Channel Auctions *

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August 2019

Abstract

Standard auction formats feature either an upper bound on the equilibrium price that descends over time (as in the Dutch auction) or a lower bound on the equilibrium price that ascends over time (as in the English auction). We show that, in some settings with costly information acquisition, auctions featuring both (viz. a narrowing channel of prices) outperform the standard formats. This *Channel auction* preserves some of benefits of both the English (truthful revelation) and Dutch (security for necessary information acquisition) auctions. Natural applications include housing, online auction sites like eBay, recording transactions on blockchains and spectrum rights.

1 Introduction

When the competitive market price for an asset is not widely known and relevant information is held by many parties, auctions are a common method for simultaneously determining prices and allocating the asset in question. The central goal of auction design is to facilitate the acquisition, revelation and integration of this information to facilitate this process. In this sense, auctions are a search and information processing scheme, like those studied in computer science, albeit one involving many agents with potentially conflicting incentives.

*Microsoft Corporation has a patent pending on many of the methods described in this document. We are very grateful to Eva Beylin and Vitalik Buterin for useful comments on this paper and to Charlie Thompson for excellent research assistance.

Despite this parallel, common dynamic auction designs are quite different than search schemes employed in computer science. In computer science, binary search protocols, involving bounds honing in on an answer from both sides, are widely acknowledged to be more efficient in many circumstances than are linear search protocols that start at one end and approach an answer. Yet, nearly all auctions involve a linear procedure. The goal of this paper is to suggest that may be improved in cases by narrowing in on equilibrium prices rather than starting on one side and moving towards them.

We propose an auction in which an upper-bound price descends as a lower-bound price rises. Bidders all begin in the auction at the lower-bound price; this represents a commitment to buy at this price. As this lower-bound price rises, bidders may at any time drop out. Any bidder who is still in the auction may buy at the upper-bound price at any time she wishes and be awarded an object. This process continues until the number of bidders remaining at the lower-bound price is at most the number of objects remaining unassigned. We refer to this design as a *Channel auction* because it involves a narrowing channel of prices honing in on the optimum and because it mixes features of ascending (usually called English) and descending (usually called Dutch) price auctions.[1]

In this paper, we analyze channel auctions in a setting where information acquisition may be important, but also may be unnecessary and wasteful. Our main result gives conditions under which an optimal Channel auction generates higher welfare than the standard auction formats. The intuition is that channel auctions give bidders information that the final price will be in some interval. This allows bidders to wait until the price is guaranteed to be close to their possible valuations to incur information acquisition costs. In contrast, standard auction formats only give information that the final price will be either below some value (in the Dutch auction), or above some value (in the English auction). We discuss some potential applications including the sale of houses and online auctions where we argue it is already informally in use though not widely discussed as such.

2 Background

Most auctions fall into one of two camps. Since the pioneering work of Vickrey (1961), economists have tended to endorse or extend *English auctions.* These involve a price or prices that gradually move upwards from zero or a low number towards the levels that clear the market. Participants stay in the auction until they are no longer willing to pay the price offered and, eventually the number of remaining participants matches the supply.

Economists have been attracted to this format because the points at which bidders drop out will typically reflect their values, given there is no cost of staying in until one's best estimate of value is reached. This tends to suggest goods will be allocated to their highest value (Vickrey, 1961) and

[1]While the English channel actually runs between England and France rather than England and Holland, the pun seems close enough to be worth making.

that much information will be revealed in the process by observing bidders drop out (Milgrom and Weber, 1982). This information helps to ensure that a good allocation is made if it informs bidders about how much the objects may be worth to them (Dasgupta and Maskin, 2000).

The other most common auction format operates on the opposite principle. In Dutch auctions, price(s) start at a high level and gradually descend. At any point, a participant may claim an object at the quoted price and the process proceeds until no objects remain. Since Vickrey, Dutch auctions have mostly been seen as a foil to highlight the benefits English auctions, as bidders will typically wait until the price has fallen below the amount they would be willing to pay before claiming the object. Because this incentive to delay purchase may differ across bidders and because the Dutch process reveals little about bidders' information until it is too late for other bidders to act, they have been seen as inferior.

However, Kleinberg et al. (2018) show that Dutch auctions have an important advantage: they provide bidders with a useful price guarantee as the auction proceeds. Because it is often necessary for bidders to research a purchase, they will often be unwilling to seriously engage with the auction if the price may rise arbitrarily high. Most people, for example, would not spend hours looking at a house if they had no clear sense of at least an upper bound on what its price might be. English auctions provide no such upper bound: a bidder may fear that, after looking at the house, the price will head far up beyond what she would ever consider paying. During a Dutch auction, on the other hand, upper bounds always exist and thus bidders can feel safe investing in acquiring information, at least if this is necessary for a purchase. This means that in cases where information acquisition is important, the Dutch format may greatly outperform the English format.

