Match-Rigging in Professional Sumo:

Elucidation of Incentive Structures and Empirical Analysis[†]

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This paper first develops a simple model to show that incentives for match-rigging in professional sumo differ depending on the rank to which a wrestler belongs. While incentives for match-rigging can arise for wrestlers in the top divisions (*sekitori*), few incentives arise for wrestlers-in-training (*makushita* and below). We then report the results of our empirical analysis, which show that match-rigging in the top divisions has declined in the post-Duggan and Levitt (2002) period, and that at the wrestler-in-training level there was no statistically detectable match-rigging during any period. We find further that match-rigging in professional sumo has stabilized at statistically undetectable levels following the mobile phone text message match-rigging scandal, and that on average the wrestlers selected for sanctions following the scandal were in fact those most involved in match-rigging.

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1 Introduction

Match-rigging in professional sumo refers to the deliberate manipulation of the outcome of matches between wrestlers by means of the exchange of monetary consideration or future wins. Match-rigging in sumo performances has been the topic of reports for years in certain weekly magazines;[1] in addition there have been several reports[2] published by insiders after their departure from the *Nihon Sumo Kyokai* (Japan Sumo Wrestling Association). The practice had been largely taken for granted, as seen in the numerous sumo-related publications touching on the topic, although the *Nihon Sumo Kyokai* had denied its existence and there was no clear evidence. The fact that a number of wrestlers had been involved in acts of match-rigging was first clearly proven in February 2011 by mobile phone text message records confiscated from related parties by the National Police Agency during its investigation of the sumo/baseball wagering scandal the previous year.

Even assuming match-rigging in professional sumo did occur at times, it is neither in itself against the law, nor causes any harm other than to the expectations of fans betrayed by its revelation, and there are those who think it best not to expose or pry into it.[3] In addition, in the past match-rigging has been reported in such scandalous fashion that there is a certain hesitation to address it head on, and Japanese economists have not taken up the problem, with the notable exception of Nakajima (2003), who considered the background of match-rigging from an economic perspective. Filling the gap was the study by Duggan and Levitt (2000, 2002), and the popularization of its findings by Levitt and Dubner (2005) in *Freakanomics*, which garnered much attention but in practice was ignored by the sumo community and had no impact on the recognition in Japan of the existence of match-rigging, that is, until the mobile phone text message match-rigging scandal in February 2011.[4]

In this paper, in order to demonstrate that sumo wrestlers' choices (i.e., match-rigging) as revealed by the results of professional sumo matches are entirely consistent with an economic incentive structure, and thus that wrestlers can be presented with completely different choices depending on the contours of the incentive structure, we shall discuss match-rigging in terms of economic theory and analyze it empirically. There has been little economic research on match-rigging in professional sumo since the ground-breaking work of Nakajima (2003) and Duggan and Levitt (2000, 2002) (we are aware only of Dietl, Lang, and Werner (2010) and, in Japan, a short article by Hanazono (2012)); yet if only in the purely academic sense of cases of incentive structures impacting human behavior,[5] research into acts of match-rigging in sumo performances are of considerable significance. One might also note that full-fledged empirical studies of match-rigging to date have all

[1] See, for example, Shukan Post Editorial Office (2000).
[2] Representative examples include ex-Oyakata Onaruto (1996) and Itai (2000).
[3] See, for example, Tamaki (2011).
[4] In November 2010, just a few months before the match-rigging scandal erupted, the court decision ordering the payment of damages by Kodansaha in the defamation suit related to the report on match-rigging in the "Shukan Gendai" magazine it publishes was affirmed.
[5] Whether or not one goes as far as Levitt et al. and other US and European researchers in categorizing match-rigging in professional sumo as cases of "corruption," the subject provides a good example to demonstrate how choices are affected by economic incentives, thus illustrating the usefulness of economics.

been left to foreign researchers; it might even be considered unnatural that, with sumo being deeply ingrained in Japanese culture, Japanese researchers (who have a much more detailed grasp of the facts) have yet to grapple with the topic.

In this paper, therefore, we first develop a theoretical model slightly extending that of Nakajima (2003), and discuss the incentive structure for match-rigging in sumo. Specifically, what lay out the conditions for arriving at a match-rigging deal involving the purchase of wins, and the conditions for alternatively selecting a match-rigging deal involving the exchange of wins. It will become clear from this simple discussion that the incentives for match-rigging behavior in sumo performances differ depending on the rank to which each of the wrestlers belongs. In matches between the marquee wrestlers, incentives can arise for match-rigging taking the form of purchasing a win, whereas for wrestlers at other levels (so-called *hiramaku* and *juryo*) incentives are stronger to rig matches in the form of trading wins. In contrast, we can infer that for wrestlers-in-training (*makushita* down through *jonokuchi*), few incentives for match-rigging arise.

Based on the theoretical considerations in the first part of the paper, the second part then presents the results of our empirical analysis that extends the Duggan and Levitt (2002) style analysis to matches of wrestlers and wrestlers-in-training (*makushita* and below) from 2000 onward. Doing so, we make use of match-level data obtained from the "Sumo Reference" website, which covers all matches for the period from the November 1988 tournament (*basho*) through the July 2012 tournament, 390,000 in all. We start by reproducing the basic findings of Duggan and Levitt (referred to hereafter as D&L) and confirm the unnaturally high winning percentage for wrestlers for whom *kachikoshi* (more wins than losses) is at stake in the match — what D&L consider proof of match-rigging — and then proceed to analyze matches after D&L's study (i.e., post-2000) and at the wrestler-in-training level. The results suggest that in recent years match-rigging at the *hiramaku* and *juryo* level has declined considerably from the period studied by D&L, and that at the wrestler-in-training level there was no statistically detectable match-rigging during any period. In addition, when we analyze whether one could say that match-rigging has disappeared following the mobile phone text message match-rigging scandal, we find that match-rigging in professional sumo has stabilized at statistically undetectable levels since the technical examination tournament held in May 2011, and confirm that on average the wrestlers selected for sanctions following the scandal had in fact been those most involved in match-rigging.

This paper is structured as follows. First, in Section 2, we develop a theoretical model extending that of Nakajima (2003) and lay out the conditions for arriving at a match-rigging agreement involving the purchase of wins (Section 2.1), the conditions for selecting the exchange of wins (Section 2.2), and the incentive structure for match-rigging for each wrestling rank (Section 2.3). In Section 3, after briefly presenting an outline of the data used in the study, we discuss the relationship, as revealed by the data, between wrestlers' win-loss distribution and the impact (or

benefit) of one win on a wrestler's position on the *banzuke* (official listing of rank). In Section 4, after reproducing the basic findings from D&L, we examine the following three issues: (1) trends in match-rigging since 2000 and the situation as regards wrestlers-in-training (Sections 4.1 and 4.2); (2) trends in match-rigging following the mobile phone text message match-rigging scandal (Section 4.3); and (3) the appropriateness of the sanctions against those involved in response to the scandal (Section 4.4). Finally Section 5 presents our conclusions and discusses their implications.

2 Theoretical Model

In economic terms, match-rigging in sumo requires a situation where a net benefit arises that can be allocated in such a way that both wrestlers involved in a match can expect an advantage. Proceeding from this notion, this section extends to some degree the model given in Chapter 6 of Nakajima (2003)[6] and discusses the conditions under which match-rigging can occur with respect to both purchasing wins and trading wins.

