matches between two wrestlers in the preceding year has a positive impact on a wrestler’s likelihood of winning a match on the bubble, although the result is not statistically significant at the .05 level in either specification. Relative to two wrestlers who did not meet in the last year, wrestlers who faced each other four times in the last year are 4-5 percent more likely to see the wrestler on the bubble win (off of a baseline of about 15 percent). Wrestlers in the last year of their career are 4-5 percent less likely to win on the bubble, although the result is statistically significant in only one of the columns. Both of these results are consistent with the theory that part of the mechanism enforcing collusive arrangements is the threat of future punishment, but difficult to reconcile with an effort story.

With the exception of the last year, success on the bubble increases over the career. A five-year veteran is about five percentage points (off a baseline of 13 percentage points) more likely to win on the bubble than a rookie. This is consistent with the importance of developing a reputation.

As hypothesized above, wrestlers who are close to kink points in the incentive structure (i.e. near the very top or bottom of either juryo and maegashira) do better when on the bubble. A wrestler near a kink point wins an extra 2-5 percent of his bubble matches.[23] When the opponent is in the running for winning one of the special prizes awarded, any benefit of being on the bubble disappears. This result is consistent with opponents in the running for prizes being unwilling to throw a match. Interestingly, the very top ranked wrestlers tend to do quite poorly on the bubble. This result may be attributable to the fact that there is great prestige associated with beating a top-ranked wrestler. For instance, one of the statistics that is kept is the number of times that a given wrestler has beaten a top-ranked wrestler.

<u>What happens when wrestlers meet again in the future?</u>

If collusion is the reason that wrestlers on the bubble perform well, then the opponent must be compensated in some way for losing the match. In the model presented earlier, we assumed that transfers took the form of cash payments. It is also possible that such payments are

[23]Wrestlers in maegashira have ranks ranging from M1 through M15 (both East and West) while those in juryo range from J1 to J13. Those ranked M1-3, M13-15, J1-3, and J11-13 are defined as being close to the kink point. Those ranked above maegashira are separately considered in the empirical results, while those below juryo are not included in our data set.

supplemented or replaced by promises to return the favor in the future. The likelihood that two wrestlers will meet again soon is high: in our data 74 percent of the wrestlers who meet when one is on the margin for eight wins will face one another again within a year. In most of these future meetings, however, the wrestler who sacrificed the earlier match will not be on the margin for an 8^{th} win.[24] Nonetheless, a victory early in a tournament has both direct value to a wrestler and potentially may determine whether that wrestler ultimately achieves eight or more wins in the tournament.

Table 5 explores the pattern of match outcomes over time for wrestlers who meet when one is on the margin. The even columns include wrestler-opponent interactions so identification of the parameters comes only from variation in outcomes involving the same two opponents; the odd columns do not. The regression specifications include indicator variables categorizing the timing of the meetings between two wrestlers relative to the match where one wrestler is on the bubble. The omitted category is matches preceding a bubble meeting by at least three matches.[25]

Focusing first on columns 1 and 2, which correspond to all meetings on the bubble, there are no systematic differences in outcomes in the two matches preceding the match on the bubble, as reflected in the statistically insignificant coefficients in the top row. When the wrestler is on the bubble (second row), he is much more likely to win, consistent with the earlier tables. The parameter of greatest interest is the negative coefficient for the first meeting between the two

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[24] In fact, in our data we observe 14,685 different combinations of wrestlers and opponents. 4,572 of these meet on the bubble on days 13-15 at least once. Over three-quarters of the meetings on the bubble are between wrestlers who meet only once on the bubble.

[25] We have experimented with other groupings of matches, for instance allowing a different coefficient for matches preceding/following the bubble match by more than three meetings. The parameters of interest are not sensitive to alternative specifications.

wrestlers after the match in which the wrestler is on the bubble. The wrestler who was on the margin in the last meeting is approximately seven percent *less* likely to win than would otherwise be predicted. This finding is consistent with part of the compensation for throwing a match being the promise of the opponent returning the favor in the next meeting. There is no evidence that any return of favors extends beyond the next match, as two and three matches out the winning percentages return to normal.

