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Decomposing the Afternoon Effect: An Empirical Investigation of Sequential Train Ticket Auctions*

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Abstract

The afternoon effect, i.e., that prices in a sequence of auctions with identical items are decreasing with the order in which the auctions are terminated, is a frequently observed phenomenon in empirical auction studies. Using an unsurpassed amount of data from sequential online train ticket auctions, we investigate two hitherto unexplored dimensions inherent in sequential auctions, namely, the timing of auction ends and the presentation order of the auctions in a sequence. We find that both these dimensions are important for price formation in sequential auctions, but even when controlling for them, a sizable afternoon effect remains.

JEL Classification: D02; D44.

Keywords: sequential auctions; afternoon effect; presentation order; timing.

1 Introduction

Sequential auction formats are commonly adopted when selling multiple units of a good within a predetermined time frame. Examples include the selling of flowers, highway paving contracts, school milk contracts, timber, and wine (Joker-Boned and Disendower, 2003). There are several reasons for the popularity of the format, e.g., that it requires relatively little information exchange among the buyers and the auctioneer, it easily accommodates scenarios in which buyers enter and leave the market, and it allows the auctioneer to allocate items incrementally (Bae et al., 2009). A formal theoretical analysis of the auction format is, however, not straightforward. Consequently, much of the attention has been restricted to the case when items are identical and buyers have unit-demand. In this setting, Milgrom

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and Weber (1982) predicted that prices in a sequence of second-price auctions (Vickrey, 1961) with identical items should be equal.

The theoretical prediction in Milgrom and Weber (1982) has repeatedly been refuted in empirical investigations. Indeed, evidence that prices are decreasing in rank order, i.e., the order in which the auctions in the sequence are terminated, has been presented by, e.g., Ashenfelter (1989), McAfee and Vincent (1993), and van den Berg et al. (2001).[1] This anomaly was coined "the afternoon effect" because auctions later in a sequence typically took place in the afternoon whereas early auctions typically took place in the morning.

To make a fair empirical test of the prediction in Milgrom and Weber (1982), one must obviously find an auction environment that resembles their conditions.[2] The general auction infrastructure, that Milgrom and Weber (1982) visualize, supposes that "... the bidding proceeds in rounds... In each round, the remaining bidders submit sealed bids" (ibid.,p.3) and that the auctioneer sends the winning bidder "from the room" (ibid.,p.3). Thus, in their perfect theory world, bidders are gathered in a room together with a set of identical items, and the winning bidders leave the room one-by-one together with their purchased items. This is obviously quite different from how real life auctions are conducted, e.g., as bidders may enter and leave during the sequence of auctions, and bidders may have difficulties in coordinating bids between auctions if auction ends are close. Consequently, it is possible to identify a number of real life departures from the theoretical infrastructure. In particular, this paper focuses on departures related to timing and presentation order.

When it comes to timing, it has previously been demonstrated that the time elapsed between the auctions in a sequence may affect prices. For example, Andersson et al. (2012) find that when auction ends are identical, considerable price heterogeneity is observed between auctions, and Zeithammer (2006) shows that bids are lower when similar items are being auctioned off in the near future. On the other hand, Anwar et al. (2006) observe that bidders are less likely to bid on identical goods if their respective auction end times are far apart. Regarding the presentation order, we note that choices in Milgrom and Weber (1982) are modeled from the perspective of a set of items being auctioned off. Yet, bidders, in real life, typically face lists of items being auctioned off and the presentation order on the list may influence their decisions. This may create a "primacy effect", i.e., that items high up in a list are more prominent than items low down, or a reversed "recency effect" were items low down are more prominent than items high up (see Rubenstein and Salant, 2006, for a discussion).[3]

To investigate if the above two effects can explain the afternoon effect, we use data from

[1] Ashenfelter and Genesove (1992) and Beggs and Graddy (1997) found that this observation also holds for heterogeneous items, and evidence of increasing price sequences has been observed by Donald et al. (1997).

[2] A number of theoretical explanations, connected to various forms of risk aversion, have been suggested to explain the afternoon effect (e.g., Ashenfelter, 1989; McAfee and Vincent, 1993; Mezzetti, 2011). Unfortunately, none of these models have predictions that can be tested empirically unless estimates of the risk preferences of the bidders are available.

