Bidding behavior in housing auctions*

André K. Anundsen†, Andreas Benedictow‡,
Erling Røed Larsen§, and Mikkel Walbækken¶

December 31, 2022

Abstract

Using data on more than one million bids from almost 200,000 housing transactions, we examine behavioral patterns uncovered in bidding logs. Norwegian housing transactions are arranged as ascending-bid auctions and bids are made on digital platforms. We use data from these auctions to study individual bidders both within and across auctions with temporal resolution measured in hours and minutes. In this purely empirical study, we focus our attention on how auction outcomes are affected by the degree of competition within the auction. Relative to one-by-one negotiations, we find that auctions with many bidders are associated with shorter bid-expiration deadlines, shorter intervals between subsequent bids, a lower opening bid, smaller bid increments, a reduction in time-one-market, and a higher sell-ask spread. We also find that individual bidders have a higher spread between their first and last bid in auctions with more competition. Finally, we follow repeat-bidders across auctions, and find that bidders tend to increase their maximum bid when they have been unsuccessful in previous auctions.

Keywords: Housing market, auction data, bidding strategies

JEL Codes: D14; D44; D90; R21; R31

*We are grateful to DNB Eiendom for letting us analyze their auction data. Thanks to Andreas E. Eriksen and Erling Eide Bø for comments.

†Housing Lab, Oslo Metropolitan University.

‡Housing Lab, Oslo Metropolitan University and Samfunnsøkonomisk Analyse.

§Housing Lab, Oslo Metropolitan University and BI Norwegian Business School.

¶Sopra Steria.

1 Introduction

Housing transactions are widely studied, but there is a paucity of knowledge on the dynamics of the buyer and seller interaction leading up to the sale. We exploit detailed data on bidding logs and seek answers to questions about the bidding process. We inspect the competition among bidders, the timing of bids, and characteristics of bids that are accepted. Our aim is to answer this question: What behavioral patterns stand out in housing auctions?

The answer is that competition is associated with higher sell prices, shorter bid deadlines, shorter intervals between subsequent bids, smaller bid increments, shorter time-on-market (TOM), and a higher sell-ask spread. Moreover, bidders who are unsuccessful in earlier auctions tend to increase their maximum bid as the number of unsuccessful attempts increases. These findings are sourced from a novel data set that is generated in the Norwegian housing market, which is liquid and transparent.[1] Since the processes of buying and selling a home in Norway are arranged as digital auctions with ascending bids there is a plethora of information. In particular, there is digitized information on the exact time and date of each bid. When an auction is completed, all participants in the auction have the right to see a blinded bidding log, which provides an overview of all bids that have been submitted during the auction, by which bidder (scrambled ID), at what time, and with a description of conditions stated by the bidder.

These bidding logs are saved and stored by realtor companies. We have been allowed access to all bidding logs of one realtor firm, DNB Eiendom AS; a company with a market share of about 20 percent. The data highlight unique qualities of the auctions and also represent a new source of study since the data set include all bids, not only the winning bid. Our data cover the period 2007–2021, and the trimmed data set consists of information on 195,968 transactions and 1,271,741 bids. Our contribution is purely empirical as we present patterns detected in these bids.

[1] One indication is the short countrywide TOM. The average TOM in Norway in January 2022 was 41 days for 5,416 units transacted. See eiendomnorge.no for statistics.

While auctions sometimes may be associated with forced sales or foreclosures, the institutional arrangement in Norway is such that the default option is an English auction. However, some auctions move slowly with few and infrequent bids. These processes may morph into negotiations with one single bidder who tries to find out what the seller can accept. The typical auction starts with an advertisement on the on-line platform Finn.no. In that advertisement a date for the open house is announced, and in the capital Oslo the typical advertisement is placed on the Friday nine days before the open-house Sunday. The bidding starts the first Monday after the open-house. However, auctions do differ in bidding frequency, bidding duration, increments of bids, and the use of bid expiration deadlines. We partition auctions into three classes: i) *Negotiations:* Auctions with one bidder only, ii) *Non-competitive auctions:* Auctions with at least two bidders, but in which fewer than three bidders place three or more bids, and iii) *Competitive auctions:* Auctions with at least three bidders placing at least three bids each. There are 80,914 *negotiations* in our trimmed data set, 99,524 *non-competitive auctions*, and 15,530 *competitive auctions*.

Our goal is to provide answers to a few, select questions that intuitively arise. In doing so, we present an overview of three categories: i) transaction-specific measures (bidding duration, TOM, the spread between the opening-bid and the ask price, and the sell-ask spread), ii) bidding-specific measures (expiration deadlines, time between bids, and bid increments), and iii) bidder-specific measures (difference between a bidder's highest and lowest bid within the same auction). We investigate how our measures of these dimensions vary across auction classes while we control for (the logarithm of) the ask price. We do this because a seller is the agent with the most knowledge about a unit; a knowledge that includes quality, amenities, and location; in addition to observable hedonic attributes. The ask price reflects the seller's valuation of the unit and represents an expected sell price at the time it is put on the market.[2] We add additional controls, including year-by-month fixed effects and realtor-fixed effects.

[2]In fact, in a typical regression of sell price onto ask price we would obtain explanatory power of 0.97, much higher than what hedonic models yield. The reason why is that the seller can take into account features that are unobservable to the econometrician, thus the ask price is a valuable source information.

Finally, we restrict our sample to units that have been sold at least twice, so that we can control for unobserved heterogeneity through unit-fixed effects.

We find that more than 96 percent of the units in our sample are sold within 100 days of being listed for sale, and there is a clear tendency that TOM is shorter for units sold in competitive auctions. Our results suggest that TOM is 9 days shorter for units sold in competitive auctions than units sold in negotiations.

The duration of the bidding is often short, and more than 80 percent of units are sold within a week of the first bid. Bidders often give short expiration deadlines, and almost 60 percent of deadlines are one hour or shorter. New bids arrive quickly. In fact, 74 percent of the bids are countered by another bidder within an hour. We find that bidding duration is longer for non-competitive and especially for competitive auctions, which is a result of higher activity in these auctions. Competitive auctions have significantly shorter expiration deadlines, and bids are countered more quickly. Although the competitive auctions take more time, they are more intense.

Opening bids tend to be substantially lower than the ask price. We find a pattern in which bidders place their first bid in NOK 50,000 intervals below the ask price, i.e. NOK 50,000 below the ask price, NOK 100,000 below the ask price, and so on. We observe that opening bids are significantly lower relative to the ask price in auctions that involve more competition, possibly reflecting the phenomenon that bidders are trying to tease out other bidders' willingness-to-pay.

While most bid increments are small, there are several cases of jump bids, i.e., situations in which bidders increase their bid substantially relative to the previous bid. We document a nominal bias in bid increments in that bidders seem to opt for certain nominal increments, the most common is NOK 50,000 increments, but several bidders choose either NOK 100,000, or even NOK 200,000, increments. About 25 percent of bid increments within an auction are equal to the previous bid increment. Our results suggest that increments are smaller the higher the competition among bidders.

We find that for most bidders there is a substantial difference between their first and final bids. There also seems to be a nominal bias, in which bidders' first bid is set in NOK 50,000 intervals below their final bid. Bidders in non-competitive auctions have a difference between the final bid and the first bid as a fraction of the first bid, i.e., the final-first bid spread, that is almost two percentage points higher than what we find in negotiations. In competitive auctions, it is 4.2 percentage points higher. This finding is consistent with the notion that bidders update their willingness-to-pay for a particular unit depending on how many other bidders are interested in the same unit.

To the best of our knowledge, we are the first to study how bidders behave across auctions. Thus, our findings on what losing bidders do in their next auction may be our most novel piece. There are 16,907 bidders in our data set that are observed to have participated, by extending bids, in auctions of two or more units within the same calendar year. For these bidders, we calculate the highest bid in each auction within which they have participated. We then calculate the spread between their maximum bid in their first and last auction. We see a pattern: Bidders that have competed and not succeeded in multiple auctions tend to increase their highest bid in the last auction, relative to the first auction, while bidders that compete in fewer auctions increase their highest bid by less in the last auction. Put differently, as the number of unsuccessful auctions increases, a bidder tends to increase her/his bids. In particular, bidders who have competed in two auctions have a mean increase in their maximum bid of three percent from the first to the second auction. For bidders who are observed to bid in five or more auctions, the increase in the maximum bid from the first to the last auction is seven percent. There are several potential explanations for this pattern. One possibility is that the pattern is driven by house price trends. Another possibility is that bidders become desperate as they keep losing auctions, and adjust their willingness-to-pay upwards as they participate in more auctions.