2.1 Conditions for match-rigging involving purchasing of wins

Let the wrestler purchasing the win be denoted by *i* and the wrestler selling the win by *j*. We denote wrestler *i*'s belief regarding the probability of his winning in a *gachinko* match (sumo lingo for a truly-fought match) in the match in question as q_i and wrestler *j*'s belief as q_j. We further represent the gain to wrestler *i* of winning as W_i, and the loss of losing as L_i, and the gain and loss from winning or losing for wrestler *j* as W_j and L_j. Finally, we assume that wrestler *i* believes that the probability of suffering an injury involving loss I_i in a truly-fought match is θ_i, while the probability that he will be exposed and incur a penalty equivalent to P_i if he engages in match-rigging is π_i. Similarly, for wrestler *j* these values are represented by θ_j, I_j, π_j, and P_j.

Wrestler *i* will propose to wrestler *j* match-rigging in the form of purchasing the win in the case that his gain therefrom exceeds the expected gain from a *gachinko* (non-rigged) match. Assuming that the cost of purchasing the win is *Bp* and in addition a cost of $c_i \times Bp$ is incurred (for instance, the cost of raising funds for the purchase, or a commission paid to a match-rigging intermediary known as *chubon* or arranger), which differs for each wrestler (*i*), then the following inequality must hold:[7]

$$\underbrace{W_i - (1+c_i)Bp - \pi_i P_i}_{\text{Wrestler } i\text{'s expected gain from rigging}} > \underbrace{q_i W_i - (1-q_i)L_i - \theta_i I_i}_{\text{Wrestler } i\text{'s expected gain in case of a truly-fought match}} \quad (1).$$

At the same time, in order for wrestler *j* to accept the deal he is offered, his expected gain from doing so must exceed that from a truly-fought match. This is expressed by the following inequality:

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[6] The model developed here fundamentally has the same structure as models for choosing between suing and settling in the law and economics literature (see, for example, Miceli (1997), Chapter 8, and Shavell (1982)).

[7] In this model we do not consider the possibility that after the two wrestlers involved in the match (*i* and *j*) reach an agreement to rig the match, wrestler *j*, who was supposed to give up the win, goes back on the deal and instead tries to win himself. In the sense that a choice exists to renege on the deal one cannot rule out that possibility, but in the sumo business, with its repetitive game structure, the cost of doing so would be prohibitively high (reneging is an act which destroys the sumo community's trust, and in the long term incurs a large cost), meaning that we can safely assume that such a behavior would almost never be preferred in practice.

$$\underbrace{-L_j + Bp - \pi_j P_j}_{\text{Wrestler } j\text{'s expected gain from rigging}} > \underbrace{q_j W_j - (1-q_j)L_j - \theta_j I_j}_{\text{Wrestler } j\text{'s expected gain in case of a truly-fought match}} \qquad (2).$$

If for a given match inequalities (1) and (2) are both satisfied, then there is an advantage for both wrestlers in avoiding a truly-fought match and rigging it instead, with wrestler *i* buying the win from wrestler *j* for price *Bp*.

Combining the two inequalities and simplifying, we obtain

$$\frac{(1-q_i)(W_i + L_i) + (\theta_i I_i - \pi_i P_i)}{1 + c_i} > Bp > q_j(W_j + L_j) - (\theta_j I_j - \pi_j P_j) \qquad (3).$$

At any *Bp* that satisfies the inequality above, both wrestler *i* and wrestler *j* have an incentive to rig the match.[8] The larger the difference between the left-hand side of the inequality (wrestler *i*'s gain from match-rigging before deducting transaction costs, divided by $1+c_i$) and the right-hand side (wrestler *j*'s loss from match-rigging (losing) before deducting compensation received) the greater the sum of the gains for both wrestlers from rigging the match, and the greater the incentive to do so.

Viewed in more detail, match-rigging is more likely to occur when:

(a) The importance of a match differs between the wrestlers, with the match in question being more important to the purchaser (*i*) ($W_i + L_i >> W_j + L_j$).

(b) The two wrestlers' views of their chances of winning a match differ, with the purchaser believing the opponent's chances of winning to be higher than the opponent himself. ($(1-q_i) >> q_j$).

(c) Both wrestlers are seriously concerned about the risk of injury (θ_i).

(d) Both wrestlers view the risk of exposure as match-riggers to be low (π_P).

(e) Transaction costs (costs other than the purchase price) to purchasing wrestler *i* (c_i) are low.

2.2 Conditions for match-rigging involving exchange of wins

Next, instead of the purchase of a win, we consider the case in which wrestlers agree to exchange wins in the current *basho* (tournament) and the next one. We use the same notation for the probability of winning or losing in a truly-fought match, the gain or loss from winning or losing, the risk of injury, and the risk of detection as above for the case of purchasing a win, and denote variables relating to the match in the next *basho* with superscript *f*. We represent the requested price for the exchange of wins by Be, other associated costs by $c_i \times Be$, and the probability that there will be a match between the two wrestlers in the next *basho* by ρ. Further, we assume that if there is no match in the following *basho* then the requesting wrestler will pay the difference between the purchase price and requested price

[8] Whether match-rigging actually occurs depends on whether a *Bp* can be found which satisfies inequality (3) for both wrestlers. If enough time can be taken to negotiate the purchase price (and funding and intermediary costs are ignored), a *Bp* which satisfies inequality (3) for both wrestlers can be found and a match-rigging deal which benefits both will inevitably materialize. Insider reports such as that by Itai (2000) suggest that although the price to buy a match (*Bp* in the model developed here) could be different for each match, for most matches at the *hiramaku* level or below (since the time for price negotiations is limited and funding and negotiation costs cannot be ignored), the rigging choice is governed by whether or not the "market price" set for *Bp* satisfies inequality (3).

(*Bp*-*Be*) to his opponent (in addition to incurring the associated cost $c_i \times (Bp\text{-}Be)$). To simplify the discussion we assume a discount rate of zero.

The possibility that wrestler *i* will make a request to wrestler *j* arises when the expected gain from match-rigging involving the exchange of wins exceeds the expected gain from a truly-fought match. Mathematically, this is expressed by the following inequality:

$$\underbrace{W_i - (1+c_i)Be - \pi_i P_i - \rho_i L_i^f - (1-\rho_i)(1+c_i)(Bp-Be)}_{\text{Wrestler } i\text{'s expected gain from rigging}} > \underbrace{q_i W_i - (1-q_i)L_i - \theta_i I_i + \rho_i[q_i^f W_i^f - (1-q_i^f)L_i^f - \theta_i^f I_i^f]}_{\text{Wrestler } i\text{'s expected gain in case of a truly-fought match}} \quad (4).$$

On the other hand, to accept the request for an exchange of wins, the expected gain for wrestler *j* from accepting the match-rigging request must exceed the expected gain from a truly-fought match, which is expressed by the following inequality:

$$\underbrace{-L_j + Be - \pi_j P_j + \rho_j W_j^f + (1-\rho_j)(Bp-Be)}_{\text{Wrestler } j\text{'s expected gain from rigging}} > \underbrace{q_j W_j - (1-q_j)L_j - \theta_j I_j + \rho_j[q_j^f W_j^f - (1-q_j^f)L_j^f - \theta_j^f I_j^f]}_{\text{Wrestler } j\text{'s expected gain in case of a truly-fought match}} \quad (5).$$