[3] In the literature on sponsored search (e.g., Agarwal, 2011) and position auctions (e.g., Edelman et al., 2007), evidence of a primacy effect, from the perspective of the seller, is found.

more than 42,000 online train ticket auctions grouped into 7,200 sequential auctions. To identify and separate the effect of rank order to that of the timing and presentation order, a special design feature of the auction data is used. Namely, in all auction sequences, each ticket is assigned an auction number which determines the presentation order. However, the rank order, i.e., the auction termination, for each ticket is set by a random draw, which makes the time elapsed between two consecutive auctions random. To the best of our knowledge, this paper is the first to make this separation and estimate how these dimensions affect prices in sequential auctions.

Even though our data is ideal, a negative rank order effect (i.e., an afternoon effect) is found in the data. This confirms previous findings in the literature. The presentation order is, however, shown to have a negative impact on prices, suggesting a "primacy effect". Moreover, if ending times of two consecutive auctions are close, this has a negative impact on the prices in both auctions. However, the relationship shows substantial non-linearities so being placed far apart is also harmful to prices. Finally, we note that the rank order effect is essentially unaffected when controlling for presentation order and timing and, hence, a substantial part of the anomaly persist indicating that further research is needed to fully understand the afternoon effect.

2 The Sequential Train Ticket Auction

Statens Järnvägar (SJ, henceforth) is a publicly owned company that mainly runs passenger trains in Sweden. In 2007, they began to auction train tickets on the eBay-owned website Tradera which is the leading auction site in Sweden. This section describes the sequential auction mechanism that was adopted by SJ on November 15, 2010 and for the duration of the collected data.

Before introducing the notion of a sequence of auctions, we note that each train ticket is auctioned off in a separate auction. More specifically, each ticket is displayed at the website of Tradera exactly at 9pm at date t, and the following information is available for potential bidders:

(i) date of departure,

(ii) the "time block" when the train departures (05:00am–09:59am, 10:00am–02:59pm, or 03:00pm–08:59pm),

(iii) departure station, and;

(iv) final destination.

The reservation price of a ticket is always set to 1 SEK (approximately 0.11 USD). Bidders place bids by entering a maximum amount that they are willing to pay for the ticket. An automatic bidder (a proxy bidding agent) places bids on behalf of the agent using an automatic bid increment amount which depends on the current standing bid. The proxy bidder will only bid as much as necessary to make sure that the bidder remains the highest bidder up to the bidder's maximum amount (note that a bidder's maximum willingness to pay is kept confidential until it is exceeded by another bidder). The winner is the bidder with the highest bid when the auction ends, and the winner pays one bid increment above the highest loosing bid. In this sense, each train ticket auction resembles a second-price auction (Vickrey, 1961). Upon winning an auction, the winning bidder is asked to fill in his name and cell phone number, and the ticket is subsequently sent as a personal ticket by an SMS text message.

Two tickets are considered to be *identical* if conditions (i)–(iv) from the above are identical as there is no way of distinguishing the tickets apart. A set of auctions with identical tickets is called a *group of sequential auctions* (GSA, henceforth), or, simply, a *sequential auction*. Each ticket auction in a GSA is given an auction number which determines the *presentation order* on the website, i.e., the auction with the lowest number is displayed highest up on the website and has presentation order 1, the auction that is displayed second highest up has presentation order 2, and so on.

The *rank order* of an auction within a given GSA is defined as the order in which the auction is terminated, i.e., the auction that terminates first in a given GSA has rank order 1, the auction that terminates second in the same GSA has rank order 2, and so forth. Each auction in a GSA ends on date $t + 2$ between 9pm and 10pm, but more importantly, the exact ending minute of the auction is determined by a random draw from a uniform distribution on [0,59] that is made before the auction is announced on the website. As a consequence, the rank order and the presentation order for a ticket in a given GSA may differ, and, moreover, the time span between two consecutive auctions in a GSA is random. Hence, this allows us to disentangle the effect of timing and presentation order from that of the rank order effect. Yet, we note that the presentation order is based on the default ordering on the website and a bidder may alter this ordering by using different filters (e.g., auction ending time) which may put a downward bias on how our definition of presentation order affects prices.