Related literature

Our findings relate to the literature on the distribution of bids (Levin and Pryce (2007)),

the bargaining process in the housing market (Merlo and Ortalo-Magne (2004)), auction design (Milgrom and Weber (1982), Bikhchandani and Riley (1991), Arefeva and Meng (2020) and Ettinger and Michelucci (2019)), bidding strategies (Fishman (1988), Börgers and Dustman (2005), Dodonova (2017), Hungria-Gunnelin (2018) and Sønstebø et al. (2021)), jump bids (Avery (1998), Isaac et al. (2007), Ettinger and Michelucci (2016a), Ettinger and Michelucci (2016b) and Sommervoll (2020)) and anchoring effects (Anundsen et al. (2020) and Bucchianeri and Minson (2013).

The structure of the article is as follows. The next section describes the institutional arrangements of the Norwegian housing market, while Section 3 presents the data set on bidding logs and motivates why we make a distinction between negotiations, non-competitive auctions, and competitive auctions. In Section 4, we discuss the main questions we seek to answer and the behavioral patterns we want to map. The final section concludes the paper.

2 Institutional background

Institutional arrangements

The Norwegian housing market is characterized by speedy sales[3] and low transaction costs. A typical sales process begins with a seller who contacts several real-estate agents. They evaluate the the market for the unit and discuss what the ask price would be. When the seller decides which realtor to hire, they find a suitable date for the unit to be put on the market and announce a date for an open house, i.e. a public showing, in which all prospective buyers can inspect the unit. The advertisement, including the open house date, is placed online with the platform Finn.no, which has a market share of at least 70 percent.[4]

An open house is open to anyone who is interested. It provides an opportunity to inspect the home, while the realtor, and sometimes the seller, is present on location to answer questions. Potential buyers may also bring a professional consultant for guidance. There are

[3]See eiendomnorge.no for recent statistics on transaction volume, number of for-sale units, and TOM.
[4]https://eiendomnorge.no/housing-price-statistics/category936.html

strict laws governing the information duties of the seller, thus typically the advertisement includes a technical report performed by an appraiser.

The auction

In Norway, sellers plan to sell homes through an ascending bid auction, and only when few or none bids are obtained will the planned auction-scheme become a more stretched out negotiation process. Bids are submitted in writing, via fax (rare today), or by electronic submission using digital platforms (most common today). The realtor informs the participants, as well as other people who have volunteered their name on the list of interested people, about developments in the auction.

Any bid placed or accepted is legally binding for the buyer (bid) and for the seller (acceptance). After a bid has been accepted, laws regulate what the seller can do to with a unit that has been sold. In essence, the legal transfer of ownership occurs on the exact time the seller accepts a bid. However, the seller may still live in the unit until the take-over date, which typically was suggested along with the bid. Since a bid may be conditional upon the take-over date, the take-over date can be seen as part of the bid. Sellers who have already bought another home typically prefer the take-over date to arrive shortly in order to avoid owning two homes and paying interest on two mortgages. Sellers who have not bought a home typically prefer the take-over date to be later in order for them to find a new home. For buyers, the opposite holds. Thus, the take-over date can be a variable over which buyers and sellers negotiate. The contract signature meeting usually takes place a few weeks after the accepted bid. The registration in public registers takes place after the take-over date.

When the auction has been completed, all participants have the right to see a version of the bidding log in which all bidders are anonymous. The log provides an overview of all the bids placed during the auction, by which stakeholder (using a scrambled ID), at what time, and with what reservations.

Regulation of real estate brokerage and auctions

The current law on real estate entails strict requirements for the realtor, but still allows for the sales process and auction to be set up differently by different realtors, companies, and parts of the country. The law sets no requirement that homes are sold on the basis of an auction, or a specific type of auction, presence of home-seller, or home-buyer insurance, etc. Yet, nearly all ordinary sales are arranged through an ascending-bid auction. Exceptions are inheritance settlements, divorce agreements, within-family transfers etc. In recent years, regulation has been tightened. Since 2011, educational and practical requirements have been set for real estate agents and assistants, as well as for lawyers that undertake realtor assignments. As of 1 July 2010, the earliest possible acceptance deadline for a bid that is communicated via a realtor is at 12:00 PM the day after the last open house. Since 1 January 2014, realtors can only mediate signed bids, acceptances, or rejections.

Auction arrangement may affect outcomes

The Real Estate Brokerage Act gives realtors room for maneuver in designing the sales process. Therefore, it is interesting to sellers, buyers, realtors, economists, and authorities how the construction of the auction architecture affects outcomes, especially the sell price, but also the TOM and other characteristics (number of bidders, number of bids per bidder, frequencies of short expiration bids, etc.).

Of particular interest is the question of whether auction design can cause bidders to change plans along the way. One concern among policymakers is that auctions can get heated and lead to bidding wars, in which inexperienced participants may make legally binding bids that are outside the scope of their economic plan. Ultimately, whether economic agents stick to their plans or deviate from plans is an empirical question; a question that we shall return to below.

Realtors are required to facilitate a fair and sound settlement of the auction and adjust the pace of the bidding so that both the seller and potential buyers have a basis for acting

responsibly and in line with their own interests. However, current laws and regulations do not set clear requirements for the duration of the expiration deadlines. The exception is the requirement that the realtor cannot mediate bids with a deadline earlier than 12:00 PM the first working day after the last announced open house. [5]

3 Data and auction types

3.1 Bidding log data

Our data allow us to study behavioral patterns within and across housing auctions. The data set consists of Norwegian bidding log data provided by DNB Eiendom AS, which is the realtor arm of Norway's largest bank, DNB. The data consist of bid-by-bid and include detailed information of the auction, e.g., the exact time when bids are placed, by whom, under what conditions, and the value of the bid. These data are combined with information in public registries that contain information on attributes of the object for sale. Our data cover the period 2007 to 2021.

We start out with a data set in which we have ensured that there is no missing information on the sell price, the ask price, bids, or the size of the unit transacted. This data set consists of 227,026 transactions and 1,508,072 bids.

We then remove all transactions of units that are sold more than five times over our sample period. We also truncate on the 1^{st} and 99^{th} percentiles of the sell price, ask price, and size. This truncation is done year-by-year and for nine different regions of Norway. This leaves us with 216,404 transactions and 1,436,967 bids.

We remove "unserious" bids – bids that are less than 60% of the ask price. We also identify the 99^{th} percentile of the bid-distribution, and remove the entire auction if at least

[5] In Denmark and Sweden, home buyers in practice have more time. In Sweden, a bid is not binding, which constitutes an advantage for the highest bidder, who in the aftermath of the auction can assess the home with professional assistance and choose to withdraw the bid. In Denmark, it is possible to withdraw from the transaction against a fee that represents a percentage of the selling price.

one bid in the auction is greater than or equal to the 99^{th} percentile. This is done to rule out clerical errors and bids that are extreme. We are left with 1,400,031 bids and 214,546 auctions.

Finally, we remove transactions that are recorded with a sell date that differs from the date of bid-acceptance, units for which the final bid is recorded as being accepted before it was placed, auctions for which any bid expires when or before it is placed. Our final data set consists of 195,968 transactions and 1,271,741 bids.

We use this data set to calculate a set of transaction-specific measures: size, sell-ask spread, number of bids, number of bidders, number of bids per bidder, TOM, and bidding duration. We also calculate the spread between the first bid in each auction and the ask price. These variables are summarized in the upper part of Table 1, in which we also record the fraction of auctions that are owner-occupied and the fraction of apartments.

In the lower part of Table 1, we show the distribution of a set of auction-specific variables: expiration deadline of bids (in minutes from placing the bid), the time elapsed between the placement of subsequent bids within an auction, and the percentage change in bid increments. Finally, we present our measures of the spread between a given bidder's highest and lowest bid within the same auction, conditional on observing that the bidder makes at least two bids.

The median sell-ask spread is zero, which suggests that the ask price has predictive power for the sell price. It does, however, have a right-tailed distribution, with a positive mean sell-ask spread.