Rearranging inequality (4) we obtain

$$[W_i - (1+c_i)Bp - \pi_i P_i] + \rho_i[(1+c_i)(Bp-Be) - q_i^f(W_i^f + L_i^f) + \theta_i^f I_i^f] > [q_i W_i - (1-q_i)L_i - \theta_i I_i] \quad (4)'$$

where the first set of square brackets on the left-hand side and the square brackets on the right-hand side correspond to the left-hand and right-hand sides of inequality (1). It follows that if a match is expected in the next *basho* (ρ_i>0), then the sign of the expression in the second set of square brackets on the left-hand side, i.e.,

$$\underbrace{(1+c_i)(Bp-Be)}_{\text{Saving from switching from purchase to exchange of win}} - \underbrace{[q_i^f(W_i^f + L_i^f) - \theta_i^f I_i^f]}_{\text{Cost of returning the win by losing in next basho}} \quad (6)$$

determines whether wrestler *i* prefers to buy or trade a win, and under the condition that inequality (1) is satisfied, if the sign is positive, then wrestler *i* will choose to exchange wins rather than purchasing the win (conversely, if the sign is negative, he will choose to purchase the win).[9]

Similarly, we can rearrange inequality (5) to obtain

$$[-L_j + Bp - \pi_j P_j] + \rho_j[(1-q_j^f)(W_j^f + L_j^f) + \theta_j^f I_j^f - (Bp-Be)] > [q_j W_j - (1-q_j)L_j - \theta_j I_j] \quad (5)'$$

Hence, based this time on a comparison with inequality (2), the sign of the expression in the second set of square brackets on the left side, i.e.,

$$\underbrace{(1-q_j^f)(W_j^f + L_j^f) + \theta_j^f I_j^f}_{\text{Gain in case of a definite win in the next basho when win is returned}} - \underbrace{(Bp-Be)}_{\text{Difference between gain from selling win vs. exchange win}} \quad (7)$$

determines whether wrestler *j* prefers to sell the win or trade it, and under the condition that inequality (2) is satisfied, if the sign is positive, then wrestler *j* will accept the offer to trade wins.

[9] Even in the case where inequality (1) is not satisfied and thus there is no advantage to wrestler *i* in rigging the match, depending on the magnitude of the positive second term on the right-hand side it is possible that there would be an advantage in rigging the match via trading of wins.

Thus, in addition to conditions (a) to (e) above, which detail under what circumstances match-rigging involving the purchase of wins is likely to occur, we obtain the following conditions regarding the circumstances under which the preference will be to rig the match in the form of trading wins:

(f) There is a possibility that the same two wrestlers will be scheduled to fight in the next *basho* ($\rho>0$).

(g) The cost to wrestler *i* (the one requesting the trade in wins) of having to lose the bout in the following *basho* is less than the reduction in associated costs from choosing to rig the match as a trade.

(h) The advantage to wrestler *j* (the one being offered the trade) of definitely being able to win in the following *basho* is larger than the reduction in compensation from trading the win instead of selling it.

If *Bp* and *Be* are given by their "market prices," condition (g) is more likely to hold if other associated costs c_i are large; if the value of winning in the match with the same opponent is expected not to be very large for wrestler *i* in the next *basho* ($W_i^f - L_i^f \to 0$); if wrestler *i* believes that the probability of winning over *j* in the next *basho* in a truly-fought match is small ($q_i^f \to 0$); or if wrestler *i* is seriously concerned about the risk of an injury in the next *basho* ($\theta_i^f I_i^f$). On the other hand, condition (h) is more likely to hold if the value of winning in the match against the same opponent in the next *basho* ($W_j^f - L_j^f$) is expected to become larger for wrestler *j*; if the probability that *j* can win against *i* in the next *basho* in a truly-fought match is small ($q_j^f \to 0$); and if wrestler *j* is seriously concerned about the risk of an injury in the next *basho* ($\theta_j^f I_j^f$).

2.3 Incentive structures by rank of wrestler

Applying the conditions derived up to Section 2.2 to *yokozuna* (grand champion), *ozeki* (champion) and other marquee wrestlers, since marquee wrestlers are likely to have easy access to credit, and the *kenshokin* (special prize money) riding on the matches provides in-hand liquidity, funding costs c_i are likely to be small and can be ignored. Furthermore, the (monetary) value of a win is in general greater for top-ranking wrestlers than mid-ranking ones, meaning that in a match between a top-ranking and a mid-ranking wrestler it is likely that the top-ranking wrestler will be on the purchasing side and inequality (3) will hold.[10] At the same time, in the case of a higher-ranking wrestler, since the majority of his matches are against lower-ranking wrestlers, the likelihood of winning in the next *basho* in a truly-fought match is high. In addition, higher-ranking wrestlers are essentially expected to rack up ten or more wins each *basho*, making it unlikely in principle that the

[10] Even in matches between upper-ranked wrestlers, in cases such as when one has a chance to win the tournament and the other does not, or a promotion to *yokozuna* or *ozeki* is riding on the tournament results for one of the wrestlers, inequality (3) will hold and the possibility arises that the wrestler for whom the championship or promotion is at stake will wish to purchase a win.

value of a match in the next *basho* will decline greatly, which combined with a small value of c_i will lead to a negative value for eq. (6). Hence, the marquee wrestlers will almost never choose to trade a win rather than buying one. In other words, to the extent that the marquee wrestlers do engage in match-rigging, one may infer that in most cases this will take the form of purchasing a win.

On the other hand, for regular *sekitori* wrestlers not at the top level, there are fewer special prizes and therefore funding cost c_i is higher; in addition, the value of a win can change dramatically before and after a wrestler achieves more wins than losses (*kachikoshi*), and the prospects of being able to win in a truly-fought match in the next *basho* is lower than for a marquee wrestler. Eq. (6) will therefore likely be positive and such wrestlers will tend to prefer an exchange of wins. If the wrestler *j* receiving the offer is also a non-elite *sekitori*-level wrestler, but does not think highly of his chances of being able to win in a truly-fought match in the next *basho*, equation (7) will be positive, and hence it becomes advantageous to accept the offer to trade a win. In other words, to the extent that match-rigging occurs among *hiramaku* or *juryo*-level *sekitori*, it is likely in the majority of cases to take the form of trading wins.

Finally, considering the case of so-called ”wrestlers-in-training” at the *makushita* level or below, the monetary value of a win is intrinsically smaller than for a *sekitori*, meaning that the difference in the importance of a win between two wrestlers is also smaller. Furthermore, since one probably cannot ignore funding costs for wrestlers-in-training, c_i is larger. Thus inequality (3) does not hold, and at this level we can predict that match-rigging in the form of buying wins will rarely arise. One might wonder whether, in lieu of money, matches might be rigged as trades, but in the case of *makushita* and below the probability of a match in the next *basho* with the same opponent is extremely low ($\rho \to 0$), and it is therefore hard to imagine a situation where win purchasing would not occur but win trading would. In other words, we can infer that in matches at the wrestler-in-training level almost no incentives for match-rigging would arise.

3 Data

3.1 Data sources

Based on the discussion in the preceding sections, we will now carry out an empirical analysis of match data for professional sumo over the last quarter century. The data used in the analysis in this paper comes from the detailed “Sumo Reference” information (about wrestlers, rankings, and matches) available publicly on the internet.[11] Although some parts of the “Sumo Reference” are incomplete, it contains ranking data all the way from 1757, and match information from 1909, through the present. To the authors’ knowledge it provides the most comprehensive record of sumo performances available to the general public. Taking data availability and the time range used by Duggan Levitt (2002), the primary earlier study, into account, we chose to conduct our analysis using

[11] See <http://sumodb.sumogames.de/>,

all ranking and match data for the 24-year period from the November 1988 tournament through the July 2012 tournament.

Table 1 provides an overview (number of observations) of the data used in the analysis. The sample is considerably larger than that used by D&L, with a time range slightly more than twice as long, and all wrestlers including wrestlers-in-training covered, for a total of 3,379 wrestlers (D&L had 200+), and 390,000 matches (D&L had 32,000).