This suggests an improvement on both schemes. If the role of the upper-bounding Dutch prices is primarily to give bidders security, while the role of the lower bounding English price is to promote information revelation, it may be possible to have a bit of each of these advantages. A Dutch price can descend as an English price rises. The Dutch price provides security and occasionally may be used for allocation, while most sales will occur through the English phase expiring. In this design, a "channel" of prices between the Dutch and the English gradually narrows in on the equilibrium price, similar to the honing of a binary search.

Another important potential advantage of the channel auction, on which we focus in the next section, relates to the possibility that information acquisition may turn out to be wasteful. Consider a bidder who doesn't know how much the object is worth to her and has an opportunity to pay a price for information about its value. Kleinberg et al.'s analysis indicates that she won't be willing to pay this price (or may end up regretting paying it) unless she has confidence that the price is below some level. Effectively, if the price is above some level, it is out of her price range and she would like to know that before she investigates it.

Conversely, if the price turns out to be low, she may regret having acquired information because she would have been wiling to take the object without knowing its exact value to her, and thus acquiring information turns out to have been a waste. Effectively, if the price is low enough, she would buy the object regardless of how good she finds it to be. A channel auction can avoid both the risk of too high a price and the risk of too low a price.

3 Definition of the Single-Item Channel Auction

The simplest, single-item Channel auction works as follows. There is a single object to be auctioned to one of N bidders. Time t starts at 0 and proceeds until one of three conditions listed below is met. The auction has a weakly decreasing upper price $P(t)$ at time t, called the "Dutch price", at which any bidder still in the auction can clinch the object. The auction also has a weakly increasing lower price $p(t) \leq P(t)$, called the "English price", at which every bidder remaining in the auction commits to be willing to purchase the object. At any time, bidders in the auction can buy the object at a price of $P(t)$, or drop out of the auction. The three conditions for termination of the auction are:

1. Only a single bidder remains in the auction. In this case that bidder pays the English price and receives the object.
2. A bidder claims the object. In this case that bidder pays the Dutch price and receives the object.
3. The Dutch and English prices converge. In this case, the object is uniformly randomly allocated among the remaining bidders at the common Dutch-English price.

We illustrate this basic process in Figure 1.

Note that the English and Dutch auctions are special cases of the Channel auction. The English auction corresponds to the case of $p(t) = \bar{v} \cdot t$ and $P(t) = \bar{v}$ where $\bar{v}$ is greater than any bidder's valuation. The Dutch auction corresponds to the case of $p(t) = 0$ and $P(t) = \bar{v} \cdot (1 - t)$.

4 Theory

4.1 Model

We consider an auction game with information acquisition. Three risk-neutral bidders with quasi-linear preferences want to acquire an object. One of the bidders is the *collector*. The collector's *valuation* v for the object has a distribution F with density f. The collector is uncertain about her valuation. She needs to pay an *inspection cost* c to learn her valuation. If she receives the object without inspection, she eventually learns everything at no cost, receiving an average payoff $\mathbb{E}[v]$, which we denote $\bar{v}$.