3 Data Description

The data set consists of all train tickets sold by SJ on Tradera during the period 2010–11–15 to 2011–06–14. In total, $42,007$ tickets were sold in 42 different departure–destination routes during this period. These tickets can be partitioned into 7,202 GSAs with a total of more than 15,000 participating bidders. Table 1 summarizes the main characteristics of interest by route.

[**Table 1 about here**]

As can be seen from Table 1 some routes, usually from and/or to small communities, contain very few observations. This may be routes where auctions failed to generate enough bidding or "trial routes" that were discontinued. In addition, some particular routes, typically only the most popular ones (e.g., Göteborg C – Stockholm C), contain a few GSAs with very long sequences. In the empirical analysis, we therefore exclude the 10 routes with fewer than 100 tickets, and all GSAs containing more than 15 tickets. We also exclude auctions with only one bidder. Given these restrictions, the reduced dataset still contains 5,999 GSAs with a varying number of bidders and tickets.

4 Analysis

We get a rough initial indication of an afternoon effect, reminiscent of previous findings (e.g., Ashenfelter, 1989; McAfee and Vincent, 1993; and van den Berg et al., 2001), by simply plotting the average price for each rank order in Figure 1.

[**Figure 1 about here**]

To more precisely confirm the existence of an afternoon effect, a linear fixed effects model where each GSA is treated as an unbalanced panel is estimated. The specifications are quite flexible as we allow for quadratic terms in all variables of interest. Table 2 shows the main estimation results. Model (1) confirms the existence of an afternoon effect when we are not controlling for timing and presentation order. Model (2) includes a control for presentation order and in Model (3), we also include controls for timing by measuring the distance, in minutes, to the previous ("Minutes to previous") and next ("Minutes to next") auction in a GSA. We note that the rank order jumps up in Model (3) but this may be due to the fact that we, by construction, are excluding the first and last auction in each GSA in Model (3). The left panel in Figure 2 shows the estimated average marginal effect of rank order on prices for Model (3) in Table 2, and it illustrates that the negative price trend continues to hold even for high rank orders, even though the effect is diminishing as the rank order increases.

[**Table 2 about here**]

The right panel in Figure 2 shows the estimated marginal effect of presentation order on prices for Model (3) in Table 2. From the figure, it can be seen that the optimal placement, from the perspective of the seller, is at the top of the website. This indicates a primacy effect and corroborates previous findings from sponsored search literature (see, e.g., Agarwal 2011). However, in contrast to the literature on sponsored internet search, where the items are heterogenous and their position is usually determined by a position auction (see, e.g., Edelman et al., 2007; Varian, 2007), our items are completely homogenous. We also note that even though there is a negative effect of presentation order, the effective size is less than half the effect of the rank order of the auction. As noted earlier, this may be partly explained by bidders using filters to re-order the presentation of tickets.

[**Figure 2 about here**]

The left panel (right panel) in Figure 3 shows the distribution in minutes to the next (previous) auction, and the right panel (left panel) in Figure 4 shows the estimated average effect of time from subsequent (previous) auction on prices for for Model (3) in Table 2. As can be seen in the figure, there is an upward sloping trend for small time differences. This trend can, at least partly, be explained by the results in Andersson et al. (2012) and the theoretical predictions in Zeithammer (2006). The former suggests that if auction ends are identical, bidders may have problems cross bidding, i.e., it may be difficult for bidders to coordinate bids between auctions with similar termination times. The latter, on the other hand, suggests that bidders are more likely to be forward looking when subsequent auctions are closer which makes bidder less willing to place high bids in the current auction.

In general, the timing effect shows an inverted U-shape to the previous (subsequent) auction. One potential explanation for this price hike is that the more time that has passed since the previous auction ended, the more bidders have been able to enter and place bids in the current auction. The fact that timing seems to matter for the evolution of price sequences is interesting and we have not found any such results in the existing literature. According to our estimations, the optimal timing is to have the auction ends approximately 15 minutes apart, which may counteract the rank order effect.