Both the mean and median number of bidders are equal to 2, but there are many auctions with both a lower and a higher number of bidders. The highest number of bidders recorded in our data set is 34. At the auction-level, the median number of bids is 5 and the highest number of bids is 84. Each bidder typically makes four bids (75th pct.) or less, but in multiple cases they make more bids.

TOM is short in the Norwegian housing market. 90 percent of the units in our data set

are sold within 54 days of the list date, and the median TOM is 11 days.

While several bidding processes are completed quickly, some have long duration. We define the start of the bidding process as the reception of the first bid and the end of the bidding process as the acceptance of a bid. We denote the length of time from the first bid to the accepted bid as the bidding duration. We observe that more than 75 percent of bidding processes have a duration that is less than or equal to 3 days. We observe many cases in which there are relatively short expiration deadlines, and about 75 percent of the deadlines are two hours or less. Although some bidders extend bids with long deadlines, bids are countered quickly, and the median response-time is 15 minutes.

In most auctions, the value of the first bid is well below the ask price, and the mean spread between the opening-bid and the ask price is 7 percent. Bid increments are typically relatively small, although there are cases in which increments are substantial – at the 90^{th} percentile, bids are increased by 5 percent relative to the previous bid.

At the median, the difference between the highest and the lowest bid of a bidder is 7 percent, which suggests that bidders start their bidding well below their willingness-to-pay.

3.2 Auction types

Sellers want high participation in auctions since a competitive process is associated with a higher sell price, all else being equal Bulow and Klemperer (1996) and Anundsen et al. (2020)). This herding effect (Hott (2012)) may be counteracted by an anchoring effect (Anundsen et al. (2020)) if the cause of the high number of participants was an ask price that was set strategically low.

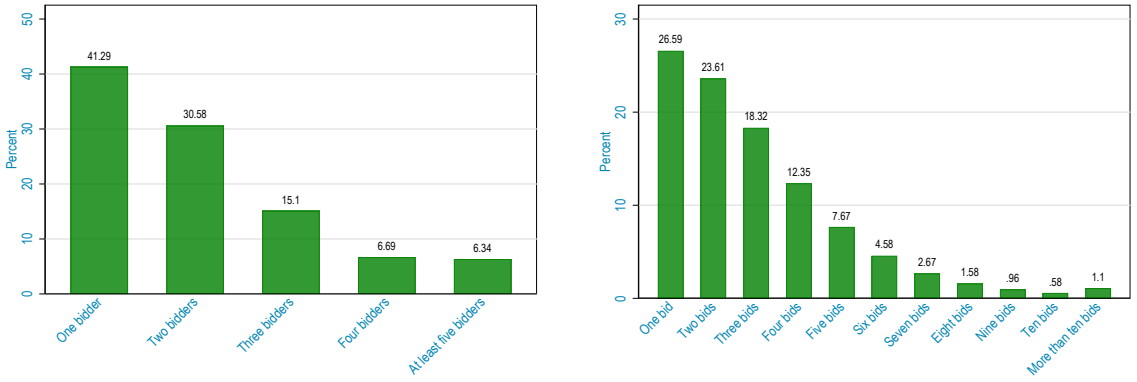
In our sample, 41.29 percent of all auctions have one bidder only, 30.58 percent have two bidders, 15.1 percent have three bidders, 6.69 percent have four bidders, and 6.34 percent have more than five bidders, see Panel a) in Figure 1.

Auctions with many bids are typically associated with many bidders (the correlation is 0.74), but there can also be a significant number of bids in auctions with only two bidders,

Table 1: Summary statistics for auction-level data. Norway, 2007–2021

Variable	10^{th} pct.	25^{th} pct.	Median	Mean	75^{th} pct.	90^{th} pct.
Auction-specific:						
Sell-Ask spr. (in %)	-5.59	-2.61	0	2.12	5.56	12.71
Size (in sqm.)	50	65	89	101.22	130	173
No. bidders	1	1	2	2.13	3	4
No. bids	1	2	5	6.49	9	14
No. bids per bidder	1	1	2	3.04	4	6
TOM (days)	7	8	11	22.87	24	54
Bidding duration (hrs.)	1	2	16	11.48	68	387
Bidding-specific:						
Expiration of bids (in min.)	15	28	44	43.85	143	1064
Time between bids (in min.)	2	6	15	14.72	68	1120
First-bid-ask spr. (in %)	-16.32	-10.78	-6.1	-6.9	-1.91	.25
Bid increment (in %)	0	.43	1.14	.37	2.38	4.84
Spread btw. highest and lowest bid (in %)	2.12	3.92	7.14	5.68	11.98	18.43
Unit-specific:						
Owner-occupied (in %)				48		
Apartment (in %)				55		
No. obs.				1,271,741		
No. auctions				195,968		

Notes: The table shows summary statistics for auction-level data over the period 2007 – 2021. We have calculated the mean and median, in addition to the 10^{th}, 25^{th}, 75^{th}, and 90^{th} percentiles for each variable. All calculations are based on auction-logs from the realtor-firm DNB Eiendom.



(a) Bidders

(b) Bids per bidder

Figure 1: Panel a) shows the distribution of the number of bidders in Norwegian housing auctions, 2007–2021. Panel b) shows the distribution of the number of bids placed by a given bidder in Norwegian housing auctions, 2007–2021. Calculations are based on auction-logs from the realtor-firm DNB Eiendom.

if they seek to outbid each other. Even with only one bidder, we often observe multiple bids (the mean is 2.7 bids), since the seller may reject the first bid or subsequent bids.

Panel b) in Figure 1 displays the distribution of the number of bids placed by a bidder within the same auction. 26.59 percent of bidders place one bid only. In the other end of the distribution, 19.14 percent place 5 bids or more, and 1.1 percent of bidders place more than 10 bids.

Due to the differences in bidding-activity across auctions, we sort auctions into different types, inspired by Coles and Muthoo (1998). They distinguish between negotiations and situations with competing bids. We find it useful to partition auctions into to three types:

- *Negotiations*: Auctions in which there is only one bidder
- *Non-competitive auctions*: Auctions in which there are at least two bidders and fewer than three bidders have three or more bids each
- *Competitive auctions*: Auctions in which there are at least three bidders with at least three bids each

Figure 2 plots the share of auctions falling into each auction class. 41.29 percent of all auctions in our sample are negotiations, 50.79 percent are *non-competitive auctions*, while 7.92 percent are *competitive auctions*.

4 Empirical results

4.1 Key questions on bidding-behavior

We ask a number of questions about auction dynamics and auction outcomes in order to illuminate the micro-structure of the housing market.

1. *How long does the selling process last? We partition this question into four sub-questions: i) What is the typical TOM? ii) How long does the bidding process last*

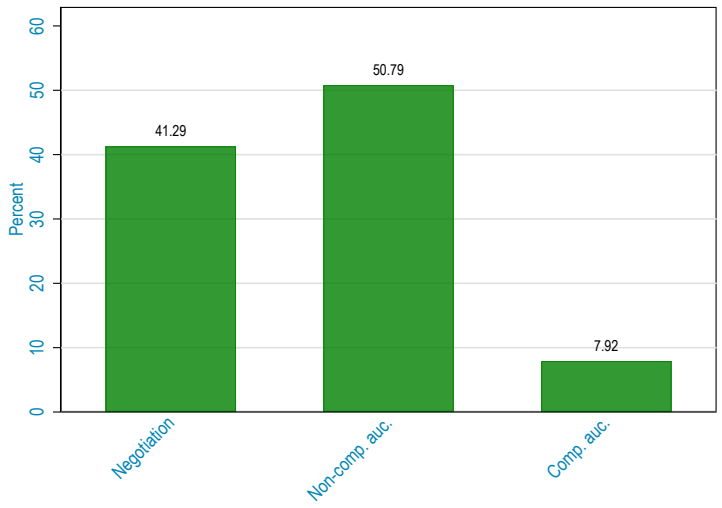


Figure 2: Auction classes. The figure shows the share of all auctions in our sample that are classified as i) Negotiations (one bidder), ii) Non-competetive auctions (at least two bidders and fewer than three bidders have three or more bids each), and iii) Competetive auctions (at least three bidders with at least three bids each). The sample covers the period from 2007 to 2021. Calculations are based on auction-logs from the realtor-firm DNB Eiendom.

after a bid has been placed? iii) What are typical expiration deadlines? iv) What is the time interval between subsequent bids?