To allow easier comparison of our findings with those of D&L, in what follows we have divided the observation period into three subperiods, the first from the January 1989 *basho* through the January 2000 *basho*; the second starting after D&L and extending to the mobile phone text message scandal, from March 2000 through the January 2011 *basho*; and the third following the scandal, from the May 2011 (technical examination) *basho* onwards.

3.2 Skew in win-loss distribution and non-linearity of payofff

The match-rigging problem in professional sumo is commonly described by the expression that "wrestlers going into the last day of the 15-day tournament (*senshuraku*) with a 7–7 record hardly ever lose," and Duggan and Levitt (2000, 2002) argue that there is a link between the skew in the win-loss distribution (7–8 records are few and 8–7 records unusually common) and the non-linearity of the payoff arising from a win (in other words, the effect of winning one additional match on the *banzuke* (official listing of rank) for the next *basho*).

Even with our expanded data set we can easily verify the skew in win-loss distribution and non-linearity of the payoff observed by D&L and shown in their diagrams (see upper part of our Fig. 1). When opposing wrestlers compete on the basis of their true strength, wins and losses should follow a binomial distribution, given that the probability of winning and losing should be equal. However, at the *sekitori* level and above, the distribution of results clearly displays a smaller number of wrestlers ending with seven wins, and conversely an unnaturally large number of wrestlers ending with eight (Fig. 1 A1). Fig. 1 B1 shows the result of computing the marginal effect on the *banzuke* for the next *basho* from one extra win, obtained by first calculating the average of how much the *banzuke* ranking for the next *basho* changed for wrestlers with each record (number of wins) and then taking the difference in the averages (the difference in the averages for each one additional win). D&L argue that the benefit from a win (marginal effect) is dramatically larger for the eighth win, hence the incentives for match-rigging for the eighth win.

Nevertheless, as is obvious to any Japanese with a modicum of sumo knowledge, the value of a win (or, which win is more important) differs widely depending on the rank of the wrestler, as does the distribution of win-loss records. The middle row of Fig. 1 (A2 and B2) shows the distribution of win-loss records and non-linearity of the payoff for five tiers in the *sekitori* level (*yokozuna*, *ozeki* and *komusubi*, *hiramaku*, and *juryo*). The results demonstrate the special importance of the eighth win

as hypothesized by D&L, but indicate also that a noticeable irregularity can be discerned only for *hiramaku* and *juryo* wrestlers.

This is in line with the theoretical model in the previous section, which showed that the incentive structures for match-rigging differ for marquee wrestlers vs. other regular *sekitori.* Given this, in the empirical section below, we conduct our analysis for all *sekitori* in order to allow comparisons with D&L, as well as for *hiramaku* and *juryo* only in order concentrate on those levels where match-rigging incentives around *kachikoshi* are most pronounced (therefore, we do not directly address the possibility that match-rigging by marquee wrestlers may take other forms than the one we focus on here, i.e., that wrestlers for whom *kachikoshi* is at stake are unnaturally likely to win).

Finally, the bottom row of Fig. 1 (A3, B3) depicts the win-loss distribution for wrestlers-in-training at the *makushita* level and below, and the payoff from one win for each number of wins. What is particularly interesting is that (more or less in line with the theoretical considerations above) although the payoff pattern clearly is similarly non-linear at the wrestler-in-training level (where the fourth win has particular importance), we find that the win-loss distribution for wrestlers-in-training almost perfectly tracks the binominal distribution. In other words, there is no skew in the win-loss distribution for wrestlers-in-training such as is seen for *sekitori* that would lead to suspicions of match-rigging. The fact that (almost) no match-rigging can be discerned, in spite of the non-linearity of the value of (i.e., payoff from) one win, can be attributed to the fact that the great majority of matches between wrestlers-in-training, unlike matches between *sekitori*, are of the so-called *aiboshi* form (where wrestlers with identical records in that tournament up to the point of the match are paired) (Figure 2), as well as the impact of the wrestlers-in-training having no money to buy wins and no possibility of a rematch in the next tournament that could be used to trade wins.

4 Empirical Analysis

The theoretical considerations in Section 2 and the overview of the data provided in the previous section suggested that, from the perspective of economic theory, there was a high likelihood of match-rigging in professional sumo performances, and that a skew is present in the actual win-loss distribution (especially at the *hiramaku* and *juryo* level) that is consistent with the theoretically derived match-rigging patterns. This section examines the skew more formally by applying to the extended dataset used in this paper a number of variations of the regression analysis (regression showing noticeably heightened winning percentage in matches in which the possibility of *kachikoshi* is at stake[12]) carried out by Duggan and Levitt (2002).

[12] A higher probability of winning in matches in which *kachikoshi* is at stake is not, in itself, adequate proof of match-rigging. The reason lies in the possibility that a wrestler placed in such a situation may win simply due to "trying harder." To reject this "trying harder" hypothesis, Duggan and Levitt (2002) show that the phenomenon of higher winning probabilities when *kachikoshi* is at stake (1) is less frequent immediately following spates of news reports of match-rigging; (2) is more pronounced with veteran wrestlers; and (3) is especially high in bouts between members of the same *heya* or stable; moreover, they show (4) that in the *basho* following a match suspected to be rigged, the winning percentage of the winner in the earlier *basho* declines in a way suggestive of win-trading. Because the primary objective of the empirical analysis here is not to

4.1 Confirmation and extension of Duggan and Levitt study

Of all the theoretically derived factors creating the incentives to rig a match, one relatively more likely to be observed is the difference in the importance of the match to the opposing wrestlers. As shown in Figure 1 in the previous section, in professional sumo the effect of a win on the *banzuke* for the next tournament is greatest for the eighth win (or the fourth win for *makushita* and below), which determines *kachikoshi*, meaning that when *kachikoshi* is at stake for one wrestler but not the other, the match is almost without exception more important to the first. The difference in importance, furthermore, grows larger the closer to *senshuraku* (the 15th and last day of the tournament) a match is, as shown in the theoretical model by Duggan and Levitt (2000). Focusing on this issue, Duggan and Levit (2000, 2002), estimated a linear probability model along the following lines:

$$DWin_{i,j,t} = \sum_{n=11}^{15} \beta_n Dday_n \times Dbubble_{i,j,t} + \gamma \; Rankdiff_{i,j,t} + OtherCntrl + \varepsilon_{i,j,t} \qquad (8),$$

where *i* and *j* represent the two wrestlers involved in the match, and *t* is the tournament (*basho*). The unit of observation is one match by one wrestler (a single match thus counting twice in the data). The dependent variable (*DWin*) is a dummy variable taking 1 if the wrestler in question wins the match. $Ddav_n$ is a dummy variable which is 1 for the *n*th day of the tournament, otherwise 0. *Dbubble* is an indicator variable set to 1 if *kachikoshi* is at stake for that wrestler, -1 if for his opponent, and 0 if for neither. Matches where *kachikoshi* is at stake are defined as those on the 15th day where a wrestler has seven wins, on the 14th day where a wrestler has six or seven wins, on the 13th day where a wrestler has five, six or seven wins, and so on. *Rankdiff* is the difference in ranks between the wrestlers (wrestler *i* and wrestler *j*) if listed in *banzuke* order from *yokozuna* all the way down to *jonokuchi*. *OtherCntrl* represents other control variables such as wrestler fixed effects.