The final four columns of Table 5 replicate the first two columns, except that the sample is divided into cases where the wrestler wins when on the margin versus instances when the wrestler loses when on the margin.[26] One would not expect a wrestler to intentionally lose in future meetings to an opponent who does not throw the match on the margin. Thus, breaking down the data in this way provides a natural test of the hypothesis that the poor performance in the next match is due to a deferred payoff to an opponent who threw a match. The data provide clear support for the collusion hypothesis. Wrestlers who win on the bubble tend to do slightly better than expected leading up to the bubble match, then do much worse in the next meeting with the same opponent. Relative to the surrounding matches, the first post-bubble match sees the wrestler losing approximately 10 percentage points more frequently than would be expected (i.e. row 3 minus row 1).

The pattern for wrestlers who lose to the opponent when on the margin for achieving eight wins is very different. In the matches just prior to the bubble match, the wrestler is slightly underperforming. This continues unaffected through the post-bubble matches as well. Unlike

[26] In columns 3-6, the actual matches taking place on the bubble are excluded from the regression since there is no variation. In columns 3 and 4, all bubble matches are won by the wrestler on the bubble; in columns 5 and 6 no matches are won by the wrestler on the bubble.

columns 1-4, there is no downward spike in wins following the bubble match. The finding that winners on the bubble fare badly the next time they face the same opponent, but losers do not, is consistent with the match-rigging hypothesis, but not with an effort story. If increased effort is responsible for strong performances in matches on the margin, there is no reason to expect systematic under-performance the next time the two wrestlers meet, and certainly not exclusively among those who won on the bubble.[27]

The payment-in-kind story suggested by the results above is unlikely to be the only form of compensation for wrestlers who throw matches. Based on Table 5, roughly two-thirds of the excess wins garnered on the bubble are returned the next time the two wrestlers meet. This price – two-thirds of a match down the road in return for throwing a match today – is too low to represent the only form of payment. When rumors circulate about match rigging in sumo, they often suggest the presence of cash transfers, although we are unable to provide any direct evidence about this channel.

Differential involvement across sumo stables?

As noted earlier, the lives of sumo wrestlers center around the stable, or heya, that they are associated with. Stables are led by masters known as Oyakata, who are themselves retired wrestlers. These stable-masters exert a tremendous influence over both the wrestling career of

[27] When two wrestlers meet and both are on the bubble, there is similarly no evidence that the wrestler who wins fares more poorly the next time the two wrestlers meet. This is consistent with no match rigging occurring when both wrestlers on the bubble, as predicted by the model.

More generally, there is no evidence of negative serial correlation in match outcomes. When multiple lags of past match outcomes between the two wrestlers are added to the specifications, the coefficients are positve.

wrestlers and their lives more generally.[28] Given the important role of the stable, and the fact that stable-masters benefit from having highly ranked wrestlers, it would not be surprising if corruption were coordinated at the stable level. For example, stables might have collective reputations, with stable-masters enforcing punishments on wrestlers who pursue their individual best interests at the expense of the stable. Some stable leaders, on the other hand, may not condone match rigging because of ethical concerns or risk aversion.

We explore these possibilities by examining how wrestlers in different stables perform when they are on the margin for an eighth win and when their opponents are on the margin. If match rigging is organized at the stable level, then one would expect those stables that actively engage in corruption to do very well when needing an eighth win and perform exceptionally badly when the opponent is seeking an eighth win. Note that this prediction would not arise in a model where effort is the key component of victory. If effort is the story, then there is no reason for those stables who perform particularly well on the margin to do especially badly when the opponent needs a win. On the contrary, one might think that wrestlers capable of exerting particularly high effort when they need a win might also rise to the occasion when faced with the opportunity to beat a very motivated opponent.

To test this hypothesis, we estimate specifications similar to those in Table 2, except that for wrestlers in the 10 largest stables we include interactions between stable dummies and whether the wrestler is on the margin on days 13-15, as well as interactions between stable dummies and whether the opponent is on the margin on days 13-15. The coefficients on these

[28] For instance, it is expected that the foremost sumo wrestler in a stable will marry the daughter of the stable-master, and that upon the master's retirement, will assume the role of master.

stable-level interactions are plotted in Figure 3. The horizontal axis is how much better a stable's wrestlers do than expected when they are on the bubble; the vertical axis is how they do when the opponent is on the margin. There is a striking negative relationship. Stables that perform especially well when seeking an eighth win offer the least resistance to opponents when they need a victory. This is consistent with a model in which the stable plays a role in coordinating match rigging. Of the 10 stables, we can reject the null hypothesis that performance is not affected by either the wrestler or the opponent being on the margin in nine of the ten cases. Only for one stable is there no clear evidence that bubble matches affect win rates. Two aspects of Figure 3 appear inconsistent with an effort story: (1) the downward slope of the points and (2) the presence of some stables that do not perform appreciably better when on the margin. If effort were the reason that wrestlers performed better when seeking an eighth win, one might expect this benefit to be spread equally across stables.