2. *How much below ask price do bidders place the value of their first bid?*

3. *What are typical bid increments?*

4. *What is the typical difference between the lowest bid and the highest bid for the same bidder within the same auction?*

5. *What is the typical sell-ask spread?*

6. *Do bidders change their maximum bid across auctions?*

For the first five questions, we explore how the answers vary across auction classes. In particular, we estimate the parameters in an equation of the following form:

$$X_i = \alpha + \eta_h + \eta_r + \eta_t + \beta_1 \text{Non-competetive}_{h,k} + \beta_2 \text{Competetive}_{h,k} + \gamma log(Ask_{h,k}) + u_i, \tag{1}$$

in which i indexes i) the transaction for transaction-specific measures (TOM, bidding duration, the spread between the opening bid and the ask price, sell-ask spread), ii) bids for bid-specific measures (expiration deadlines, time between bids, and bid increments), and iii) bidder for bidder-specific measures (the percentage difference between highest and lowest bid of a given bidder within the same auction). The subscript h indexes the unit, r the realtor, and t the year-month in which the unit is sold. Thus, η_h represents unit-fixed effects, η_r are realtor-fixed effects, whereas η_t denotes year-by-month fixed effects. Non-competitive is a dummy variable that takes the value one if auction k of unit h is a non-competitive auction, and a value of zero otherwise. Likewise, competitive is a dummy variable that takes the value one if auction k of unit h is a competitive auction. It is zero otherwise. Negotiation is the benchmark category. Finally, $log(Ask_{h,k})$, is the logarithm of the ask price on unit h in transaction k. When estimating (1), we consider units that are sold at least twice, so that we can control for unit-fixed effects.

4.2 Answers from data

Question 1: How long does the selling process last?

In this article, we differentiate between TOM (from listing to accepted bid), duration of the auction (from the first day after open house to accepted bid), and bidding duration (from the first bid to accepted bid). Many Norwegian housing auctions are characterized by bidding processes with high bidding activity. In these processes there are many bidders and a substantial number of bids per bidder. Still, the institutional setting is such that bidding typically starts the day after the last open house and in many cases the bidding process ends

on the same day.

In Panel a) of Figure 3, we show the distribution of bidding duration. We find that 45.83 percent of the bidding processes are completed within the same day. In fact, as seen from the light green bars in Panel a) of Figure 3, almost 27 percent of all bidding processes are completed within the first two hours of the placement of the first bid. Another 23.48 percent of the bidding processes are completed on the second day. After one week, more than 83 percent of the bidding processes are completed.

Although a substantial share of bidding processes are characterized by many bids, most bidding processes are completed relatively fast. One factor that is found to be a determinant is short expiration deadlines. An expiration deadline is the time (and date) when a bid expires, i.e. it defines the end of the decision window that is available to a seller. A seller must make a decision whether to accept or reject a bid within this time window. A bid is legally binding within the expiration deadline. Panel b) of Figure 3 displays the distribution of expiration deadlines for all bids placed in our sample. 57.48 percent of the deadlines are within one hour, while only 5.35 percent of the bids have an expiration deadline exceeding 24 hours.

Since a seller has to decide whether or not to accept a bid before the expiration deadline, other interested parties must also make a decision of whether to place bids or not before the expiration deadline of the previous bid is due. If the last bid is attractive there is a high probability that the seller accepts this bid. Thus, bidders that have a higher willingness-to-pay than the current bid, risk losing the auction if they do not make a quick decision to bid higher. However, they also risk making a too quick decision since the seller might reject the bid, in which case they have more time. The distribution of the time elapsed between subsequent bids is shown in Panel c) of Figure 3. When a bid is placed, a new bid typically comes in shortly. Within the first hour of the placement of a bid, 73.74 percent are countered by a new bid. In fact, more than 40 percent of new bids arrive within 10 minutes of the previous bid. Only 7.66 percent of new bids arrive after 24 hours.

We emphasize the difference between bidding duration and TOM. It may take a long time to sell a unit from its list date, i.e. in which case TOM is long, but the bidding duration is short if all bidding activity takes place at the end of the TOM period. In Panel d) of Figure 3, we show the distribution of TOM. The format of the dates allows us to measure TOM accurately only starting 2018, since before this year the data only include information on the date on which the realtor is hired, not when the unit is listed for sale. From 2018, we know the exact date on which the unit was listed on the online platform. TOM is defined as the number of days from the unit is listed for sale until it is sold. We see that TOM is short in Norway.[6] Almost 64 percent of the units are sold within two weeks of being listed. Within 100 days, 97 percent are sold.

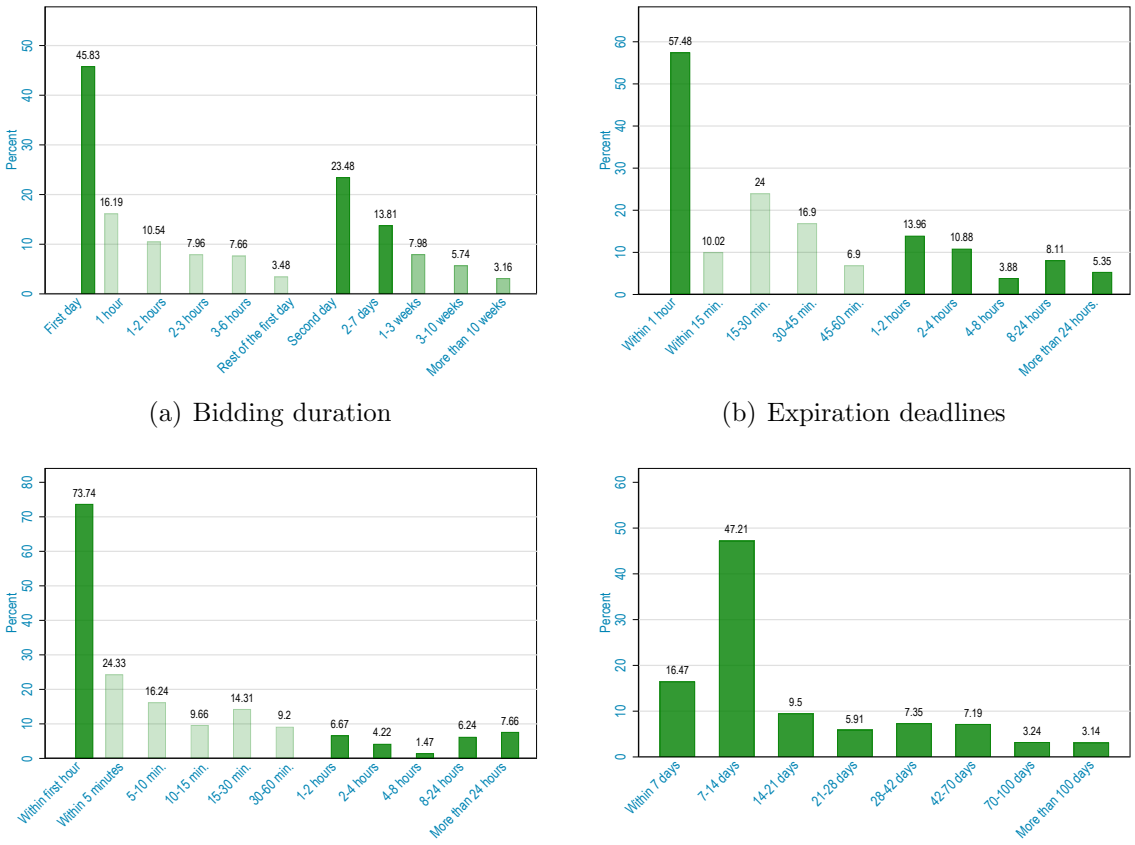
To investigate if, and how, bidding duration, expiration deadlines, time between subsequent bids, and TOM relate to the different auction classes, we estimate equation (1). Results are shown in the first four columns of Table 2.

We restrict the analysis of bidding duration to within-same-day auctions, i.e. auctions with bidding processes that are completed within the day the first bid is received. We find that both non-competitive and competitive auctions are associated with longer bidding duration than negotiations.

When we study expiration deadlines and time-between bids, we restrict the analysis to bids that fall below the 75^{th} percentiles. Results are not materially affected by this, but coefficient estimates are distorted by very long deadlines or cases in which it takes a long time before a new bid arrives.

Although both non-competitive and competitive auctions have bidding processes that last longer than negotiations, we find that both expiration deadlines and time between bids are typically shorter in these auctions. This is particularly accentuated for competitive auctions. There are more bids in these auctions, which makes them last longer, although they are more intense than negotiations.