[**Figure 3 about here**]

5 Conclusions

According to the received theory, prices in a sequence of auctions with identical items should be equal. This paper has investigated this theoretical prediction by taking a thorough look at prices in sequential auctions for train tickets in Sweden. We find that even when controlling for presentation order and the timing of auctions, which are important for price formation, average auction prices are declining in a sequence. This further strengthens the anomalous (afternoon effect) findings in the empirical auction literature. In addition, it is demonstrated that the presentation order on the auction website has a significant negative impact on prices, i.e., a primacy effect. When it comes to the effect on prices of the time distance between two consecutive auctions, it is found that having closeness in the time dimension has a negative impact on prices in both auctions. Consequently, the policy implication for the auction designer is that one should be careful in posting two auctions "too close" to each other as it may result in lower prices (for both items). Moreover, by randomizing the presentation order, the primacy effect may be down-played, but as it is hard to inherently control this order its effect on prices may be small.

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Table 1: Summary statistics for the considered departure–destination routes.

Departure – Destination	#A	#B/A (mean)	#B/A (sd)	#GSA	Price (mean)	Price (sd)	Min price	Max price
Arvika stn – Stockholm C	13	2.2	1.3	5	51.8	114.2	1.0	330.0
Duved stn – Stockholm C	166	2.5	1.2	41	72.4	87.9	1.0	350.0
Falun C – Stockholm C	2393	3.5	1.5	433	70.5	51.9	1.0	263.0
Göteborg C – Kalmar C	5	1.2	0.4	5	1.2	0.4	1.0	2.0
Göteborg C – Koebenhavn H	470	4.0	1.8	119	63.2	51.4	1.0	235.0
Göteborg C – Malmö C	885	3.6	1.7	184	68.5	55.1	1.0	265.0
Göteborg C – Oesterport	559	3.8	1.8	103	56.8	50.4	1.0	280.0
Göteborg C – Stockholm C	5385	5.5	2.6	480	188.2	141.2	1.0	900.0
Göteborg C – Sundsvall C	2	1.0	0.0	1	1.0	0.0	1.0	1.0
Halmstad C – Stockholm C	111	5.0	2.4	27	213.0	147.2	1.0	500.0
Hudiksvall stn – Stockholm C	3	1.7	1.2	1	2.3	2.3	1.0	5.0
Kalmar C – Göteborg C	2	1.0	0.0	2	1.0	0.0	1.0	1.0
Karlstad C – Stockholm C	2548	3.3	1.7	564	81.7	82.9	1.0	460.0
Kiruna C – Luleå C	416	2.2	1.1	177	50.0	61.5	1.0	245.0
Koebenhavn H – Göteborg C	281	4.1	1.6	70	75.1	51.0	1.0	250.0
Koebenhavn H – Stockholm C	147	5.9	2.2	44	193.9	117.0	1.0	560.0
Luleå C – Kiruna C	400	2.3	1.2	169	60.3	67.7	1.0	280.0
Luleå C – Narvik	379	2.2	1.1	158	51.5	62.8	1.0	389.0
Malmö C – Göteborg C	951	3.6	1.7	217	67.7	59.6	1.0	305.0
Malmö C – Stockholm C	3219	5.6	2.3	437	205.9	124.9	1.0	710.0
Mora stn – Stockholm C	3	1.7	0.6	1	6.7	8.1	1.0	16.0
Narvik – Luleå C	370	2.1	1.2	161	45.8	59.6	1.0	327.0
Odense – Stockholm C	23	5.3	2.3	5	144.9	114.6	7.0	370.0
Oesterport – Göteborg C	925	3.5	1.7	152	54.1	48.1	1.0	231.0
Oesterport – Stockholm C	219	6.4	2.3	53	264.5	141.8	4.0	630.0
Stockholm C – Borlänge C	392	3.0	1.5	105	50.8	47.3	1.0	260.0
Stockholm C – Duved stn	178	2.8	2.0	50	85.0	121.9	1.0	491.0
Stockholm C – Falun C	2098	3.3	1.7	447	63.1	56.5	1.0	295.0
Stockholm C – Göteborg C	5411	5.0	2.8	469	169.1	157.2	1.0	1075.0
Stockholm C – Halmstad C	45	3.3	2.5	14	122.0	153.1	1.0	598.0
Stockholm C – Karlstad C	2582	3.1	1.6	487	70.6	79.2	1.0	510.0
Stockholm C – Koebenhavn H	224	5.7	2.3	73	240.6	130.8	1.0	667.0
Stockholm C – Malmö C	1931	5.8	2.2	347	234.7	136.8	1.0	1225.0
Stockholm C – Odense	4	4.3	0.5	1	169.8	65.6	105.0	261.0
Stockholm C – Oesterport	786	4.9	2.3	166	193.9	147.8	1.0	1125.0
Stockholm C – Sundsvall C	3176	3.8	1.8	451	104.5	96.5	1.0	550.0
Stockholm C – Åre stn	508	3.3	1.8	106	117.4	121.1	1.0	550.0
Stockholm C – Östersund C	597	3.5	1.4	158	129.6	120.6	1.0	760.0
Sundsvall C – Stockholm C	3095	4.2	1.9	449	119.2	95.8	1.0	600.0
Ånge stn – Stockholm C	1	1.0	–	1	1.0	–	1.0	1.0
Åre stn – Stockholm C	379	3.7	2.0	84	126.0	115.3	1.0	580.0
Östersund C – Stockholm C	725	4.0	1.9	185	150.7	132.4	1.0	810.0
Total	42007	4.3	2.3	7202	129.6	125.8	1.0	1225.0