We further explore the link between a wrestler's performance on the bubble and how he does when an opponent is on the bubble in Table 6. In this table, we compute average win rates for individual wrestlers *when an opponent is on the bubble*. This variable, along with its interaction with whether a wrestler is on the bubble, are included in regressions similar to those presented earlier (although for simplicity in exposition, only the interaction term is reported in the table). Observations in which the opponent is on the bubble are dropped from the specification in Table 6, because the outcomes of these observations were used in computing the variable described above. The results, of this estimation are presented in columns 1 and 2. A wrestler who is 10 percent more likely to win when his opponent is on the bubble, is 2.3-2.9 percent *less* likely to win when he himself is on the bubble.

Columns 3 and 4 of Table 6 repeat the exercise of the first two columns, but substitute the win rate of the stable as a whole when the opponent is on the bubble. Once again, strong performances on average by wrestlers in the stable when opponents are on the bubble are associated with poor outcomes when the wrestlers themselves are on the bubble.

Columns 5 and 6 of Table 6 once again repeat the exercise, but this time the variables are based on interactions between two particular stables, i.e. how well do wrestlers in one stable do against wrestlers of a particular stable when those opponents are on the bubble. This specification allows for targeted reciprocity deals between stables, rather than simply assuming that some stables are uniformly more corrupt than others. Once again, the results are similar.

The final two columns of Table 6 combine the individual-level, stable-level, and stable-stable interactions into one specification. The results for individuals and for the stable-stable interactions remain, but the stable-level effects disappear. These results suggest two findings. First, the personal identity of the wrestler influences the degree of match rigging above and beyond any stable-level effects. Second, there do appear to be stable-level effects, but these do not operate as uniform differences across stables, but rather, as specific reciprocity arrangements between particular pairs of stables. Given the bubble history between two stables, controlling for the stable's experience in other bubble matches adds little to the predictive power.

<u>How do wrestlers on the margin perform when the costs of collusion are high?</u>

During our sample, there have been two periods in which media attention has focused on match rigging. The first of these was in April and May of 1996. A former sumo wrestler who had become a stable-master came forward with allegations of match rigging. At the same time, another former wrestler also came forward to decry rigged matches. Ironically, both of these men died a few weeks later, just hours apart, in the same hospital. This fueled speculation among the media of foul play, although a subsequent police investigation revealed no evidence for this. The second period of media scrutiny took place in late 1999-early 2000. The first sumo wrestler mentioned above had his book Yaocho ("Rigged Matches") released posthumously. The publication of this book led to widespread media coverage, even in the United States.

During times of media scrutiny, the likelihood of detection when match rigging is likely to be higher, increasing the cost associated with this activity. The fact that there are only two such time periods in which match rigging may be difficult limits us to anecdotal analysis, but the results are nonetheless intriguing. In the three tournaments most likely to be affected by the media attention (May 1996, November 1999, and January 2000), a total of 33 wrestlers finished with eight wins and seven losses, compared to 31 wrestlers with seven wins and eight losses, for a ratio of 1.06. This stands in stark contrast to the overall ratio of these variables in our data set of almost two to one. It is interesting to note, however, that match outcomes returned to normal soon after the scandals.

V. Conclusion

This paper provides strong statistical analysis documenting match rigging in sumo wrestling. The incentive structure of promotion leads to gains from trade between wrestlers on the margin for achieving a winning record and their opponents. We show that wrestlers win a disproportionate share of the matches when they are on the margin. Increased effort can not explain the findings. Consistent with predictions of game theoretic models of cooperation in repeated games, competitors who meet more frequently appear more likely to rig matches and collusion declines near the end of a wrestler's career. Wrestlers who are victorious when on the bubble lose more frequently than would be expected the next time they meet that opponent, suggesting that part of the payment for throwing a match is future payment in kind. Systematic differences across wrestling stables suggest that the stables play a role in facilitating the corruption.