[6]For comparison, median TOM in the US in 2021 was 48 days in 2021 (St. Louis Fed)



(a) Bidding duration

(b) Expiration deadlines

(c) Time-to-next bid

(d) Time-on-market

Figure 3: Panel a) shows the distribution of bidding duration. Bidding duration is defined as the time elapsed from when the first bidder place his first bid to the seller accepts a bid. The green bars show the number of days, the pale green bars show the different hours within the first day, while the yellow bars show weeks. Panel b) shows the distribution of expiration deadlines. Expiration deadlines are set by the bidder and bids are legally binding within this time-frame. The green bars show the number of hours, whereas the pale green bars show the different minute-intervals within the first day. Panel c) shows the distribution of the time elapsed between subsequent bids within the same auction. The green bars show number of hours whereas the pale green bars show the different minute-intervals within the first day. Panel d) shows the distribution of the TOM, i.e., the number of days elapsed from the unit is listed and until it is sold. The calculations in Panel a)– Panel c) are based on auction-logs over the period 2007–2021. The calculations in Panel d) are based on data over the period 2018–2021. The data are from the realtor-firm DNB Eiendom.

When we study the association between TOM and auction classes, we cannot control for unit-fixed effects, since we only have an accurate measure of TOM starting in 2018. Instead,

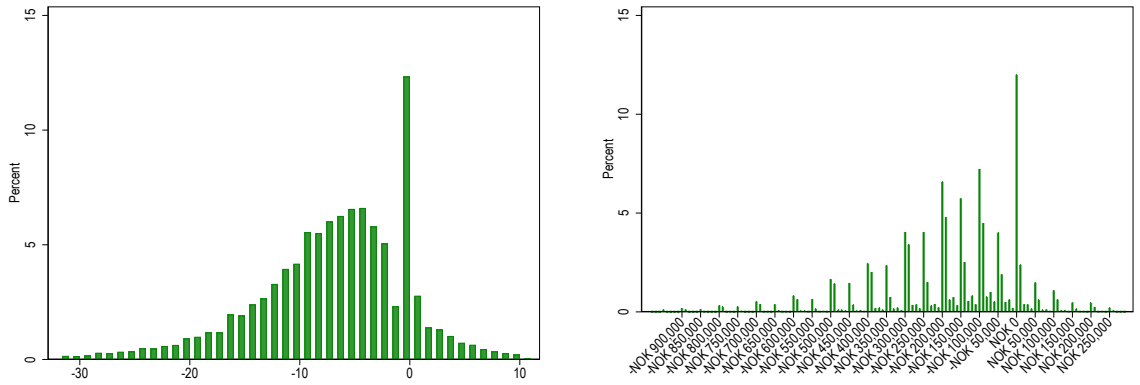
we add controls for the logarithm of the size, dummies for house type (detached versus apartment, etc.), dummies of ownership type (coop versus owner occupied), and zip-code fixed effects. Results are shown in column four of Table 2. It is evident that TOM is about six days shorter for non-competitive auctions than negotiations. For competitive auctions, TOM is almost nine days shorter than in negotiations. The reason why bidding processes are longer but TOM shorter for competitive and non-competitive auctions compared to negotiations is most likely that for negotiations there is typically a long period after listing in which the first bid does not arrive. Thus, in negotiations the bidding processes, using our definition, does not start until long into the period measured by TOM. However, when it starts there are only two agents involved, one seller and one bidder, thus they may quickly come to an agreement whereas in competitive auctions the bidding processes involves several bidders and multiple bids.

Question 2: How much below ask price do bidders place the value of their first bid?

We compute both the percentage difference and the nominal (NOK) difference between the first bid in an auction and the ask price. We refer to this variable as the first bid-ask spread. The 1^{st} and 99^{th} percentiles are trimmed away. Figure 4 displays the distributions. Panel a) shows the percentage spread between the opening bid and the ask price. We observe that many bidding processes start with a bid close to the ask price, although a bid below the ask price is more frequent. Very few bidding processes start with a bid above the ask price.

When we look at the nominal difference between the first bid and the ask price in Panel b), a pattern emerges. We observe clusters around NOK 50,000 intervals, i.e. NOK 50,000 below the ask price, NOK 100,000 below the ask price, and so on. There is also a tendency that many place the first bid NOK 40,000 below the ask, NOK 90,000 below the ask, and so on. Other nominal amounts below the ask price are much less common.

To investigate how the percentage first-bid ask spread relates to auction classes, we



(a) First bid less ask price on ask price. Percent

(b) First bid less ask price on ask price. NOK. NOK.

Figure 4: Panel a) shows the distribution of the percentage spread between the ask price and the first bid in an auction. Panel b) shows the distribution of the nominal (NOK) spread between the ask price and the first bid in an auction. In both figures, we truncate on the 1^{st} and 99^{th} percentiles. Calculations are based on bidding logs from the realtor-firm DNB Eiendom logs over the period 2007–2021.

estimate (1) with the full set of control variables.

Results are summarized in column five of Table 2. In both non-competitive and competitive auctions, the first bid is substantially lower relative to the ask price than in negotiations. For non-competitive auctions, it is 2.4 percentage points lower than in negotiations, while it is 2.9 percentage points lower in competitive auctions than in negotiations. Although both are economically and statistically significantly lower than in negotiations, there is not much difference across these two auction types. The presence of competing bidders is seen to co-vary with a low opening bid from the first bidder relative to the ask. This is consistent with the notion that the first bidder tempts to induce other prospective bidders to reveal their willingness-to-pay. However, it is also consistent with the notion that the low opening bid from the first bidder invites more bidders. A third possibility is that in auctions with more participants there is a higher probability that some participants have lower willingness-to-pay. We cannot establish the cause-effect relationship here.

Question 3: What are typical bid increments?

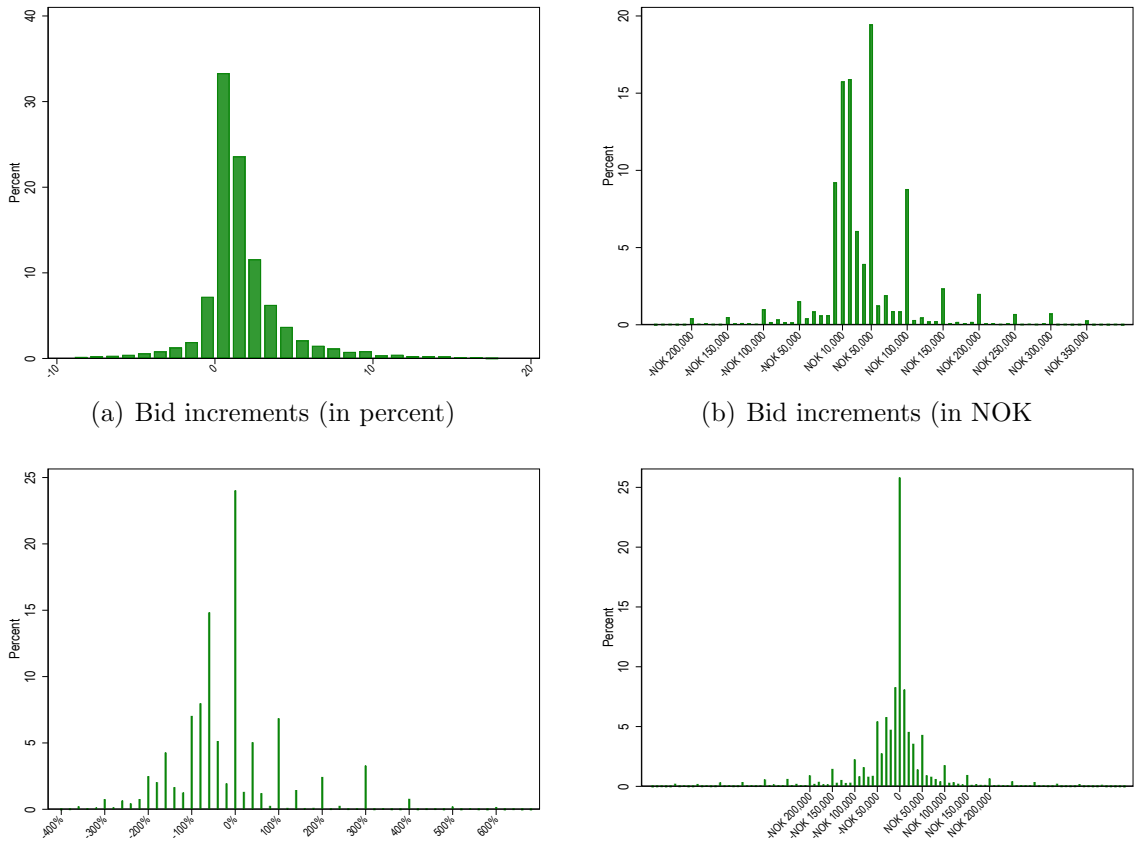
When a bid is placed in an auction, a new bidder may counter this bid. The new bidder can increase the bid marginally or by a substantial amount. There are no constraints on bid increments, which is a function of the bidding strategies bidders employ. We calculate the bid increments for each bid in each auction that has at least two bids. The percentage and nominal distributions of bid increments are shown in Panel a) and Panel b) of Figure 5. We have trimmed on the 1^{st} and the 99^{th} percentiles.