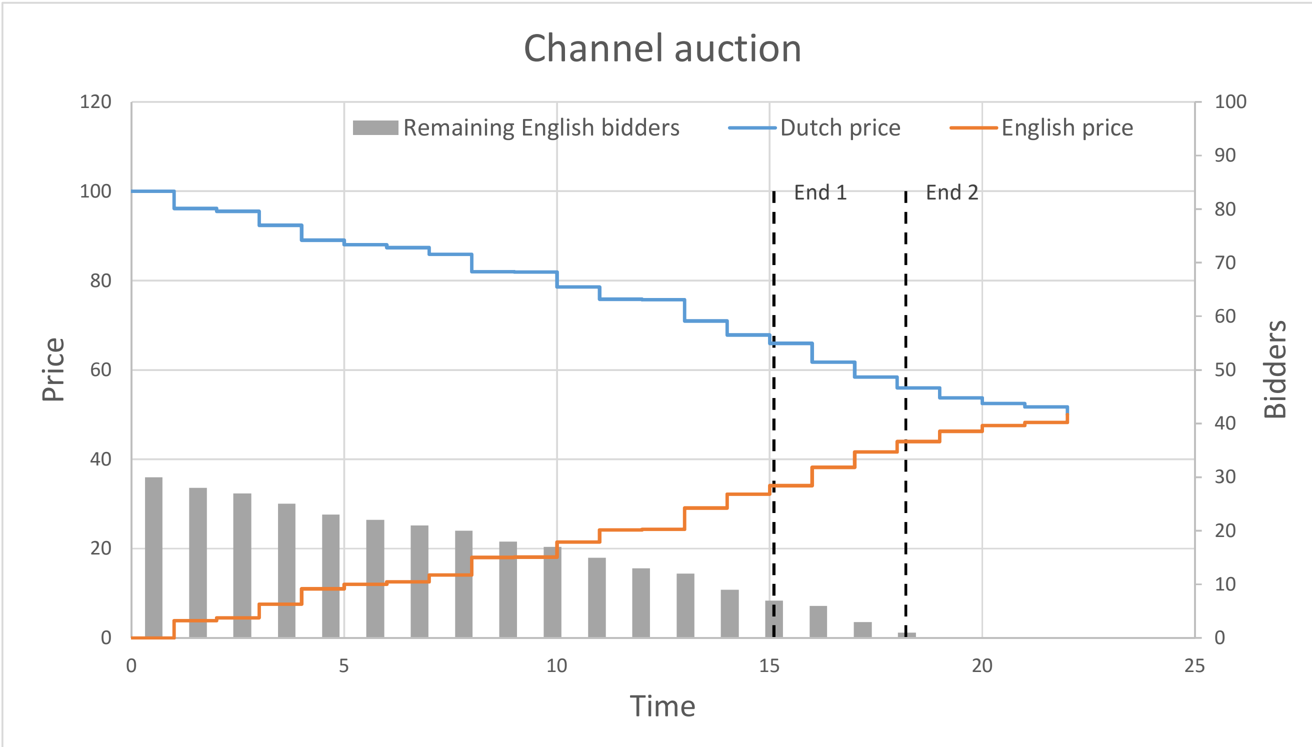

Figure 1: Illustration of a single-item Channel auction with continuous price changes. As the ascending price rises (red line), bidders drop out of the auction (gray bars). The auction may end when a bidder claims the item at the Dutch price (End 1) or at the English price when only one bidder remains (End 2).

The collector faces two other *competitors*. The competitors have the same *value* w for the object, which they both know. The competitors also know each others' values. Their value w has a distribution G with density g with bounded support and is independent from the collector's value.

The object is initially owned by a risk-averse *seller* with quasilinear preferences and zero value for the object. Social welfare is defined as the sum of individual utilities.

4.2 First-best

We start with the first-best with no asymmetric information. That is, how to maximize social welfare given the information available to the bidders. Initially, the bidders only know w. So we have to decide whether to inspect given w, and then decide how to allocate the object. We term the optimal inspection decision conditional on w the *first-best inspection strategy*. We term the set of values of w for which inspection is optimal the *first-best inspection range*. We term the optimal welfare as *first-best welfare*.

The following proposition summarizes the optimal inspection strategy.

Proposition 1 (First-best inspection strategy)**.** *Consider the first-best inspection strategy. Given*

F and c, there are values of w for which it is optimal to inspect if and only if

$$E[(v - \bar{v})^+] \geq c. \tag{1}$$

If this holds, inspection is optimal if and only if $\underline{\sigma} \leq w \leq \bar{\sigma}$ where

$$\mathbb{E}[(v - \bar{\sigma})^+] = c, \tag{2}$$

$$\mathbb{E}[(\underline{\sigma} - v)^+] = c. \tag{3}$$

Proof. There are three options:

1. Do not inspect and allocate to the collector, obtaining $\bar{v}$.
2. Do not inspect and allocate to a competitor, obtaining w.
3. Inspect and allocate to the larger value (v or w), obtaining $\mathbb{E}[\max\{w, v\}] - c$.

First, we consider the condition that Option 3 is better than Option 1:

$$\begin{aligned} & \mathbb{E}[\max\{w, v\}] - c \geq \bar{v} \\ \iff\ & \mathbb{E}[\max\{w, v\}] - \mathbb{E}[v] \geq c \\ \iff\ & \mathbb{E}[\max\{w, v\} - v] \geq c \\ \iff\ & \mathbb{E}[(w - v)^+] \geq c. \end{aligned}$$

The left side is strictly increasing in w, so we find this holds if and only if $w \geq \underline{\sigma}$. Similar calculations show that Option 3 is better than Option 2 if and only if $w \leq \bar{\sigma}$. This proves that inspection is optimal if and only if $\underline{\sigma} \leq w \leq \bar{\sigma}$.