If matches are rigged, then the winning percentage for wrestlers for whom *kachikoshi* is at stake should be (unnaturally) higher, and grow as *senshuraku* approaches, meaning that we would expect the estimated coefficients to show the pattern $\beta_{15} > \beta_{14} > .... > 0$. Row (a) in Table 2-1 is an attempt to re-examine the most basic findings of D&L (2002) from matches by all *sekitori* from the January 1989 through the January 2000 *bashos*. As expected, we were able to reproduce larger significant positive coefficients as *senshuraku* neared. In other words, we were able to confirm D&L's finding that the winning percentage was significantly higher for wrestlers for whom the importance of the match was greater. Row (b) in Table 2-1 applies the same regression to *hiramaku* and *juryo* wrestlers only – that is, omitting the marquee wrestlers (*sanyaku* or above, i.e., *komusubi, sekiwake*, *ozeki,* and *yokozuna*). As predicted by the theoretical considerations, omitting from the sample matches in which the marquee wrestlers were involved makes the obtained pattern even more distinct.

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prove the existence of match-rigging, but rather to look at how the match-rigging patterns shown by D&L evolved in the period after that examined by D&L, we omit a similar analysis here, so that other than confirming the win-trading patterns (Section 4.2), we will proceed with our discussion with an eye solely on the winning percentage of wrestlers for whom *kachikoshi* was at stake.

So how has the match-rigging pattern found by D&L (2002) developed since the publication of their study? Row (c) of Table 2-1 shows the results of applying exactly the same methodology to match data for *hiramaku* and *juryo* from the March 2000 *basho* through the January 2011 *basho* (right before the text message match-rigging scandal erupted). It is noteworthy that the match-rigging pattern ($\beta_{15} > \beta_{14} > \beta_{13} > .... > 0$) during this period is again significant, but the coefficients are generally less than half the size of those for the period studied by D&L (2002). Put simply, this may indicate that while match-rigging continued, it was less widespread than before.[13]

Applying the same analysis to match data for wrestlers-in-training, regardless of the time range, we find no similar match-rigging pattern as observed in *sekitori* matches (Table 2-2). This finding, which is in line with our theoretical considerations, suggests that in matches at the wrestler-in-training level truly-fought matches are the norm even in non-*aiboshi* matches (matches between wrestlers with different win-loss records). Since the non-linearity of the effect of one win on the *banzuke* for the next tournament should be the same for wrestlers-in-training (for whom the fourth win is most meaningful), for a match to be rigged some condition other than the difference in importance of the match also must be playing a key role.

4.2 Investigation of the trading of wins

Section 2 suggested that match-rigging at the *hiramaku* and *juryo* level more commonly takes the form of trading wins. Being able to confirm a pattern of trading wins would be evidence that a higher winning percentage by wrestlers for whom *kachikoshi* is at stake is a reflection of match-rigging.[14] If match-rigging is taking place in the form of trading wins, then in a match during the following *basho* between the same two wrestlers previously suspected of making a match-rigging deal (where the wrestler for whom *kachikoshi* was at stake won), the wrestler who took the fall the previous time should have a significantly higher probability of winning (or, the wrestler who won the previous time should have a significantly lower probability of winning). To examine whether this is the case, we estimate the following linear probability model:

$$\begin{aligned} DWin_{i,j,t} = {} & \beta Dbubble_{i,j,t} + \alpha_s Dbubble_{i,j,t-1} \times DMrig_{i,j,t-1} \\ & + \alpha_f Dbubble_{i,j,t-1} \times (1 - DMrig_{i,j,t-1}) + \gamma Rankdiff_{i,j,t} + Others + \varepsilon_{i,j,t} \end{aligned} \tag{9}$$

DMrig is a dummy variable taking 1 if, in the match in the previous *basho* between wrestler *i* and wrestler *j*, the wrestler with *kachikoshi* at stake won, and 0 otherwise. If in fact match-rigging of the trading wins variety was occurring, we expect the estimated coefficients to be $\beta > 0$, $\alpha_s < 0$, and $\alpha_f \fallingdotseq 0$.

The results are shown in Table 3. For the time period used by D&L (2002), we observe a distinct win-trading pattern (column *c*), but in matches after 2000 the results are less distinct (column

[13] It is fascinating to ask why match-rigging declined following the time period analyzed by D&L. In their follow-up study of D&L using data through 2006, Dietl, Lang, and Werner (2010) argue that the reduction in match-rigging is due to a one-time weakening of the non-linearity of the effect of a win on the *banzuke* for the next *basho*. We feel that the importance of *kachikoshi* to a wrestler did not change that much and that their argument is rather unconvincing, but shall leave this issue for a future study.

[14] Regarding this point, see footnote 12.

f). The conclusion derived in the previous subsection, namely that match-rigging patterns appear most distinctly during the D&L period, and after 2000 moderate somewhat but do not completely disappear, also seems to be supported from the perspective of trading of wins.

4.3 Trends following the mobile phone text message match-rigging scandal

Our follow-up examination of Duggan and Levitt (2002) and the results of the analysis of the post-2000 match data for *sekitori* (excluding *sanyaku* and above) suggest that while match-rigging as defined by Levitt did decline starting in 2000 (compared to the period analyzed by D&L), it persisted until the uncovering of the match-rigging text message issue in February 2011. Upon learning of the mobile text message match-rigging scandal, the *Nihon Sumo Kyokai* was forced to cancel the Spring 2011 *basho* and then start over again with the technical examination *basho* in May of that year. The fact that those whose involvement in match-rigging (23 people in total) was confirmed were essentially driven out of the Kyokai must also have had a major impact on the wrestlers' awareness of the risk of being exposed as match-riggers.

The simple question in anyone's mind at this point is whether match-rigging has disappeared from professional sumo following the mobile text message match-rigging scandal.[15] To examine this question, it suffices to apply the type of regression from Tables 2 and 3 to the match data starting with the May 2011 technical examination *basho*. The points of note will be whether the β_n in model (8) take the form $\beta_{15} > \beta_{14} > .... > 0$ with significance, and whether the α_s in model (9) satisfy $\alpha_s < 0$ with significance. Table 4 shows the regression results from the match data starting with the technical examination *basho* for *hiramaku* and *juryo*. First, the β_n in model (8) not only are no longer significant, but also no longer show the pattern of becoming larger towards the end of the tournament. As to the α_s in model (9), although we do see negative coefficients, their magnitude (absolute value) has declined further from the post-2000 levels, and they are also not statistically significant. In other words, it appears that match-rigging at the *hiramaku* and *juryo* level has disappeared nearly completely in any form that can be detected statistically.[16]

4.4 Appropriateness of the sanctions on those involved

Upon learning of the problem that matches were being rigged via text messages, in addition to cancelling the Spring 2011 *basho*, the *Nihon Sumo Kyokai* established a special investigative committee to elucidate the situation, and based on its findings designated 23 people as having been involved in match-rigging, issuing recommendations to retire from active status to 19 wrestlers, recommendations to retire from employment to one stablemaster (*oyakata*), and two-year bans on match participation to a total of three wrestlers and stablemasters. While issuing these punishments, the executives of the *Kyokai* also tried to draw the curtain on the match-rigging scandal, claiming that

[15] That match-rigging can no longer be detected after the scandal provides evidence that it did exist prior to the scandal (in other words, that the observed patterns are not the result of the "trying harder" hypothesis).

[16] It must be understood that the analysis in this paper cannot distinguish between the elimination/reduction of match-rigging and match-rigging becoming more sophisticated, so that it becomes more difficult to detect.

"this is an entirely new problem which did not exist in the past whatsoever," and that no involvement by other wrestlers could be found, including those at the *yokozuna*, *ozeki*, *sekiwake*, and *komusubi* level. But some criticize this stance, saying that match-rigging in professional sumo has a long history, cannot be solved by simply cleansing the sport of a few unscrupulous wrestlers, and therefore it is unfair to punish only the wrestlers whose names happened to come out.