While some bidders place a lower bid than the previous bid, it is more frequently observed that the subsequent bidder places a higher bid. Around 90 percent of bids are higher than the previous bid. That it is not 100 percent in an English auction requires explanation, and the explanation lies in the bid expiration. A bid is only legally binding before the expiration time. If the seller does not accept another bid may be lower. If a substantial time has passed since the expiration of the last bid, a bidder might be tempted to place a lower bid, hoping that the seller has reduced her or his reservation price, i.e. that bidder bargaining power has increased. Another possibility is that the higher, non-accepted bid was placed with a constraint, e.g., that some specific pieces of furniture is to be included or that the take-over date was incompatible with the seller's plans, and therefore a lower bid without conditions might be accepted.

When we examine nominal bid increments, we see that an increase of NOK 50,000 is most common. However, there are also many bidders that increase their bids relative to the previous bid by only NOK 10,000 or NOK 20,000. We also observe a high frequency of bidders that increase their bid, compared to the existing bid, by NOK 100,000, or even NOK 200,000. To explore whether there are signs of increment-inertia within an auction, we look at the distribution of the change in bid increments within an auction. The percentage and nominal changes are shown in Panel c) and Panel d) of Figure 5. Again, we trim at the 1^{st} and the 99^{th} percentiles.

Panel c) shows that almost 25 percent of bid increments are equal to the previous bid

increment. This observation is consistent with the idea that bidders anchor their bid increments relative to previous bid increments. It is also evident that bidders either decrease or increase their increments in round percentages, i.e. they double or cut in half the increment relative to the previous bid.



(a) Bid increments (in percent)

(b) Bid increments (in NOK

(c) Change in bid increments (in percent)

(d) Change in bid increments (in NOK)

Figure 5: Panel a) shows the distribution of the percentage bid increments (percentage change in subsequent bids) for all bids in auctions with at least two bids. Panel b) shows the distribution of the nominal (NOK) bid increments for all bids in auctions with at least two bids. Panel c) shows the distribution of the percentage change in bid increments (percentage change in subsequent bid-increments) for all bids in auctions with at least three bids. Panel d) shows the distribution of the nominal (NOK) change in bid increments for all bids in auctions with at least three bids. In all figures, we truncate on the 1^{st} and 99^{th} percentiles. Calculations are based on bidding logs from the realtor-firm DNB Eiendom over the period 2007–2021.

We report results based on estimating (1), with the percentage bid increments and the

percentage change in bid increments as dependent variables in column six and column seven in Table 2.

Both non-competitive and competitive auctions are associated with smaller bid increments than negotiations. For non-competitive auctions, bid increments are 0.58 percentage points lower than in negotiations. Bid increments are even smaller for competitive auctions, in which they are 1.15 percentage points lower than in negotiations.

Question 4: What is the typical difference between the lowest bid and the highest bid for the same bidder within the same auction?

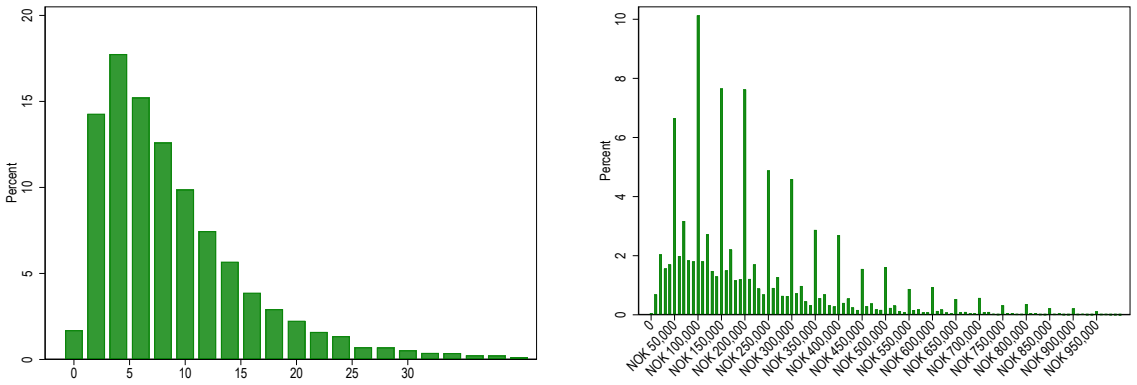
A bidder often makes multiple bids within the same auction. We examine the difference between the highest bid and the lowest bid for each bidder that places at least two bids in the same auction. The distribution of both the percentage differences and the nominal differences are displayed in Figure 6. We have trimmed on the 1^{st} and 99^{th} percentiles.

About 70 percent of the bidders increase their bids by 10 percent or less, measured from lowest to highest bid. However, we do find multiple bidders that increase their maximum bid substantially more. In fact, 10 percent of the bidders place a maximum bid that is at least 20 percent higher than their minimum bid.

When we look at the nominal distribution, we see that the highest bid of a bidder is typically NOK 50,000, NOK 100,000, NOK 150,000, etc. higher than her lowest bid. Again, we see a pattern that is consistent with the notion of nominal anchoring between maximum and minimum bids for a given bidder. About 25 percent of of the bidders increase their bid by NOK 300,000 (app. USD 35,000), or more.

Again, we investigate whether there are systematic differences in the spread between the minimum and the maximum bid within an auction for a given bidder across auction types. Results are shown in Column eight of Table 2.

In non-competitive auctions, the maximum-minimum bid difference is 1.8 percentage points larger than the maximum-minimum bid difference found in negotiations. In com-



(a) Deviation between the lowest bid and the highest bid per bidder (in percent)

(b) Deviation between the lowest bid and the highest bid per bidder (in NOK)

Figure 6: Panel a) shows the distribution of the percentage spread between a bidder's maximum and minimum bid in the same auction. Panel b) shows the distribution of the nominal (NOK) spread between a bidder's maximum and minimum bid within the same auction. In both figures, we truncate on the 1^{st} and 99^{th} percentiles. Calculations are based on bidding logs from the realtor-firm DNB Eiendom over the period 2007–2021.

petitive auctions, the maximum-minimum bid for the same bidder is 4.2 percentage points larger than in negotiations. While it is hard to infer the causal explanation behind these associations, one hypothesis is that people update their willingness-to-pay when they observe that other people are interested in the same unit. In other words, the pattern we observe is consistent with bidders using Bayesian updating.

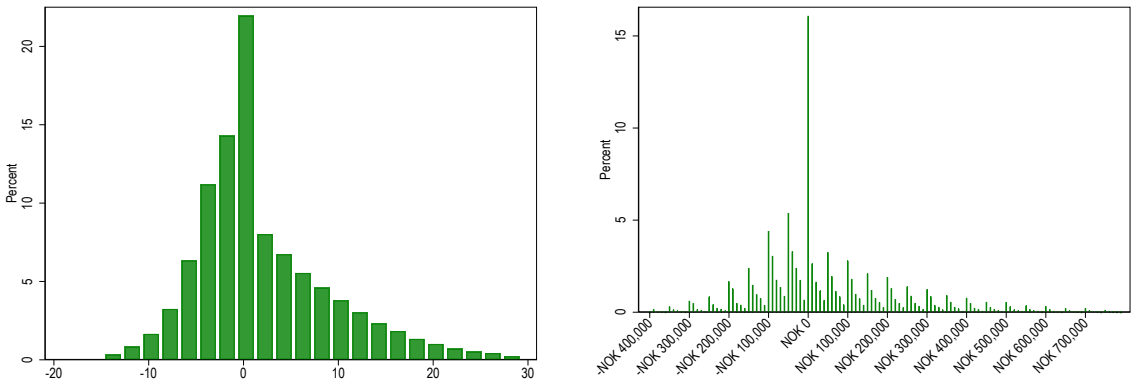
Question 5: What is the typical sell-ask spread?