This also shows that there exist cases where inspection is optimal if and only if $\underline{\sigma} \leq \bar{\sigma}$. It only remains to prove that this is the case iff equation (1) holds. Let

$$M(w) := \min\left\{\mathbb{E}[(w - v)^+]\ ,\ \mathbb{E}[(v - w)^+]\right\}.$$

We first claim that $\underline{\sigma} \leq \bar{\sigma}$ if and only if there exists w such that $M(w) \geq c$. Proof: if $\underline{\sigma} \leq \bar{\sigma}$, then $M(w) \geq c$ for every w in between, by the above calculations. If $\underline{\sigma} > \bar{\sigma}$, then every w is either strictly below $\underline{\sigma}$, in which case $\mathbb{E}[(w - v)^+] < c$; or strictly above $\bar{\sigma}$, in which case $\mathbb{E}[(v - w)^+] < c$.

We next observe that $\bar{v}$ is the unique value of w such that $\mathbb{E}[(w - v)^+] = \mathbb{E}[(v - w)^+]$. This implies that $M(w)$ is maximized at $w = \bar{v}$, because one term is strictly decreasing in w and the other is strictly increasing. So there exists w with $M(w) \geq c$ if and only if $M(\bar{v}) \geq c$. □

The proposition makes two points. First, the first-best inspection range is a (possibly empty) interval. This is intuitive. If the competitors' value is very low, then it is better to just give the object to the collector without incurring the inspection cost. Likewise, if the competitors' value is very high, it is better to just give the object to one of the competitors. So inspection is only worthwhile for w between $\underline{\sigma}$ and $\bar{\sigma}$.

Second, the first-best inspection strategy is related to option pricing. As mentioned in Kleinberg et al. (2018), equation (2) defining $\bar{\sigma}$ is a standard formula in option pricing. Namely, value $\bar{\sigma}$ is the strike price of a call option for an underlying asset with value v and actuarially fair price c (cf. Dixit and Pindyck (1994)). Given that it is always possible to allocate to a competitor for w, inspecting can be interpreted as paying c for the option to allocate to the collector instead. If $v \geq w$, we exercise the option, gaining the asset for value v but giving up or "paying a price" of w. Therefore, it is only worthwhile to purchase the option (inspect the item) if w is less than the strike price.

Similarly, $\underline{\sigma}$ is the strike price of a *put* option for an asset with value v and fair price c. Given that it is always possible to allocate to the collector without inspecting, for a welfare of v, inspection can be interpreted as paying c for the option to allocate to a competitor instead. If $w \geq v$, we exercise the option, gaining a "payment" of w but giving up the asset valued at v. This is only worthwhile if w exceeds the strike price of this put option.

However, our assumption that the collector may buy the object without inspection makes first-best inspection strategy more complex than just checking the option pricing formula for $\bar{\sigma}$. The optional inspection means that we also have to check whether w is above $\underline{\sigma}$, so that the first-best inspection range is an interval.

The key implication of this proposition is that neither the English nor the Dutch auction can generate optimal inspection behavior. In the English auction, price only goes up. In the Dutch auction, price only goes down. Either way, it is impossible for inspection to take place in an interval of values of w. In contrast, we will see how to use the option pricing formula to design a Channel auction that achieves first-best welfare.

4.3 Analysis of Auction Formats

We analyze three auction games, following the notation from Section 3. Define the *English* and *Dutch* auctions as in Section 3. Define the *optimal channel auction* as the auction that first lowers the Dutch price to the strike price $\bar{\sigma}$, then raises the English price to the strike price. Formally,

- For $0 \leq t \leq 1$, $p(t) = 0$ and

$$P(t) = (1-t) \cdot \max\{w | w \in \text{support}(G)\} + t \cdot \bar{\sigma}$$

.

- For $1 \leq t \leq 2$,

$$p(t) = (t-1) \cdot \bar{\sigma} + (2-t) \cdot 0$$

and $P(t) = \bar{\sigma}$.

We consider perfect Bayesian equilibrium. The exact games can be specified in standard ways as in Milgrom and Weber (1982), but are cumbersome. So we follow the literature in stating the results and analyzing the key points in the proof without defining all of the moves in each game. We assume elimination of weakly dominated strategies. This implies that in equilibrium of either a Dutch, English, or Channel auction, a competitor obtains the item whenever a price reaches w. In a Dutch portion of an auction, a competitor has negative utility for claiming the item if the price is still above w, while either competitor will attempt to outbid the other if he waits for the price to go strictly below w, so this cannot occur in equilibrium. In the English portion, we have assumed no weakly dominated strategies, so competitors do not drop out either strictly before or strictly after the price reaches w.

We establish two results. The first result shows that the Dutch and English auctions cannot achieve first-best welfare.