While it is in the best interest of any individual sumo wrestler to rig matches, there are efficiency costs associated with the behavior uncovered in this paper. Match-rigging presumably detracts from the quality of competition viewed by millions of individuals. Recent examples in cricket and cycling reveal that the utility loss borne by viewers, while not necessarily known at the time of the competition, is significant.[29] Highly skilled wrestlers who are less willing to give and receive bribes may choose not to enter the sport or to retire early. Veterans of the sport are likely to benefit at the expense of younger wrestlers who are unable to break into the top ranks. Ranks within the sport are less accurate measures of an individual wrestler's skill than they would be in the absence of match-rigging. This will distort wrestlers' incentives to practice for future tournaments, as wrestlers will have opportunities to purchase victories from their competitors.

Although the aggregate social costs of match-rigging in sumo wrestling may be relatively

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[29]The admission by the captain of South Africa's cricket team earlier this year that he had accepted money in exchange for match-fixing led to a crisis within the sport that is still ongoing. Drug testing at the 1999 Tour de France revealed that several participants had taken banned substances to enhance their performance by increasing endurance. Many commentators believe that this practice is so widespread that any cyclists who choose not to do it are at an enormous disadvantage.

small, similar corrupt practices within public or private organizations could lead to substantial efficiency losses. The case study provided by Japan's national sport is potentially of use to future economic analysis of corruption. Anecdotal allegations of corrupt practices among sumo wrestlers have occasionally surfaced, but have been dismissed as impossible to substantiate. In this paper, we demonstrate that the combination of a clear understanding of the incentives facing participants combined with creative uses of data can reveal overwhelming statistical evidence of corruption. Details of the corrupt practices, the data sources, and the tell-tale patterns in the data will all vary from one application to the next. Nonetheless, the success of our study in documenting the predicted patterns of corruption in one context raises the hope that parallel studies with more substantive economic focus may yield similar results.

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Figure 1: Payoff to Tournament Wins