Our final question in the category of within-auction dynamics is how the sell-ask spread magnitudes are. Figure 7 shows both the percentage (Panel a) and the nominal (Panel b) spread between the sell and the ask price. We have truncated on the 1^{st} and 99^{th} percentiles.

We find that relatively frequently, the sell price equals the ask price. While multiple transactions are observed with a negative sell-ask spread, the right-tail of the distribution is substantially thicker. More than 25 percent of the transacted units have a sell-ask spread that exceeds five percent. When we inspect the nominal distribution, we find clustering around NOK 50,000 in the difference between the sell and the ask price. About 10 percent

of the units sell at a price that is more than NOK 320,000 (app. USD 37,000) higher than the ask price.

We explore how the sell-ask spread relates to auction type by estimating (1) with the sell-ask spread as the dependent variable. Results are shown in the final column of Table 2. While non-competitive auctions have a sell-ask spread that is 4 percentage points higher than the spread is for negotiations, it is almost 10 percentage points higher in competitive auctions. This is consistent with the notion that sell-ask spreads are associated with the number of bidders.



(a) Sell-ask spread. Percent

(b) Sell ask spread. NOK.

Figure 7: Panel a) shows the distribution of the percentage sell-ask spread. Panel b) shows the distribution of the nominal (NOK) sell-ask spread. In both figures, we truncate on the 1^{st} and 99^{th} percentiles. Calculations are based on bidding logs from the realtor-firm DNB Eiendom over the period 2007–2021.

Question 6: Do bidders change their maximum bid across auctions?

While our reports so far have been confined to within-auction dynamics, our data set allows us to follow the same bidder across multiple auctions. Within the same auction, we have seen that a bidder's maximum bid may be considerably larger than the bidder's minimum bid. A natural extension of examining repeat-bidders within auctions is an examination of repeat-bidders across auctions. We are particularly interested in studying patterns that involve a given bidder's maximum bid in each auction the bidder participates in. To this

Table 2: Association with auction outcomes and type of auction. Unit FE

	Bid. Dur	Deadline	Time btw bids	TOM	First-bid-ask	Bid incr.	Chg. in bid incr.	High.-low. bid	Sell-ask
Non-comp. auc.	255.493***	-4.514***	-8.621***	-2.727***	-2.446***	-0.583***	67.077***	1.781***	3.989***
	(66.672)	(0.324)	(0.215)	(0.317)	(0.123)	(0.034)	(2.427)	(0.123)	(0.106)
Comp. auc.	194.691*	-6.330***	-12.559***	-6.848***	-2.937***	-1.149***	63.555***	4.185***	9.781***
	(116.383)	(0.411)	(0.246)	(0.574)	(0.215)	(0.043)	(2.821)	(0.168)	(0.187)
Controls:									
log(Ask)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year-month FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Realtor FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Unit FE	✓	✓	✓	✗	✓	✓	✓	✓	✓
Other controls	✗	✗	✗	✓	✗	✗	✗	✗	✗
No. obs.	25,262	128,306	109,252	46,893	24,366	143,991	115,404	39,289	24,374
Adj. R^2	0.034	0.180	0.192	0.120	0.132	0.061	0.041	0.189	0.425

Notes: The table shows how different auction outcomes and measures of auction-activity are related to auction classes. The benchmark category is *negotiations*, which are auctions with one bidder only. *Non-competitive auctions* are auctions with at least two bidders, but fewer than three bidders have three or more bids each, and *competitive auctions* are auctions with at least three bidders who make at least three bids each. We control for the logarithm of the ask price, year-by-month fixed effects, realtor-fixed effects. and unit-fixed effects. In the regression for TOM, we cannot control for unit-fixed effects, since this variable is only precisely measured from 2018. In that case, we replace the unit-fixed effects with a set of hedonic controls; the logarithm of the size, house type dummies, dummies for ownership type, as well as zip-code fixed effects. With the exception of TOM, all estimates are based on data covering the period 2007–2021. Data are collected from the realtor-firm DNB Eiendom. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

end, we follow repeat-auction participants, which we define as bidders that have participated in at least two auctions.

There are a total of 22,479 repeat-auction participants in our data set. 75 percent of these participate in their first and last auction within the same calendar year. Our analysis is confined to this sub-set of bidders. There are 16,918 such bidders. In Figure 8, we show the distribution of how many auctions they participate in. A vast majority of bidders are observed to participate in two auctions, but 1,690 bidders participate in three auctions. Only 78 bidders are observed in more than five auctions.

For each of the repeat-bidders, we calculate the difference between the highest bid in the final auction they participate in and the highest bid in the first auction they participate in. We then truncate on the 1^{st} and 99^{th} percentiles to rule out bidders that are looking for entirely different objects in the first and the final auction.

Panel a) in Figure 9 shows the mean and the median percentage difference between the highest bid in the last auction in which a bidder participates and the highest bid in the first auction in which the bidder participates. We present the differences for participants in two,

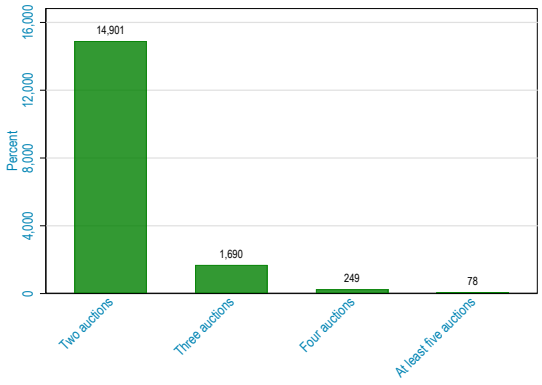


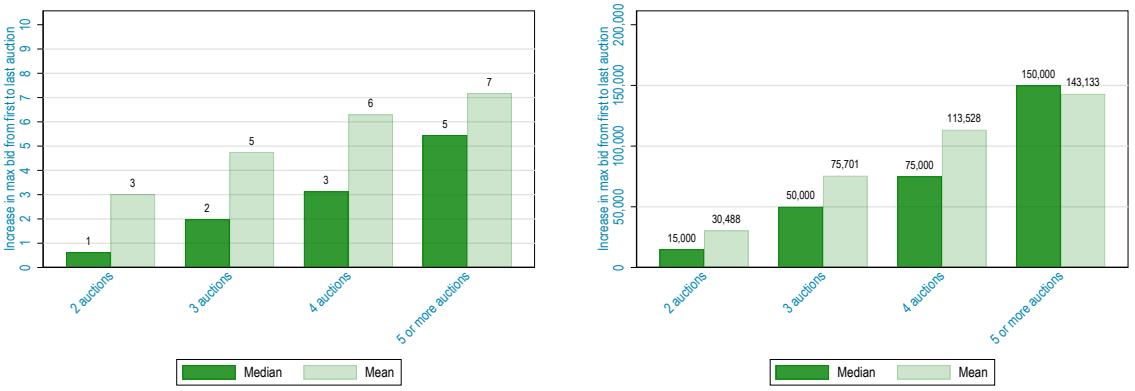
Figure 8: Number of bidders participating in more than one auction, 2007—2021.

three, four, and five or more auctions. The pattern is clear. The highest bid in the first auction in which a bidder participates is lower than the highest bid in the next auction. In fact, bidders increase their highest bid, the more auctions in which they participate. When we inspect the results presented in Panel b), we observe that bidders that participate in at least five auctions in the same calendar year increases their maximum bid by NOK 150,000 (app. USD 17,000) at the median.

These results are consistent with the hypothesis that bidders update their beliefs about what they need to bid in order to win an auction. However, we cannot separate the hypothesis that this behavior is based in rational updating or based in psychological effects of desperation. We do not pursue the question in any detail in this paper since our goal is to report detectable behavioral patterns. However, we shall study the possibility that these patterns reflect market developments.