Notes: #A = number of auctions, #B/A = number of bidders per auction, #GSA = number of GSA, and sd = standard deviation.

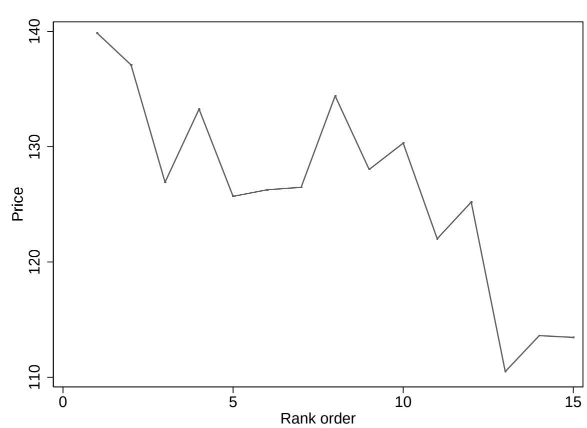

Figure 1: The rank order effect on prices

Table 2: The effects of rank order, presentation order, and timing on prices

Dependent variable: Price	Model (1)	Model (2)	Model (3)
Rank order	-2.788***	-2.767***	-4.133***
	(0.566)	(0.567)	(0.840)
Rank order^2	0.148***	0.148***	0.159**
	(0.0542)	(0.0543)	(0.0732)
Presentation order		-0.966**	-0.988**
		(0.404)	(0.460)
Presentation order^2		0.0531	0.0644*
		(0.0347)	(0.0380)
Minutes to previous			2.802***
			(0.224)
Minutes to previous^2			-0.0964***
			(0.0108)
Minutes to next			1.615***
			(0.215)
Minutes to next^2			-0.0568***
			(0.0104)
Constant	154.5***	157.0***	141.8***
	(1.199)	(1.470)	(2.513)
Observations	29,927	29,927	18,718
Number of GSA	5,999	5,999	5,036

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of observations decrease as we add the timing regressors since auctions with only one ticket are excluded and because the first and the last auction in each GSA always are excluded. “Minutes to next” and “Minutes to previous” measures the difference in minutes between the current auction end to the subsequent and previous auction end, respectively.