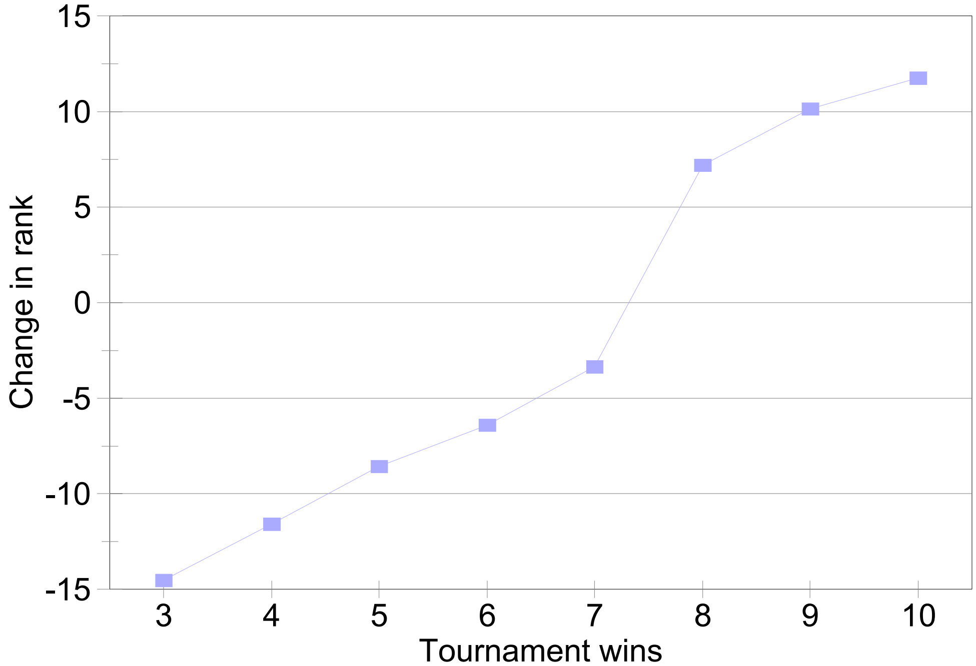

Figure 2: Wins in a Sumo Tournament

Actual vs. Binomial

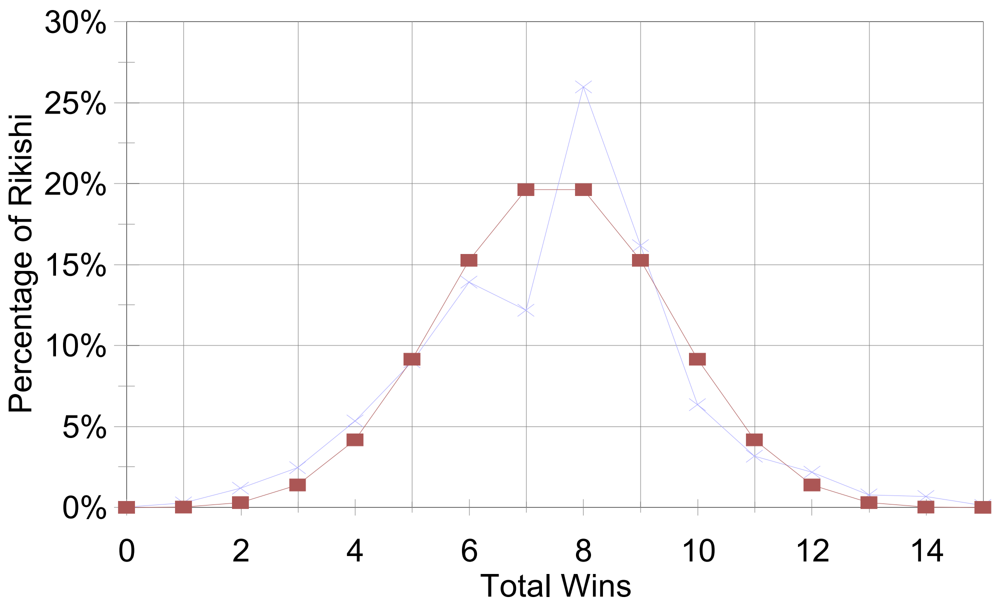

Figure 3: Heya-average Win Percentages when a Wrestler or his Opponent are on the Bubble (For the ten largest wrestling stables)