It is possible that the patterns reflect bidding in a market that experiences a price increase. A bidder needs to increase bids in the last auction within the same calendar year compared to the first auction if house prices increase throughout the year. Another confounding factor is the possibility of unobserved heterogeneity in the competition a bidder faces in different auctions.

To shed some more light on these possibilities, we estimate the parameters in an equation



(a) Spread between max-bids. Percent

(b) Spread between max-bids. NOK.

Figure 9: Panel a) Percentage change in maximum bid from first to last auction. Multiple-auction bidders. Panel b) Nominal (NOK) change in maximum bid from first to last auction. Multiple-auction bidders.

of the following form:

$$\begin{aligned}\frac{\text{Highest bid}_i^{Last} - \text{Highest bid}_i^{First}}{\text{Highest bid}_i^{First}} &= \alpha + \beta_1 \frac{\text{Ask}_i^{Last} - \text{Ask}_i^{First}}{\text{Ask}_i^{First}} + \beta_2 \frac{\text{Size}_i^{Last} - \text{Size}_i^{First}}{\text{Size}_i^{First}} \\ &+ \beta_3 \left(\text{No. bidders}_i^{Last} - \text{No. bidders}_i^{First}\right) \\ &+ \beta_4 \left(\text{Month}_i^{Last} - \text{Month}_i^{First}\right) + \varepsilon_i\end{aligned} \tag{2}$$

in which subscript i denotes bidder i. The dependent variable is the percentage change in the highest bid from the first to the last auction in which the bidder has participated within the same calendar year. We control for the percentage difference in the ask price between the two units in the two auctions in which the bidder places bids. Such a control would partially tease out the effect of an increase in house prices over the window we are considering since ask prices reflect market developments. It also controls for the potential unobserved heterogeneity among units since the ask price reflects unobserved quality and spatial attributes. Further, we control for any differences in the number of bidders in the two auctions since higher bidding activity may lead a bidder to place a higher bid than the bidder otherwise would tend to do. We also control for the percentage difference in the size

Table 3: highest bid among repeat-auction participants

	(I)	(II)	(III)
Constant	3.263***	1.901***	1.463***
	(0.160)	(0.095)	(0.119)
Percentage change in ask		0.787***	0.786***
		(0.005)	(0.005)
Change in no. bidders		0.810***	0.804***
		(0.034)	(0.034)
Percentage change in size		0.017***	0.016***
		(0.003)	(0.003)
Months elapsed between the two auctions			0.339***
			(0.055)
No. obs.	16,575	16,575	16,553
Adj. R^2	0.000	0.680	0.680

Notes: The dependent variable is a bidder's highest bid in the bidder's first and last auction in the same calendar year. This variable is regressed on the percentage change in the ask price and the unit's size between the first and final auction, the change in the number of bidders between the two auctions, and the number of months that have elapsed between the two auctions. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

of the two units. Finally, to further control for market developments, we add the number of months elapsed between the first and the last auction. We estimate three variants of this equation, adding more and more control variables. Results are shown in Table 3.

The intercept is statistically significant in all cases, which suggests that bidders increase their highest bid in the last auction over and above what can be explained by the control variables. Further, we see that bidders who bid for a unit with an ask price that is one percentage point higher for the last unit than for the first unit for which they bid, increase their highest bid by almost 0.8 percentage point. Thus, there appears to be an imperfect pass-through from ask price changes to maximum-bid changes. If there is one more bidder in the last auction relative to the first auction, we find that bidders increase their highest bid by 0.8 percentage points. A larger size is also associated with a higher maximum bid. Finally, the maximum bid increases in the number of months since the first auction.

5 Concluding remarks and policy implications

We present patterns that emerge when we study a novel data set on Norwegian bidding logs in housing auctions. The data set is sourced from Norway's second largest realtor firm, DNB Eiendom, and contains more than one million bids and about 200,000 housing transactions. These bidding logs do not only contain time and date of winning bids, but also time, date, and value of unsuccessful bids. Moreover, the bidding logs have a unique bidder ID that is consistent across auctions.

We utilize the bid-by-bid logs, the timing of the bids, and the identification of unique bidders to describe behavioral patterns in housing auctions. We also link these patterns to the degree of competition in the transaction. We find that a higher degree of competition is associated with shorter TOM, shorter expiration deadlines, and a shorter time-interval between subsequent bids. We also find that auctions with more competition are associated with lower opening bids, smaller bid increments, and a higher sell-ask spread. Finally, we find that bidders that face more competition increase the distance between their first and final bid within a given auction.

As a final exploration into bidding-behavior, we follow the sub-group of repeat-auction participants. Repeat-auction participants are defined as bidders who have competed in at least two auctions within the same calendar year. We find that bidders who have lost auctions tend to increase their maximum bid in subsequent auctions. This finding is robust to controlling for differences in a) ask prices between the units they are bidding for, b) the size of the units they are bidding for, c) number of competitors in the two auctions, and d) number of months elapsed between placing the two bids.

While we cannot conclude that the pattern we find of an association between increases in maximum bid and number of auctions in which a bidder has participated is due to Bayesian updating or psychological effects, the observation has potential relevance to policymakers. If there is a cycle effect that implies more auctions per participant in a heated market, bidders would tend to increase their maximum bid of the last auction relative to the maximum bid

of their first auction more, simply because they would tend to participate in more auctions. This could imply larger mortgages everything else being the same, which would be relevant to macro-prudential policies.

References

Anundsen, A. K., Larsen, E. R., and Sommervoll, D. E. (2020). Strategic price-setting and incentives in the housing market. *Housing Lab working papers*, 1.

Arefeva, A. and Meng, D. (2020). How to set a deadline for auctioning a house. *Available at SSRN 3520197*.

Avery, C. (1998). Strategic jump bidding in english auctions. *The Review of Economic Studies*, 65(2):185–210.

Bikhchandani, S. and Riley, J. G. (1991). Equilibria in open common value auctions. *Journal of Economic Theory*, 53(1):101–130.

Börgers, T. and Dustman, C. (2005). Strange bids: Bidding behaviour in the united kingdom's third generation spectrum auction. *The Economic Journal*, 115:551–578.

Bucchianeri, G. W. and Minson, J. A. (2013). A homeowner's dilemma: Anchoring in residential real estate transactions. *The Review of Economic Behaviour and Organization*, 89:235–260.

Bulow, J. and Klemperer, P. (1996). Auctions versus negotiations. *American Economic Review*, 86(1):180–94.

Coles, M. G. and Muthoo, A. (1998). Strategic bargaining and competitive bidding in a dynamic market equilibrium. *The Review of Economic Studies*, 65(2):235–260.

Dodonova, A. (2017). Preemptive bidding and pareto efficiency in takeover auctions. *Economics Letters*, 159:214–216.

Ettinger, D. and Michelucci, F. (2016a). Creating a winner's curse via jump bids. *Review of Economic Design*, 20:173–186.

Ettinger, D. and Michelucci, F. (2016b). Hiding information in open auctions with jump bids. *The Economic Journal*, 126(594):1484–1502.

Ettinger, D. and Michelucci, F. (2019). Manipulating information revelation with reserve prices. *Annals of Economics and Statistics*, 133:87–92.

Fishman, M. (1988). A theory of preemptive takeover bidding. *Rand Journal of Economics*, 19(1):88–101.

Hott, C. (2012). The influence of herding behaviour on house prices. *Journal of European Real Estate Research*, 5(3):177–198.

Hungria-Gunnelin, R. (2018). An analysis of auction strategies in apartment sales. *Journal of European Real Estate Research*.

Isaac, R. M., Salmon, T. C., and Zillante, A. (2007). A theory of jump bidding in ascending auctions. *Journal of Economic Behavior & Organization*, 62(1):144–164.

Levin, E. J. and Pryce, G. B. (2007). A statistical explanation for extreme bids in the house market. *Urban Studies*, 44(12):2339–2355.

Merlo, A. and Ortalo-Magne, F. (2004). Bargaining over residential real estate: evidence from england. *Journal of urban economics*, 56(2):192–216.

Milgrom, P. R. and Weber, R. J. (1982). A theory of auctions and competitive bidding. *Econometrica: Journal of the Econometric Society*, pages 1089–1122.

Sommervoll, D. E. (2020). Jump bids in real estate auctions. *Journal of Housing Economics*, 49:101713.

Sønstebø, O. J., Olaussen, J. O., and Oust, A. (2021). Opening bid strategies in english auctions. *Journal of Real Estate Research*, 43(1):123–143.