Can we really say that the wrestlers who were punished were more deeply involved in match-rigging than regular wrestlers who were not punished? Some of the punishments are now the topic of lawsuits and in this paper we cannot evaluate the situation with regard to individual wrestlers in terms of the appropriateness of the punishments. However, to confirm the overall pattern (the average appropriateness of punishment) it suffices to conduct a regression of the following form:

$$DWin_{i,j,t} = \beta Dbubble_{i,j,t} + \beta_{RR} Dbubble_{i,j,t} \times DRR_{i,j,t} + \beta_{RN} Dbubble_{i,j,t} \times DRN_{i,j,t} + \gamma Rankdiff_{i,j,t} + OtherCntrl + \varepsilon_{i,j,t} \quad (10)$$

where *DRR* is a dummy variable set to 1 if both wrestlers in the match in question were ones who were punished, and 0 otherwise, and *DRN* is a dummy variable set to 1 if one wrestler in the match in question was punished and the other was not, and 0 otherwise. We would expect that if only those wrestlers being punished were involved in match-rigging, and other wrestlers were clean, then $\beta \fallingdotseq 0$, $\beta_{RN} \fallingdotseq 0$, and $\beta_{RR} > 0$. Conversely, if there is no difference between the wrestlers who were punished and those who were not, then we should have $\beta > 0$, $\beta_{RR} \fallingdotseq 0$, and $\beta_{RN} \fallingdotseq 0$.

Table 5 summarizes the results of various estimations we tried across different time periods. For all time periods, the estimates largely show $\beta_{RR} > \beta_{RN} > \beta > 0$. At least based on these results, the inference is that the wrestlers who were punished in general did have a higher level of involvement in match-rigging, although one cannot go so far as to say that the wrestlers who were not punished were clean.[17]

5 Conclusions

In this paper we presented a simple theoretical model to elucidate the economic incentive structures in acts of match-rigging in professional sumo, and carried out several types of regression analysis following in the footsteps of Duggan and Levitt (2002).

The theoretical analysis showed that the incentive structure faced by wrestlers has a large influence on match-rigging behavior. Specifically, the analysis showed that incentives for match-rigging in the form of purchasing of a win will be greater when (1) there is a large difference in the importance of a match to the opposing wrestlers; (2) the risk of detection is thought to be small, while concerns over injury in a truly-fought match are large; and (3) funds for match-rigging can be easily obtained. On the other hand, an exchange of wins will be preferred when (4) there are strong

[17] The findings here mean that the wrestlers who were punished were, on average, more involved in match-rigging than those who were not punished, but that is not to say it means that the match-rigging punishments meted out this time to those wrestlers whose names happened to have come out were appropriate.

prospects that the same opponents will meet in the following *basho*; (5) it is expected that the value of a particular match will differ greatly between this *basho* and the next; and (6) funding-related costs cannot be ignored. The incentive structure shown by the theoretical model suggests that if marquee wrestlers engage in match-rigging this will take the form of purchasing a win, with it being most likely that the choice comes to the purchasing wrestler, while in the case of non-marquee wrestlers (*hiramaku/juryo*), there is a greater probability of choosing to exchange wins. On the other hand, at the wrestler-in-training level of *makushita* and below, it is hard to envision large incentives for match-rigging.

Next, from the results of the empirical analysis we carried out, using a data range twice as long as Duggan and Levitt (2002), and including wrestlers-in-training, we found that (1) it is highly likely that match-rigging at the *hiramaku/juryo* level, although reduced after 2000, existed throughout from the beginning of the period examined by D&L up to the beginning of 2011; (2) at the wrestler-in-training level, no match-rigging existed at a statistically detectable level; (3) following the mobile text message match-rigging scandal, match-rigging even at the *sekitori* level also disappeared in any form that is statistically detectable; and (4) compared to wrestlers who were not punished for match-rigging, those who were, at least on average, were highly likely to have been more deeply involved in match-rigging.

The findings in this study suggest that sumo wrestlers' choices vis-à-vis match-rigging, as revealed by the results of professional sumo matches, are entirely consistent with an economic incentive structure, and thus the wrestlers may possible be presented with entirely different choices depending on the contours of the incentive structure.

At present match-rigging in professional sumo is suppressed more than ever before, due most likely to a heightened awareness of the risk of exposure. This concern about risk of exposure can be attributed to having seen the uncovering of the issue and the punishments that followed, but there have been no other structural changes that would eradicate the incentives for match-rigging. It is thus undeniable that the possibility exists for a resurgence of match-rigging when memories of the people involved fade and concerns about risk of exposure recede. Of course, it is not necessarily right to consider professional sumo purely as a sport and therefore to seek to completely stamp out match-rigging. In a broader sense, one might be able to adopt the concept that the priority should be to enjoy, to the greatest extent possible, the entire culture including the human dynamics of winning and losing. In any case, if the *Nihon Sumo Kyokai* believes that it is important to control match-rigging for its own survival, then it will be essential for it to change the incentive structures giving rise to advantages from choosing to rig matches.

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Figure 1. Sample statistics (Number of observations)

		Number of *basho* (tournaments)	Number of *rikishi* (wrestlers)	Number of match combinations	Number of matches
Whole sample (From Jan. 1989 to Jul. 2012)	All *rikishi* (wrestlers)	141	3,379	231,346	387,562
	All *sekitori* wrestlers	141	354	14,560	68,586
	Hiramaku and *juryo* wrestlers	141	348	13,118	52,474
	Wrestlers-in-training	141	3,333	220,205	318,976
Duggan and Levitt (2002) period (From Jan. 1989 to Jan. 2000)	All *sekitori* wrestlers	67	205	7,111	32,091
	Hiramaku and *juryo* wrestlers	67	199	6,308	24,467
	Wrestlers-in-training	67	2,213	120,035	164,710
Post-D&L, before the mobile phone text message match-rigging scandal (From Mar. 2000 to Jan. 2011)	All *sekitori* wrestlers	66	200	7,244	32,505
	Hiramaku and *juryo* wrestlers	66	193	6,454	24,965
	Wrestlers-in-training	66	1,686	97,703	139,560
After the technical examination tournament (From May 2011 to Jul. 2012)	*Hiramaku* and *juryo* wrestlers	8	81	1,560	3,042

Notes: 1. Numbers by rank exceed the total for all *rikishi*, since a *rikishi* and a match can appear repeatedly in the different ranks. Similarly, the sum of the sub-period numbers does not necessarily agree with the number for the "Whole sample," since a *rikishi* or a match can be recorded repeatedly in multiple sub-periods.

2.The number of matches for all *sekitori* is defined as the number of all matches in which at least one of wrestler is *sekitori*. On the other hand, for *hiramaku* and *juryo* wrestlers, the number of matches is defined as the number of matches in which both of the wrestlers are at *hiramaku*/*juryo* level. Therefore, the matches between a *hiramaku* wrestler and a *sanyaku* wrestler are not counted as matches for *hiramaku* and *juryo* wrestlers.