Proposition 2. *If there is positive prior probability on all three possibilities $w < \underline{\sigma}$, $w > \bar{\sigma}$, and $\underline{\sigma} < w < \bar{\sigma}$, then equilibria of the English and Dutch auctions do not achieve first-best welfare.*

Proof. First consider either auction and suppose that, in equilibrium, the collector never chooses to inspect. There is a positive chance that $\underline{\sigma} < w < \bar{\sigma}$, in which case this choice is strictly suboptimal for social welfare.

Now consider the English auction and suppose the collector chooses to inspect at some ascending price t. In this case, given that the competitors have not yet dropped out, there is a positive probability that their value w is, in particular, above $\bar{\sigma}$. Conditioned on this case, it is strictly socially suboptimal to inspect.

Similarly, suppose in equilibrium of the Dutch that the collector inspects at some descending price t. In this case, given that the competitors have not yet claimed the item, there is positive probability that their value w is, in particular, below $\underline{\sigma}$. Conditioned on this case, it is strictly socially suboptimal to inspect. □

The next result shows that an appropriate Channel auction does achieve first-best welfare.

Proposition 3. *There is an equilibrium of the optimal Channel auction that achieves first-best welfare.*

Proof. The case where inspection is never optimal, $\underline{\sigma} > \bar{\sigma}$, is trivial. We now consider the interesting case, where $\underline{\sigma} \leq \bar{\sigma}$.

We show that the collector inspects precisely when socially optimal, and the item is awarded in a socially optimal way. First, imagine the collector knew w, which could only improve her utility. Given a fixed value of w, the collector's utility for choosing to inspect at any time prior to the end of the auction would be

$$U(w) := \mathbb{E}[(v - w)^+] - c.$$

This follows because she pays c to inspect and wins only in the event $v \geq w$, paying w.

Now by definition, if and only if $w \geq \bar{\sigma}$, then $U(w) \leq 0$. If and only if $w \leq \underline{\sigma}$, direct calculation shows $U(w) \leq \bar{v} - w$, which is the expected utility for obtaining the item without inspection. Therefore, if the collector knew w exactly, she would conclude that a best response is to: not win the item if $w \geq \bar{\sigma}$; win the item without inspecting if $w \leq \underline{\sigma}$, paying w; and inspect otherwise, winning if $v \geq w$ and paying w. Note this matches the socially optimal inspection and allocation decision.

Now, we argue the collector can achieve this optimal utility without knowing w as follows: do not claim the item during the Dutch portion; wait to inspect until the English price rises to $\underline{\sigma}$; then inspect and drop out when the English price exceeds v. This is a best-response by all players, hence an equilibrium. □

4.4 Illustrative Example

We now consider a stylized numerical example to clarify the intuition for how Channel auctions can outperform the standard formats. The object is an antique vase. The collector is uncertain about her value v for the vase. There is a probability of 50% that the vase is a rare artifact from the Ming dynasty worth \$1,000 to the collector, but otherwise the vase is worthless to her. To determine her valuation, the collector has to pay for an appraisal with inspection cost c equal to \$100. The collector can also acquire the object without knowing her valuation. In that case, she eventually learns the valuation, so that the expected valuation without any information is the expected value $\bar{v}$ of \$500.

The collector faces two other competitors. As in the theoretical analysis, the competitors value the object at the same value, which they both know. The competitors also know each others' values. This leads the competitors to always compete away each others' rents. They clinch the object if the Dutch price is below their value, and they drop out of the auction if the English price is above their value. The competitors' value w equals \$1, \$501, or \$1,000 with probabilities respectively 0.2, 0.3, and 0.5, which is independent of the value of the item to the collector.

Note that this example is further simplified from the theoretical analysis because we consider discrete distributions for v and w. This does not influence any of the key points, while making all calculations transparent. The strike price $\bar{\sigma}$ is given by

$$\mathbb{E}[(v - \bar{\sigma})^+] = c$$

$$\frac{1}{2}(1000 - \bar{\sigma}) = 100$$

so that the strike price $\bar{\sigma}$ is \$800. The lower inspection threshold $\underline{\sigma}$ is given by

$$\mathbb{E}[(\underline{\sigma} - v)^+] = c$$
$$\frac{1}{2}\underline{\sigma} = 100$$

so that the lower inspection threshold is \$200.