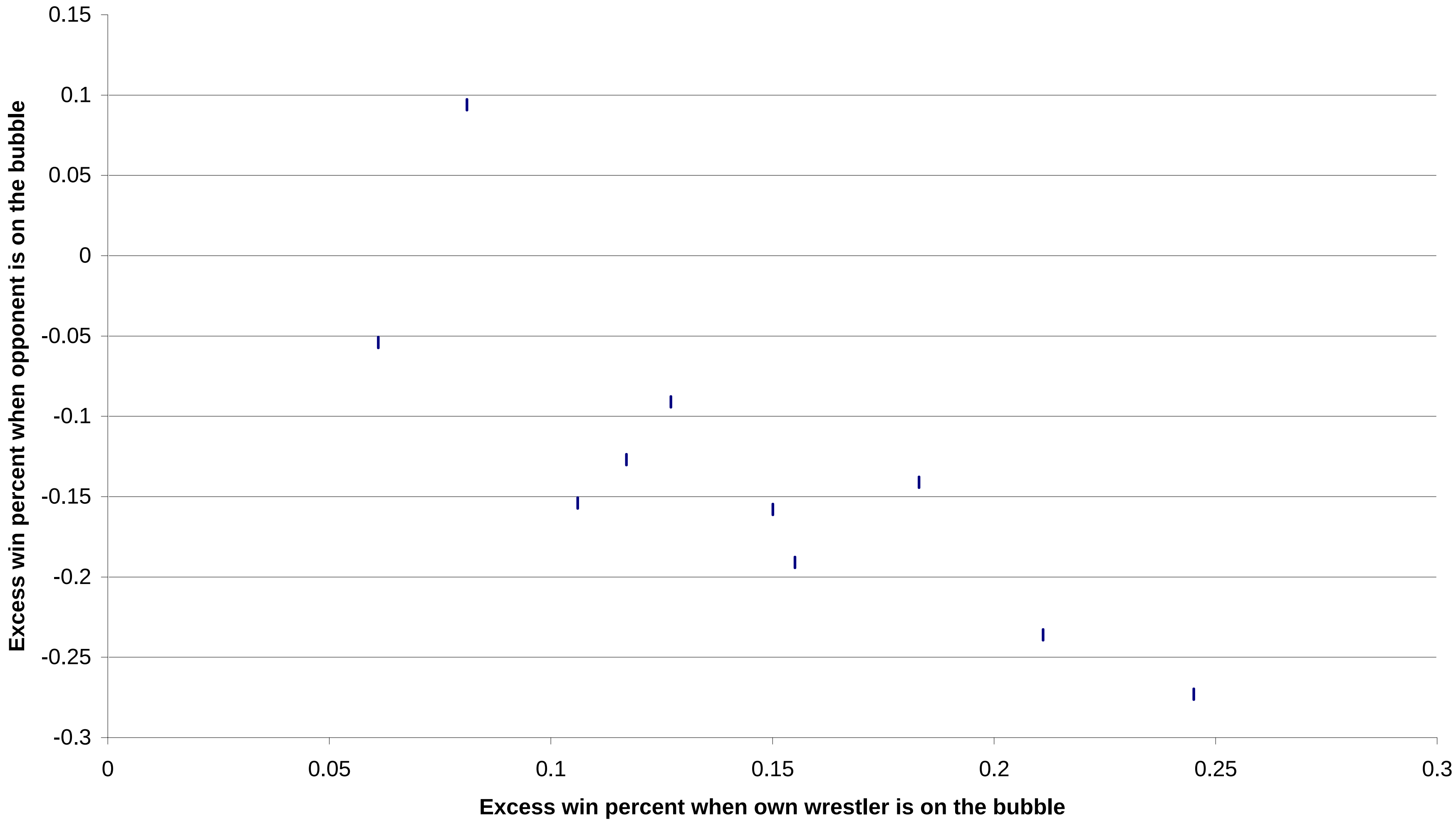

Table 1: Win Percentages of Wrestlers with Seven Wins Entering the Final Day, by Number of Previous Opponent Victories

Number of wins for opponent entering the final day	Number of actual matches	Actual win percentage of wrestlers with seven wins entering the final day against these opponents (%)	Predicted win percentage of wrestlers with seven wins entering the final day against these opponents, based on earlier round results (%)	Actual minus predicted (%)
Less than 3	32	71.9	67.3	4.6
3-5	99	77.8	53.7	24.1
6	101	76.2	51.2	25.0
8	201	79.6	48.7	30.9
9	79	73.4	47.2	26.2
10 or more	46	39.1	39.6	-0.5

Notes: Except for the column reporting the number of matches in our sample, table entries are the percentage of victories for wrestlers with seven wins entering the final day of the match in bouts against opponents with the number of wins in the first column. Actual wins are from our full sample of bouts. Predicted wins are base on regression results of bout outcomes on the tenth day of the tournament as a function of the winning percentage of each wrestler through the first nine bouts of a tournament and the difference in ranks of the two wrestlers. Predicted win percentages are calculated using the mean values in the sample for wrestlers with seven wins entering the final day and mean values for their opponents.

Table 2: Excess Win Percentages for Wrestlers on the Margin for Achieving an Eighth Win, by Day of the Match

On the margin on:	(1)	(2)	(3)	(4)	(5)	(6)
Day 15	.244 (.019)	.249 (.019)	.249 (.018)	.255 (.019)	.260 (.022)	.264 (.022)
Day 14	.150 (.016)	.155 (.016)	.152 (.016)	.157 (.016)	.168 (.019)	.171 (.019)
Day 13	.096 (.016)	.107 (.016)	.110 (.016)	.118 (.016)	.116 (.019)	.125 (.019)
Day 12	.038 (.017	.061 (.018)	.064 (.017)	.082 (.018)	.073 (.020)	.076 (.021)
Day 11	.000 (.018)	.018 (.018)	.015 (.018)	.025 (.018)	.010 (.021)	.012 (.021)
Rank difference	-----	.0053 (.0003)	-----	.0020 (.0003)	-----	-.0020 (.0004)
Constant	.500 (.000)	.500 (.000)	-----	-----	-----	-----
R-squared	.008	.018			.0634	.0653
Number of observations	64,272	62,708	64,272	62,708	64,272	62,708
Wrestler and opponent fixed effects	No	No	Yes	Yes	Yes	Yes
Wrestler-opponent interactions	No	No	No	No	Yes	Yes