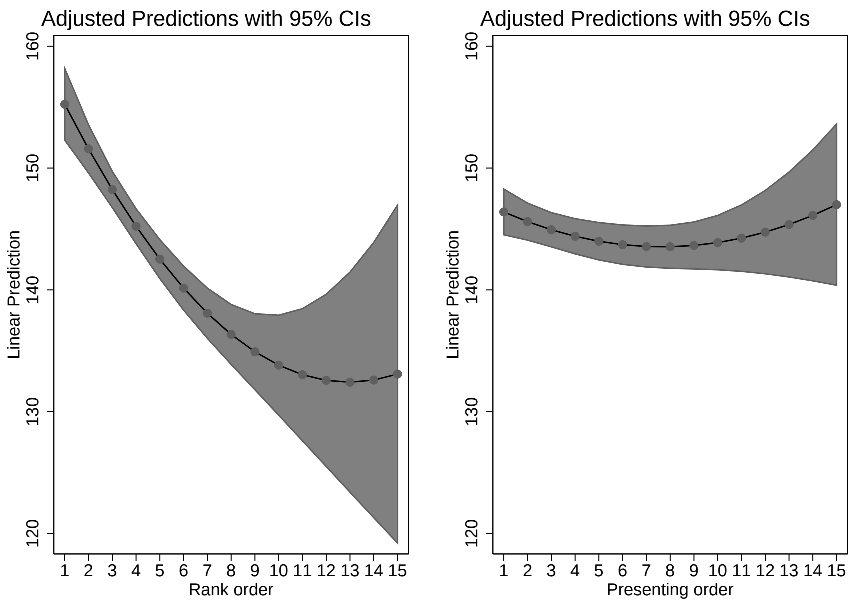

Figure 2: Marginal effect of rank order.

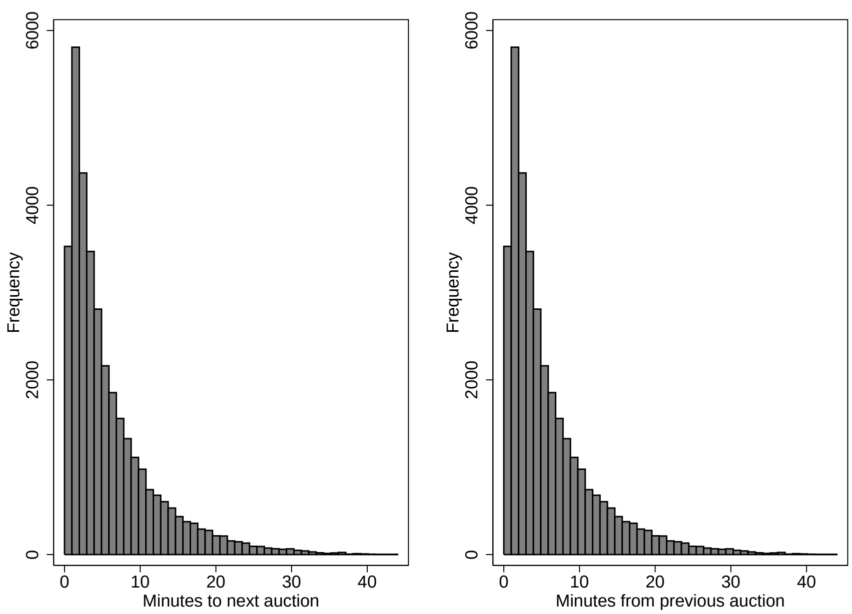

Figure 3: Minutes to previous and next auction.

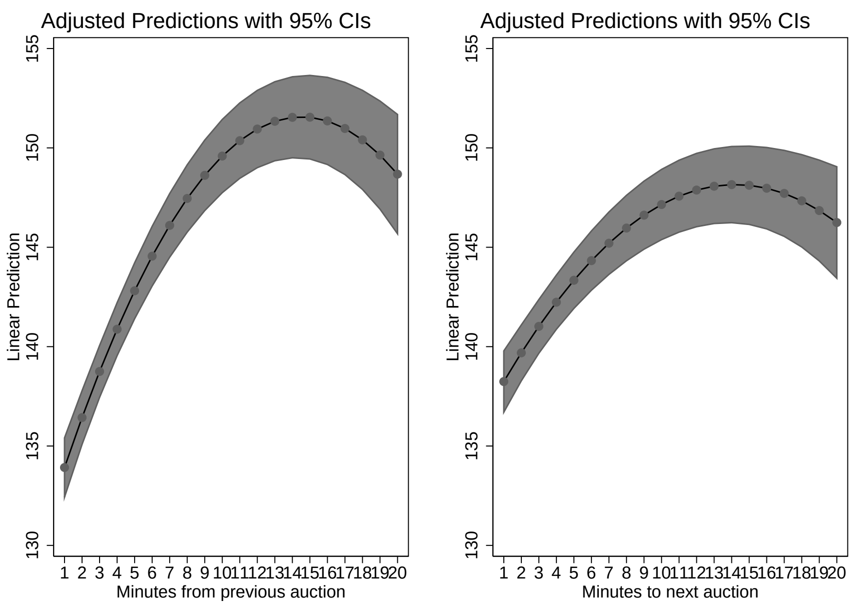

Figure 4: Marginal effect of timing.