Efficient information acquisition is simple. If the competitors' value is \$1, the object should always go to the collector. If the competitors' value is \$1,000, the object should go to the competitors. The only case where it is efficient for the collector to acquire information is when the competitors' value is \$501 (which is the only value in the efficient inspection interval $[\underline{\sigma}, \bar{\sigma}]$). In this case, it is efficient for the collector to acquire information, and receive the object only if it turns out to be the valuable artifact. The first-best expected social welfare is

$$0.2 \cdot 500 + 0.5 \cdot 1000 + 0.3 \cdot (0.5 \cdot 1000 + 0.5 \cdot 501 - 100) \approx 795.$$

We now consider equilibrium behavior under the classic auction formats and the Channel auction.

Dutch auction. In a descending-price auction, if the collector does nothing, the price will fall to the competitors' valuation, at which point the competitors clinch the item. This leaves the collector with two potentially profitable strategies. The most obvious strategy is to acquire no information, and only buy the item if the price drops all the way to \$1. This "no information" strategy yields an expected payoff of

$$\Pi^{NI} = 0.2 \cdot (500 - 1) \approx 100. \tag{4}$$

The other strategy is to first wait until the price reaches \$501 (assuming the competitors do not claim the item immediately at \$1000), then spend the \$100 to acquire information, and buy the object immediately if it turns out to be valuable. This yields a payoff of

$$\Pi^{\text{Dutch}} = 0.5 \cdot (0.5 \cdot (1000 - 501) - 100) \approx 75.$$

In this expression, given that the price reaches \$501 (probability 0.5), the collector spends \$100 to inspect and, if the item is valuable (probability 0.5), pays \$501 to acquire it.

The collector prefers not to inspect, so the expected social welfare of the Dutch auction is

$$0.5 \cdot (1000) + 0.3 \cdot (501) + 0.2 \cdot (500) \approx 750.$$

English auction. Here, the collector has to choose when to inspect the item and when to drop out. It never makes sense to drop out while the price is lower than the expected value \$500. So the collector does nothing until the price reaches \$500. At that point, she should either drop out or inspect the item. If she drops out, the payoff Π^{NI} is exactly the same as when not acquiring information in the Dutch auction (equation 4). If she inspects the item, she will either win the item at \$501, or be outbid by the competitors at \$1,000. This yields a payoff of

$$\Pi^{\text{English}} = 0.2 \cdot (500 - 1) + 0.3 \cdot 0.5 \cdot (1000 - 501) - 0.8 \cdot (100) \approx 95.$$

This expression is the sum of the expected gain from wins at \$1, plus the expected gain from wins at \$501, minus the expected inspection costs. Again, the collector prefers not to inspect, so the expected social welfare of the English auction is also 750.

Channel auction. Consider a Channel auction where the prices start at $p(0) = 0$ and $P(0) = 1,000$. Then the Dutch price goes down to \$800. Then the English price goes up to $\$800 = p(1) = P(1)$.

While the Dutch price is dropping, the only time the competitors might choose to clinch is at \$1,000. The collector never wants to bid at that value, so the collector never clinches in the descending phase.

If the competitors do not clinch during the descending phase, the English price starts to rise. As long as the English price is lower than \$500, the collector wants to stay on, since this is her average value. So the collector's only real choice is what to do at \$500. The collector can either drop out without inspecting, which gives a payoff of Π^{NI}, exactly as in the classic auctions (equation 4); or she can inspect and buy only in the case where the object is valuable. This yields an expected utility of

$$\Pi^{\text{Channel}} = 0.2 \cdot (500 - 1) + 0.3 \cdot (0.5 \cdot (1000 - 501) - 100) \approx 145.$$

This expression is the sum of the expected gain from wins for \$1, plus the expected gain from wins at \$501, minus the expected inspection costs. Because we have $\Pi^{\text{Channel}} > \Pi^{NI}$, the collector does choose to inspect in the Channel auction. Moreover, the collector inspects exactly in the times when it is first-best efficient to inspect. That is, she inspects exactly when the competitors' value w is \$501, which is in the efficient inspection interval $[\$200, \$800]$.

This is exactly what we should expect given the theoretical results. As in Proposition 2, the standard auction formats are inefficient because they do not reveal enough information to induce efficient inspection. And, as in Proposition 3, the appropriately designed channel auction induces first-best efficient inspection, reaching first-best welfare.

The example raises the question of how much Channel auctions can improve on the traditional formats. The following proposition gives a formal lower bound on how much Channel auctions can beat both standard auctions simultaneously.