Table 2. Excess win percentages for wrestlers on the margin of achieving *kachikoshi* , by day of the match

2-1. In the case of a *sekitori* wrestler

	All *sekitori* matches	*Hiramaku* /*juryo* matches	
	From Jan. 1989 to Jan. 2000 Duggan and Levitt (2002)	From Jan. 1989 to Jan. 2000	From Mar. 2000 to Jan. 2011
	(*a*)	(*b*)	(*c*)
Day 15	0.250 ***	0.272 ***	0.109 ***
	(0.021)	(0.023)	(0.025)
Day 14	0.146 ***	0.169 ***	0.068 ***
	(0.016)	(0.018)	(0.019)
Day 13	0.110 ***	0.145 ***	0.066 ***
	(0.016)	(0.019)	(0.019)
Day 12	0.072 ***	0.107 ***	0.038 *
	(0.018)	(0.022)	(0.021)
Day 11	0.012	0.057 **	0.046 *
	(0.021)	(0.029)	(0.024)
Rank difference	0.001	-0.001 ***	0.001 ***
	(0.0003)	(0.0003)	(0.0004)
Adjusted R^2	0.0595	0.0305	0.0386
Number of observations	64,182	48,934	49,930

Notes: 1. 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 1 if only the wrestler is on the margin of achieving eight wins, -1 if only the opponent is on the margin of achieving eight wins, and 0 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.

2. In all cases, standard errors are corrected to account for the fact that there are two observations per bout (one for each wrestler).

3. All regressions include fixed terms to control for the individual effect for each wrestler. As shown by Duggan and Levitt (2002), the effects of including the fixed terms on the key estimates are limited and do not change the main conclusion of the analysis.

4 .***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

2-2. In the case of a wrestler-in-training

	All wrestler-in-training matches	
	From Jan. 1989 to Jan. 2000	From Mar. 2000 to Jan. 2011
	(*a*)	(*b*)
Match 7	-0.003	0.020
	(0.039)	(0.040)
Match 6	-0.048	-0.030
	(0.037)	(0.036)
Match 5	0.004	-0.023
	(0.033)	(0.032)
Rank difference	0.002 ***	0.002 ***
	(0.0001)	(0.0001)
Adjusted R^2	0.0635	0.0777
Number of observations	329,420	278,276

Notes: 1. See the notes of Table 1.1 for the basic structure. The only difference is that the number of matches in a tournament in the case of wrestlers-in-training is seven. Therefore, in the 7th match, only wrestlers with three wins are on the margin. In the 6th match, wrestlers with two or three wins are on the margin, and so on.

Table 3. How distinct is the win-trading pattern?

	Hiramaku/*juryo* matches					
	From Jan. 1989 to Jan. 2000			From Mar. 2000 to Jan. 2011		
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
Wrestler on the bubble indicator variable (Day 13−Day 15)	0.184 ***	0.183 ***	0.183 ***	0.077 ***	0.077 ***	0.077 ***
	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)
Lagged indicator variable		-0.096 ***			-0.031 *	
		(0.018)			(0.019)	
Lagged indicator × the wrestler on the bubble won in the previous *basho*			-0.145 ***			-0.030
			(0.022)			(0.026)
Lagged indicator × the wrestler on the bubble lost in the previous *basho*			-0.010			-0.032
			(0.030)			(0.028)
Rank difference	-0.0011 ***	-0.0007 *	-0.0007 *	0.0017 ***	0.0019 ***	0.0019 ***
	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Indicator of whether wrestler won/lost in the previous *basho*		-0.046 ***	-0.041 ***		-0.020 ***	-0.020 ***
		(0.005)	(0.005)		(0.005)	(0.005)
Adjusted R^2	0.0267	0.0316	0.0320	0.0364	0.0371	0.0370
Number of observations	48,934	48,934	48,934	49,930	49,930	49,930

Notes: 1. The dependent variable in all three regressions is an indicator variable corresponding to whether or not a wrestler wins the match. The unit of observation is a wrestler-match.
2. "Wrestler on the bubble" refers to whether a wrestler was on the margin of kachikoshi and the opponent was not. The indicator variable takes 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 0 otherwise.
3. The lagged indicator variable is the wrestler on the bubble indicator variable in the previous *basho*. It takes 0 if the wrestler on the bubble indicator variable in the previous basho is missing.
4. The independent variable in the third row of the table is the product of the lagged indicator variable and a dummy variable taking 1 if the wrestler with *kachikoshi* at stake won, 0 otherwise. The independent variable in the fourth row of the table is the product of the lagged indicator variable and a dummy variable taking 1 if the wrestler with *kachikoshi* at stake lost, 0 otherwise.
5. Standard errors are corrected to account for the fact that there are two observations per bout.***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

Table 4. Trends following the mobile phone text message match-rigging scandal

4-1. Excess win percentages for wrestlers on the margin of achieving *kachikoshi*, by day of the match

	Hiramaku / *juryo* matches From May 2011 to Jul. 2012 (*a*)
Day 15	0.068
	(0.074)
Day 14	-0.007
	(0.058)
Day 13	0.034
	(0.052)
Day 12	0.073
	(0.056)
Day 11	-0.001
	(0.067)
Rank difference	-0.001
	(0.013)
Adjusted R^2	0.0760
Number of observations	6,084

Note: See the notes for Table 2-1.

4-2. How distinct is the win-trading pattern?

	Hiramaku / *juryo* matches From May 2011 to Jul. 2012		
	(*a*)	(*b*)	(*c*)
Wrestler on the bubble indicator variable	0.032	0.032	0.032
(Day 13－Day 15)	(0.034)	(0.034)	(0.034)
Lagged indicator variable		-0.013	
		(0.062)	
Lagged indicator × the wrestler on the bubble won in the previous *basho*			-0.031
			(0.094)
Lagged indicator × the wrestler on the bubble lost in the previous *basho*			0.0013
			(0.086)
Rank difference	0.0007	0.0006	0.0006
	(0.0013)	(0.0013)	(0.0013)
Indicator of the record in the previous *basho*		0.0048	0.0058
		(0.016)	(0.016)
Adjusted R^2	0.0672	0.0669	0.0668
Number of observations	6,084	6,084	6,084

Note: See the notes for Table 3.

Table 5. Difference between the wrestlers who were punished and who were not, before the mobile phone text message match-rigging scandal

	Hiramaku / *juryo* matches					
	From Mar. 2000 to Jan. 2011		From Mar. 2006 to Jan. 2011 (Five years before the mobile phone text message match-rigging scandal)		From Mar. 2009 to Jan. 2011 (Two years before the mobile phone text message match-rigging scandal)	
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
Wrestler on the bubble indicator variable (Day 13－Day 15)	0.077 ***	0.045 ***	0.103 ***	0.055 **	0.106 ***	0.037
	(0.012)	(0.014)	(0.017)	(0.024)	(0.027)	(0.041)
Both wrestlers in the match in question were wrestlers that were punished		0.160 ***		0.173 ***		0.138 *
		(0.044)		(0.052)		(0.076)
One wrestler in the match in question was punished and the other was not		0.077 ***		0.072 *		0.113 *
		(0.028)		(0.038)		(0.056)
Rank difference	0.0017 ***	0.0015 ***	-0.0007	-0.0007	-0.0017	-0.0016
	(0.0004)	(0.0004)	(0.0006)	(0.0006)	(0.0010)	(0.0010)
Adjusted R^2	0.0364	0.039	0.0463	0.0472	0.0510	0.0519
Number of observations	49,930	49,930	23,834	23,834	9,456	9,456

Notes: 1. The dependent variable in all three regressions is an indicator variable corresponding to whether or not a wrestler wins the match. The unit of observation is a wrestler-match.

2. The coefficients in the first row are those on the wrestler on the bubble indicator variable (see the note for Table 3 for its definition), and those in columns (*a*), (*c*), and (*e*) show the excess win percentages for wrestlers, while those in columns (*b*), (*d*), and (*f*) reads excess win percentages for wrestlers when both wrestlers in the match in question were wrestlers that were not punished.