Notes: The dependent variable in all regressions is an indicator variable corresponding to whether or not a wrestler wins the match. The unit of observation is a wrestler-match. Values reported in the table are coefficients associated with an indicator variable taking the value one if only the wrestler is on the margin for achieving eight wins, negative one if only the opponent is on the margin for achieving eight wins, and zero otherwise. On day 15, only wrestlers with seven wins are on the margin. On day 14, wrestlers with six or seven wins are on the margin. On day 13, wrestlers with five, six, or seven wins are on the margin, and so on. The omitted category in all regressions is all wrestlers who are not on the margin for achieving eight wins, as well as wrestlers in matches in which both participants are on the margin for eight wins. When a full set of wrestler and opponent fixed effects are included, the constant is omitted. In all cases, standard errors are corrected to account for the fact that there are two observations per bout (one for each wrestler). The differences in wrestler rank variable is the numerical rank order of the wrestler minus that of his opponent, based on official rankings published prior to each tournament. This variable is missing for part of our sample, leading to the decrease in the number of observations.

Table 3: Excess Win Percentages by Day of the Tournament and Wrestler Record

	No wrestler-fixed effects		Wrestler-opponent interactions	
Variable	Coefficient	Standard error	Coefficient	Standard error
On the margin:				
Day 15, 7 wins	.220	.021	.239	.025
Day 14, 7 wins	.166	.023	.186	.027
Day 14, 6 wins	.115	.024	.142	.029
Day 13, 7 wins	.080	.026	.097	.029
Day 13, 6 wins	.100	.025	.131	.029
Day 13, 5 wins	-.006	.026	.017	.031
Not on the margin:				
Day 15, 8 wins	-.057	.020	-.048	.026
Day 15, 6 wins	-.021	.023	-.011	.028
Day 14, 8 wins	-.040	.024	-.042	.028
Day 14, 5 wins	.024	.026	.051	.031
Day 13, 8 wins	-.108	.029	-.103	.032
Day 13, 4 wins	-.014	.029	.006	.035
Constant	.500	.000	-----	-----
R-squared	0.009		0.0645	

Notes: The dependent variable in all regressions is an indicator variable corresponding to whether or not a wrestler wins the match. The unit of observation is a wrestler-match. Values reported in the table are coefficients on indicator variables corresponding to the wrestler's number of wins entering a particular day of a tournament and that of his opponent. The top panel of the table corresponds to wrestlers on the margin for achieving an eighth win. The bottom panel of the table is wrestlers who have either already achieved the eighth win or are mathematically eliminated from doing so. The omitted category in all regressions is all wrestlers who are not in one of the named categories and are not facing a wrestler in one of the named categories. When a full set of wrestler and opponent fixed effects are included, the constant is omitted. In all cases, standard errors are corrected to account for the fact that there are two observations per bout (one for each wrestler). Number of observations is equal to 64,272.

Table 4: Determinants of Excess Win Likelihoods for Wrestlers on the Bubble

Variable	No wrestler-opponent interactions	Wrestler-opponent interactions
Wrestler on bubble	.132 (.023)	.134 (.027)
(Number of meetings between two opponents in the last year)*(wrestler on bubble)	.0120 (.0074)	.0095 (.0088)
(Wrestler on bubble in his last year of competing)*(wrestler on bubble)	-.054 (.032)	-.046 (.040)
(Years in sumo for wrestler on bubble)*(wrestler on bubble)	.0099 (.0031)	.0095 (.0038)
(Wrestler on bubble near kink in rankings)*(wrestler on bubble)	.023 (.022)	.047 (.027)
(Opponent in running for a prize this tournament)*(wrestler on bubble)	-.122 (.043)	-.126 (.050)
(Wrestler ranked above Maegashira)*(wrestler on bubble)	-.240 (.040)	-.207 (.047)
R-squared	.041	.274
Main effects of interactions also included in the regression but not shown	Yes	Yes
Wrestler-opponent interactions?	No	Yes

Notes: The dependent variable in both regressions is an indicator variable corresponding to whether or not a wrestler wins the match. In addition to the listed interaction terms, all main effects are also included in the specifications. Wrestler on bubble is an indicator variable that equals 1 (-1) if the wrestler (opponent) is on the bubble on days 13, 14, or 15 (record of 7-7, 7-6, 6-7, 7-5, 6-6, or 5-7) but the opponent (wrestler) is not, and zero otherwise. Matches from 1989, the first year of our sample, are excluded because the variable for the number of matches between the two wrestlers in the previous year cannot be computed. In all cases, standard errors are corrected to account for the fact that there are two observations per bout (one for each wrestler). The number of observations is equal to 58,185.