Proposition 4. *There are instances where the Channel auction achieves the first-best welfare while the English and Dutch auction lose at least 6.5% of the optimal welfare.*

Proof. In our running example, the collector chooses to inspect only in the English stage if the price reaches \$500, i.e. if and only if the competitors' value is \$501. So the optimal welfare is achieved. We have seen that in this example the ratio of the English and Dutch welfare to optimal is $\approx \frac{750}{795} \approx 94.3\%$. By tweaking the probability of comptitor value \$501 from 0.3 to $\frac{1}{3}$ and decreasing the chance of \$1 accordingly, as well as modifying \$1 and \$501 to $\$\epsilon$ and $\$500+\epsilon$, one obtains ratios of $\frac{750}{800} = 93.5\%$. $\square$

The extent to which the 6.5% efficiency loss factor can be increased is an open problem. However, it is easy to see that a separate comparison to the English and Dutch auctions yields much larger factors. For example, it is known (Kleinberg et al., 2018) that in examples with many bidders, each with a small chance of a large payoff, the welfare of the English auction can go to zero as a factor of the optimal; in these instances, the Dutch does very well, and so does an appropriate Channel auction. Meanwhile, we can construct similar instances to the above where the Dutch performs more poorly, in the range of 20% losses (although the English performs well).[2]

Given that the Channel auction nests the English and Dutch auctions as special cases, an optimal Channel auction always weakly improves on the standard formats. The forces in the example suggest that market designers may sometimes improve on a traditional format by adding some Channel auction elements, to induce more efficient information acquisition.

4.5 The Channel Auction Captures the Benefits of Traditional Formats

Channel auctions have two other notable properties. Both properties hold by definition, and capture key advantages of the English and Dutch auctions. The first advantage is that the Dutch and Channel auctions solve an exposure problem. At any point in the auction, a bidder who invests in collecting some information is guaranteed to be able to buy the object at a the price $P(t)$.[3] So the bidder does not run the risk of investing in evaluating the item and then finding out that she is outbid. In fact, the only points in time when it makes sense for a bidder to incur the inspection cost is when the inspection can influence her decision. Naturally, a bidder may inspect and decide to wait for prices to go down further, but she is always guaranteed to be able to buy at $P(t)$. Of course, this benefit only applies to the extent that the Dutch price actually falls to levels sufficient to provide appropriate guarantees to participants.

The second advantage is that, with private values, the Channel and English auctions make it a dominant strategy for a bidder to stay in the auction as long as the English price $p(t)$ is below her expected valuation.[4] This has some of the traditional advantages of strategy-proofness, such as

[2] Allow the top value of the competitors and collector to be some large value $Z \to \infty$ rather than \$1,000, and let it be achieved in each case with probability $\frac{1}{2Z}$. Let the probability of a competitor value \$501 be 0.5, and let the cost of inspection be \$200.

[3] This relies on mild assumptions about the dynamic game that the bidders play. This property will hold, for example, if prices are updated in discrete time, but at each price update bidders take turns deciding whether to drop out or clinch.

[4] This property also relies on mild assumptions about the exact dynamic game played by bidders.

outcomes being less sensitive to higher order beliefs, lowering the costs of strategizing, producing preference data, and not disadvantaging bidders who are less sophisticated. We caution that the Channel auction has a muted version of these advantages because the optimal clinching does depend on other players' strategies.

5 Applications

We discuss three areas where it may be possible to use channel auctions.

5.1 Online consumer goods

eBay has a special case of a channel auction. The Dutch price is the "Buy It Now" price, which rarely decreases. However, if an object fails to sell after a long period of time, we suspect sellers will lower this price, thereby effectively decreasing the Dutch price. Simultaneously, eBay runs an English ascending auction. Einav et al. (2018) show that more commoditized objects tend to be purchased using Buy It Now and some items, with less certain value, tend to be purchased in the English auction. This suggests that allowing both a descending and ascending price may be useful. This is reinforced by the findings of Cao and Zhang (2018) who find that in a closely related context, information acquisition costs are typically a large fraction (approximately 40%) of the value of objects purchased, but that it is "optional" in the sense that the amount of information individuals acquire before purchasing varies widely across individuals, contexts, and price levels. These conditions suggest that explicitly incorporating a descending Buy It Now price and thus effectively converting to a Channel auction could add clarity to the process and could help overcome the primary cost of delay that Einav et al. find is the cause of the increasing switching away from auctions towards sales at fixed prices.

Many individual sales that used to be conducted at garage sales and later on eBay are now conducted on Facebook. Garage sale Facebook groups exist for millions of locations around the world. In a garage sale group, the convention is as follows: the seller posts a picture and short description of the item and a price to the group's newsfeed. The first buyer willing to pay the price gets the item. Some people may post a comment that they are willing to buy for less than the seller's price. Thus the convention is a Dutch auction where the price never descends and an informal English auction. In practice, if the item doesn't sell, the seller will repost with a lower price, implementing an informal and manual Dutch auction. So in an informal way, these communities are implementing Channel auctions. With a small amount of logic, these garage sale posts could be mechanized, adding a clock to descend the seller's price (say, by $1 per day), and allowing more formal bids below the seller value. Such formalization may be particularly useful in contexts where communication is harder and trust lower, such as more decentralized versions of this procedure facilitated by blockchain technologies.