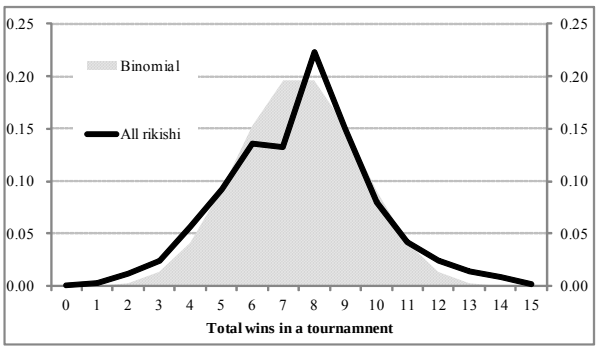
3. The coefficients in the second row are those on the product of the wrestler on bubble indicator variable and a dummy variable that takes 1 if both wrestlers in the match in question were wrestlers that were punished.

4. The coefficients in the third row are those on the product of the wrestler on bubble indicator variable and a dummy variable that takes 1 if one wrestler in the match in question was punished and the other was not.

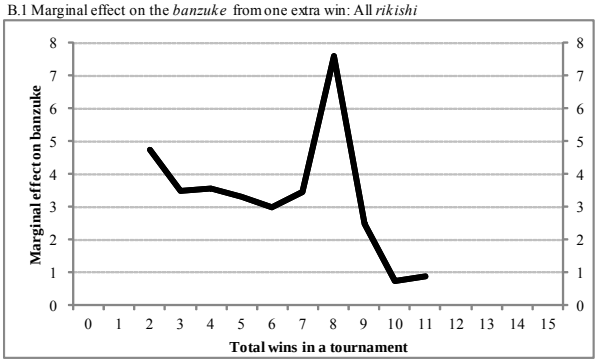
5. Standard errors are corrected to account for the fact that there are two observations per bout.***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

Figure 1. Distribution of records of sumo wrestlers (1989～2012) and marginal effect on the *banzuke* from one extra win

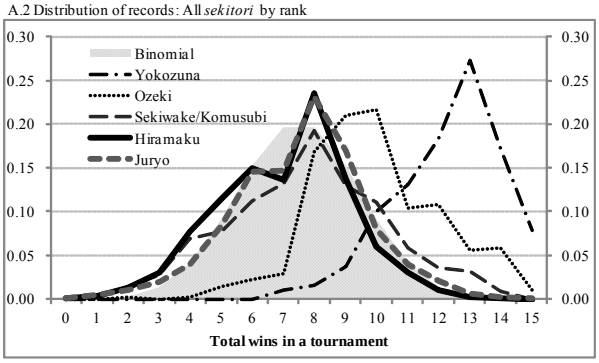
A.1 Distribution of records: All *rikishi*



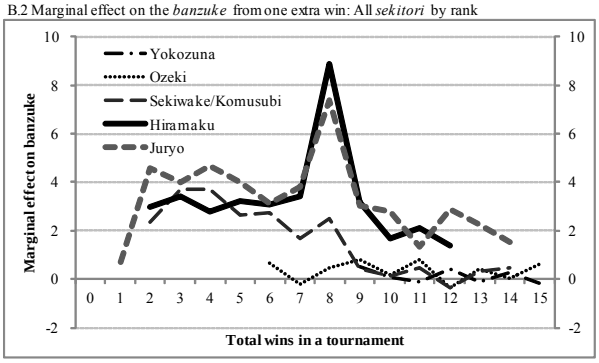
B.1 Marginal effect on the *banzuke* from one extra win: All *rikishi*



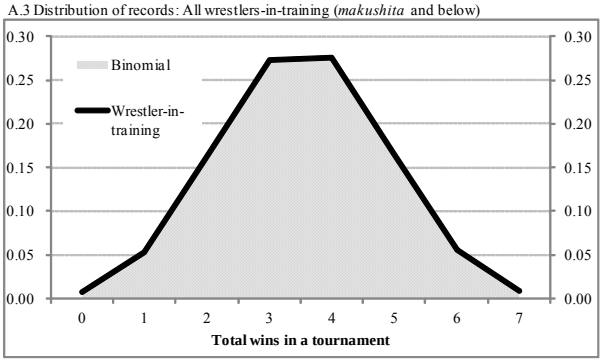
A.2 Distribution of records: All *sekitori* by rank



B.2 Marginal effect on the *banzuke* from one extra win: All *sekitori* by rank



A.3 Distribution of records: All wrestlers-in-training (*makushita* and below)



B.3 Marginal effect on the *banzuke* from one extra win: All wrestlers-in-training

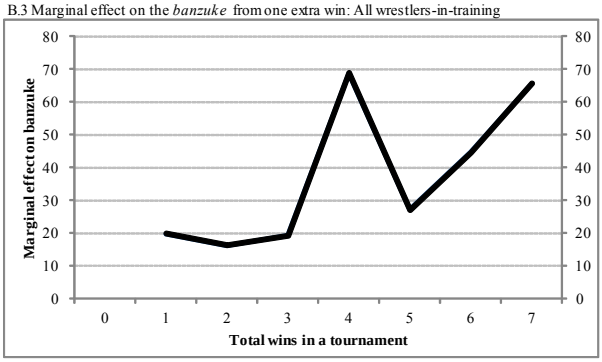
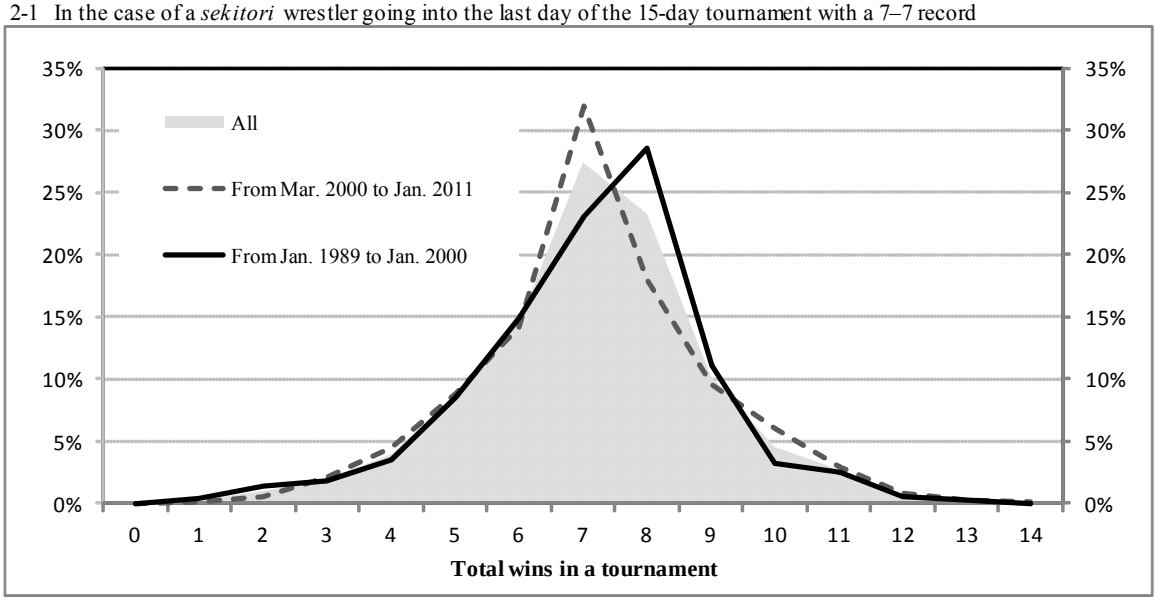


Figure 2. Distribution of records of opponent wrestlers
(until one match before the final *torikumi* in a tournament)

2-1 In the case of a *sekitori* wrestler going into the last day of the 15-day tournament with a 7–7 record



2-2 In the case of a wrestler-in-training going into the last match of the 7-match tournament with a 3-3 record