Table 5: Win Percentages in Preceding and Subsequent Matches
(For Two Wrestlers Who Meet when one is on the Margin in the Final Three Days of a Tournament)

Variable	All matches on the margin		Only matches in which the wrestler on the margin wins		Only matches in which the wrestler on the margin loses	
One or two matches prior to the bubble match	-.002 (.009)	.005 (.012)	.020 (.011)	.019 (.017)	-.041 (.016)	-.035 (.022)
Bubble match	.151 (.010)	.164 (.014)	-----	-----	-----	-----
First meeting after bubble match	-.073 (.011)	-.062 (.015)	-.082 (.015)	-.079 (.020)	-.056 (.020)	-.040 (.027)
Second meeting after bubble match	-.002 (.013)	.005 (.016)	.031 (.017)	.028 (.022)	-.061 (.023)	-.039 (.030)
Three or more meetings after bubble match	-.010 (.006)	.012 (.011)	.013 (.007)	.022 (.014)	-.045 (.008)	-.013 (.017)
Constant	.500 (.000)	-----	.500 (.000)	-----	.500 (.000)	-----
Wrestler-opponent interactions?	No	Yes	No	Yes	No	Yes
R-squared	.008	.271	.002	.279	.002	.279

Notes: Entries in the table are table are regression estimates of the outcomes of matches between, after, and contemporaneous with these two wrestlers meeting when one wrestler is on the margin for achieving eight wins on the last three days of the tournament. The dependent variable in all regressions is an indicator variable for whether the wrestler wins a match. The unit of observation is a wrestler-match. The first two columns correspond to all wrestlers who meet when one is on the margin. In columns three and four, the coefficients reported correspond only to those cases where the wrestler on the bubble wins the match. Columns five and six report coefficients only for those wrestlers on the bubble who lose the match. Columns 3 and 5 are estimated jointly, as are columns 4 and 6. Except for columns 1 and 2, bubble matches are excluded from the regressions. The excluded category in all regressions are matches occurring more than two matches prior to a bubble match and not falling into any of the other categories named. When a full set of wrestler and opponent fixed effects are included, the constant is omitted. In all cases, standard errors are corrected to account for the fact that there are two observations per bout (one for each wrestler). Number of observations is equal to 64,272.

Table 6: The Relationship between a Wrestler's Performance on the Bubble and his Performance when the Opponent is on the Bubble

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Wrestler on bubble	.122 (.016)	.135 (.020)	.053 (.024)	.073 (.030)	.214 (.026)	.219 (.030)	.138 (.047)	.150 (.055)
(Wrestler's excess win % if opponent on bubble)* (wrestler on bubble)	-.285 (.075)	-.226 (.092)	-----	-----	-----	-----	-.362 (.145)	-.275 (.183)
(Wrestler's stable's excess win % if opponent on bubble)* (wrestler on bubble)	-----	-----	-.544 (.125)	-.478 (.151)	-----	-----	.010 (.239)	-.043 (.277)
(Wrestler's stable's excess win % if wrestler from the opponent's stable is on the bubble) * (wrestler on bubble)	-----	-----	-----	-----	-.320 (.069)	-.304 (.080)	-.245 (.075)	-.240 (.085)
Constant	.524 (.002)	-----	.537 (.004)	-----	.491 (.004)	-----	.535 (.010)	-----
Wrestler-opponent interactions?	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	.006	.240	.004	.259	.002	.224	.005	.224

Notes: The dependent variable is whether a wrestler wins a match. The three interaction terms in the table reflect the impact of how a wrestler or his stablemates perform when their opponent is on the bubble for an eighth win to how the wrestler performs when he is on the bubble. A negative coefficient implies that wrestlers/wrestling stables who do well when their opponent is on the bubble do poorly when they themselves are on the bubble. The excess win percentage is calculated as the deviation from the win percentage observed when neither wrestler is on the bubble. Main effects of each variable in the interaction terms are included, even when not presented in the table. A wrestler is defined as on the bubble if the match takes place on days 13-15 and the wrestler is mathematically capable of reaching eighth wins, but has not yet done so prior to the match. Observations in which the opponent is on the bubble are excluded from the specifications because they are used in constructing the right-hand side variables. In all cases, standard errors are corrected to account for the fact that there are two observations per bout (one for each wrestler).