5.2 Real estate

Home buyers are often legally required, by governments and/or lenders, to conduct detailed inspections and appraisals. Still, these processes do not resolve all potential uncertainties about the value of a home. If a foreclosed home is selling for cheap enough, a buyer may need little due diligence to be confident in a good return on investment. But if the price of a foreclosed home goes up, the buyer may need to spend considerable time and effort to evaluate whether the opportunity is worthwhile. In a way, real estate works like an informal Channel auction at present in a manner analogous to the consumer goods example above. A buyer can usually buy a house at the seller's price. The seller will lower the price over time if the house is not selling. Otherwise, buyers compete in an English style auction.

5.3 Cryptocurrencies

Many assets within cryptocurrency and blockchain communities are sold via auction and involve substantial information acquisition. Two examples are auctions for including transactions in blocks and auctions for wallet addresses. We now briefly describe each and how Channel auctions might improve outcomes in each case.

In popular cryptocurrencies such as Bitcoin and Ethereum, the demand to include transactions in the blocks that constitute the only reliable record of changes in state of the system has outstripped the space available to record these transactions. Transaction fees are used to clear the market, most commonly by every transaction proposer (viz. currency-user) submitting a bid price for including their transaction in a block and block-makers and validators taking the top set of offers. Assuming that the value of inclusion continues to rise and limits on availability remain tight, the quality of price discovery and allocation via these competitive processes will play a significant role in the success of cryptocurrency communities.

At present transactions waiting to be included are held in a queue called a "mempool". Transactions are pulled from this pool in a priority order given by the transaction fee they bid. Thus, in practice, the transaction fee chosen determines the rate at which the transaction is included on a block and most transactions are eventually processed in a low demand period. As demand grows, latency in posting transactions is thus expected to rise.

A number of projects have recently been developed to increase the value and reduce the volume of transactions posted to the fully public, decentralized chains. Some prominent examples within the Ethereum community are State Channels and Plasma. Both of these solutions aim to create lower-cost means of recording transactions by conducting many transactions off of the main chain and only reporting summaries or net versions on the public chain. Eventually, the optimal versions of such protocols may be adaptive in the sense that they will post to the public chain less frequently if and when transaction fees are high, though they will also post more frequently when more consequential transactions have take place internally and thus the security of a summary on the public chain is needed.

In such cases, price signals and a thoughtful allocation process will be critical to allow the algorithms or individuals administering these side chains and channels to determine when it makes sense to post to the public chain. The present queue structure leads to uncertainty about latency in transaction inclusion, potentially creating security cost and some degree of chaos. A potential alternative is a batched Channel auction that takes place in the run up to the epoch associated with the block in question and that closes just before the block does, so that prices can be increasingly well forecast as the block closing approaches. Given the rapid growth of this space and the strong openness to experimentation, this may be the nearest-term application for Channel auctions.

Another interesting application in this burgeoning space is for domain names (such as addresses for wallets where tokens are held). Many within the blockchain space refer to the movement as "Web 3.0" and as such domain names and other addresses are important real estate in blockchain communities. Within Ethereum, Maurelian (2016) describes the auction currently being used to sell names. At any time, anyone can show interest in a name and start an English auction that lasts 3 days for this name.

A difficulty this system creates, however, is that trolls may sit and watch for auctions and if an interesting name arises may enter the auction and extract surplus from someone attempting to register a name. This problem is particularly acute in blockchain environments because everything is, by design, public in a way that invites such front-running behavior. This may undermine investments that are complementary with obtaining this name, harm information acquisition, create exposure problems, and so forth. A natural solution is to add a Dutch element to the system. The current system has a deadline of four years since it began operation in 2017 until it stops accepting new registrations. A global declining price could be introduced that is a cap on the price of currently unregistered domains. This could gradually fall until that final date, guaranteeing a buy-it-now price for domain names. English auctions could still be triggered, but any participant could buy a name immediately at the global Dutch price. This would bring the benefits of the Channel auction while preserving the general structure of the present system.

6 Conclusion

The most puzzling thing about Channel auctions is why they are not already more prevalent, at least as a formal proposal by economists. If Dutch auctions have some benefits and English ones others, then it's natural that there are circumstances in which combining lower and upper bounds on prices through a process of honing in would be superior to either. Our analysis above formalizes this point in a simple setting. We hope that our results will inspire further research and practical experimentation on this topic.

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